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Cristiano Storni, Keelin Leahy, Muireann McMahon, Peter Lloyd y Erik Bohemia.

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Edited by:
Cristiano Storni
Keelin Leahy
Muireann McMahon
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Catalyst

Volume 5

Editors
Cristiano Storni, Keelin Leahy, Muireann McMahon
Peter Lloyd and Erik Bohemia

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Editorial

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DRS2018, hosted by the University of Limerick and the Limerick Institute of Technology is the first international biennial conference of the Design Research Society since the 50th anniversary conference in Brighton. This represented both a challenge and an opportunity; a challenge to meet the high standards set in 2016, but an opportunity to contribute to a growing design research field. The balance between these has translated into the conference theme of *Catalyst*. A catalyst is something that precipitates events; it is the coming together of different entities to generate something new; it is the spark for wider change. Framed by the Catalyst theme, these proceedings explore existing and emergent areas at the intersections of design research, practice, education and policy.

The conference itself built further on innovations from the past two conferences; developing more interactive conversation and debate formats, and providing a forum for practice-based research through the increasingly popular workshops. A *PhD by Design* day, first initiated at DRS2016, provided a platform for PhD researchers to learn new skills, present their work, and network with other researchers. The design of the conference, however, was largely formed around the managed theme tracks which included themes relating to the Special Interest Groups of the DRS. In some cases theme tracks emerged from conversations held at previous conferences, representing a pleasing continuity.

From the initial calls for participation there was a great deal of interest in the conference. Once again we had a truly international range of work presented and published in these proceedings. The original call for theme tracks yielded 46 proposals from which 24 were selected. These formed the backbone of the conference and of these proceedings. The theme tracks represent an increasing engagement with new technologies and data but also reflect contemporary social and political concerns, and the need for different types of design research voices to be heard. In particular, the programme committee were committed to bringing diverse global perspectives into play during the conference.

Following the call for theme tracks, the call for papers resulted in 470 submissions of which, after a rigorous peer-reviewing process, 218 (46%) were finally accepted for presentation and publication. This is a slightly decrease in the acceptance rate from the previous conference indicating a corresponding increase in the quality of the proceedings papers. Although some papers were submitted to an open call, the majority of papers were submitted to theme tracks, with each track being managed through the peer-review process by a track chair and all peer-review overseen by the Programme Committee. In total nearly 1000 paper reviews were written by 330 reviewers. The opportunity for authors to rate and comment on the reviews they received has further helped drive up the quality of peer review for future conferences.

DRS2018 reflects the coming together of many different perspectives and themes. As with previous conferences its design has been emergent, developing over the two years prior to the conference. It has been the result of many discussions and collaborations both within the Limerick team and the DRS more generally. The conference, and the proceedings that have resulted, are an extensive

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collaboration between many people but we would especially like to thank the local organising committee comprising members from the University of Limerick (UL), The Limerick School of Art and Design (LSAD) at the Limerick Institute of Technology, as well as members of other Irish academic institutions all of whom contributed valuable insight and experience. We'd also like to thank the track chairs who worked tirelessly and diligently to organise their tracks, and the reviewers who have ensured the high quality of the papers within those tracks.

Lastly but not least, we need to acknowledge the system that helped shape the way we worked together and made our decisions: the ConfTool conference management system. For the uninitiated ConfTool represents an awkward and mysterious interface. For the initiated it represents an indispensable way to manage the complexity of every stage of the conference process. In a way that echoes the conference theme, ConfTool has been a catalyst for our collective effort in bringing DRS2018 together.

In this sense *Design as a Catalys*t becomes a *thing*; a thing in the Heideggerian sense of a gathering of different entities coming together to deliberate on shared issues and reaffirming the role of DRS as a leading forum for discussing design research from multiple angles. But also a *thing* in the sense of something that escapes a specific definition, reflecting the impossibility and perhaps undesirability of a specific definition of what design research is, and should be.

With this sentiment in mind, we sincerely hope that these proceedings catalyse positive change and that the changes propagate to DRS2020 and beyond.

Go raibh maith agaibh,

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Volume 5

Section 16.

Inclusive Design

DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Editorial: Designing for Diversity: Inclusive Design as a catalyst for change?

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This session aims to review contemporary contexts and new dimensions of design for human diversity, and explore the state-of- the-art in research, design and policy-making in this area. Within the past three decades, the concept of design for inclusion (also referred to as Inclusive Design, Universal Design or Design for All) has witnessed recognition and growth as an important and relevant area of practice, research and policy-making, contributing to overall quality of life. However, as the field matures and as we face rapid and complex socio-demographic, economic and political challenges, the need to revisit the core concept of design for inclusion, and to enhance its theories, scope and applications, becomes increasingly urgent.

This sense of urgency is clearly highlighted as we extend our definitions and dimensions of design for inclusion beyond the conventional age & ability axes. The contemporary societal context we operate in, presents us with complex cases of diversity and exclusion far beyond physical or sensory ability. Lifestyle exclusions such as obesity and diabetes, gender and sexual orientation diversity, invisible disabilities and neurodiversity, and social mobility are all pressing examples of such diversity. On another hand, the focus of inclusive design, research and policy-making needs to extend beyond physical accessibility. Thus, moving from 'physicality' to overall 'quality' of life, exploring non-physical and psychosocial elements of inclusivity.

On the other hand, the rapid growth of social networks and makerspaces facilitated by recent advances in ICT and rapid manufacturing, allow for innovative designs to be created, tested and made by a significantly larger part of society including extreme users, hobbyists and entrepreneurs. Social Product Development paradigms (including crowdsourcing, crowdfunding and mass collaboration) together with accessible home-use design and manufacture kits (3D printing etc.), could act as catalysts for inclusive design. This could pave the way for a new era of user co-creation driven by the people, not the enterprise, handing over the power to control inclusivity to the user.

This all builds a strong case for inclusive design to embrace and explore the full spectrum of 'human diversity' - if it is to act as a catalyst for change. This well aligns with the theme for DRS 2018, exploring and questioning the role of design as an agent of change. Hence, the Inclusive SIG this year, has adopted a more critical and reflective approach. This is intended to question the status quo, highlight the current state of the art and outline future opportunities for inclusive design,

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research and policy-making. The scope and focus of papers selected under three main streams in Inclusive SIG 2018, well reflect this priority.

The first stream called 'Advancing Definitions & Methods', presents an excellent range of latest definitions and methods for inclusive design. In 'Capturing and Communicating Individual Narrative Timelines to Reflect Real Life', the authors capture the many human sides of the concept of retirement using empathic qualitative method of narrative timelines. In 'Evaluating Inclusivity Using Quantitative Personas', authors build a strong case for use of quantitative personas as a tool to better capture design exclusion. In 'Numeral Legibility and Visual Complexity', the authors present a rigorous process and investigation of engaging with textual information. In 'Beyond Accessible Aisles? Psychosocial Inclusivity of Shopping Experience' the authors argue for the need to define and detail concept of psychosocial inclusion, moving away from physical accessibility as the only measure for inclusion.

In 'Redefining Diversity' stream, we discuss an impressive range of cases which demonstrate the wide and varied the dimensions of diversity. Moving beyond the conventional, we delve into cases ranging from kids, to citizenship and self inclusion. In 'Seeking for Diversity Among Young Users' the authors build the case for children's photography and discuss use of photography as a tool to engage and include children. In 'Smart Citizenship: Designing the Interaction Between Citizens and Smart Cities', the authors address the critical topic of human centred design of our future smart cities, aimed to accommodate and facilitate inclusive interactions between their diverse inhabitants. In 'Are two thumbs better than one?' the authors adopt a philosophical approach to exploring the concept of diversity and inclusivity, questioning the very foundations of inclusion. And finally, in 'Design for self-inclusion: supporting emotional capability', the authors present yet another interesting angle on inclusion, initiated and owned by the individual, exploring the concept of agency, ownership and self-inclusion.

In 'Assistive Futures' stream we specifically focus on new technologies as catalysts for inclusive design and explore the intersection between technology, assistive devices and inclusion from perceptive, collaborative and practical points of view. In 'Investigating perceptions related to technology acceptance & stigma of wearable robotic assistive devices', the authors present useful insights in regards to adoption, rejection and overall perception of smart wearables amongst older adults. In 'A Study of Roles and Collaboration in the Development of Assistive Devices for People with Disabilities', the authors discuss the interdisciplinary and collaborative nature of the design process, specifically focusing on interactions between clinical experts and designers. In 'Designing Play Equipment for Children with Cerebral Palsy' the authors discuss the context and report on a useful set of guidelines for designing play equipment for the children.

We hope the divergent and forward thinking presented in Inclusive SIG2018 papers, stimulates questions, insights, and a drive to move forward - collectively and forcefully.

DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
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Approaches for Capturing and Communicating Individual Narrative Timelines Reflecting Real Life (Retirement)

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This paper describes a qualitative design research study investigated through the development and application of novel qualitative research methods and tools, developed to engage research participants, and resulting in an original means of communicating findings. The topic being investigated required working closely with older people to explore their individual experiences around the topic of retirement. The research was designed to engage and empower retirees in reflection, discussion, creation and representation of their experiences. The main project output consisted of seven retirement tales referred to as 'narrative timelines' in this paper, which were communication pieces designed to present the more 'messy' research findings towards supporting empathy in discussions affecting the creation of products or services around retirement. These rich and visual communication pieces moved beyond clichéd personas to include 'real voices' and insights into unpredictable and complex life experiences, the process aiming to facilitate a better communication and hence understanding of individuals highly personal experiences.

design ethnography; co-creation; empathy; timelines

1 Introduction

1.1 Research subject

Retirement is a rite of passage experienced by most people in late adulthood. However, unlike other more typically youth-oriented rites of passage (e.g. legal age to work, leaving home, turning 21, marriage etc.) this life event is typically under-studied and can be misrepresented as a homogeneous experience that is the same for all older people. Retirement takes place in a variety of ways and involves significant life changes (i.e. financially, emotionally, operationally etc.) to meet the needs and expectations of today's older people. The difficult to capture voices of those that do not follow a standard route towards and through retirement is currently underrepresented. Hence, the intention of this research was to engage a diverse group of people to ensure that the 'messiness' of lived lives was captured and communicated.

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The research intended to help reframe how retirement is viewed, by capturing significant moments and the more 'messy' elements of lived experiences (Portigal, 2008). The pre-retirement individual is the same individual post-retirement, the main change being their work status, which can be inconsequential for some, or extremely disruptive for others, in a number of different ways. In order to get a sense of the retirement experience from initial preparation through to finding one's feet on the other side, or otherwise, this project worked with 18 individual participants in order to capture a range of experiences representative of people today. We intended to garner a better understanding of the hopes and challenges people face during retirement and understand how this period in life often requires a significant amount of planning, and current products, services and systems do not always meet the needs and aspirations of today's older people.

The intended outcome of this research was to present a more realistic representation of retirement by engaging older people in the conversation and creation process, and building 'narrative journeys' around their voices, needs and expression. Participants were aged between 60-80 and their thoughts, ideas and concerns were captured through co-creation tasks, interviews and workshops. The intention was to move beyond specific stereotypes such as the frail housebound pensioner or the iPod wielding grandmother power-walking down the high street, to capture what older people themselves are saying about retirement.

1.2 Research Process

Selection of participants commenced by utilising existing networks of older users established by the Helen Hamlyn Centre for Design (HHCD) in non-related projects - a total of 18 participants were engaged. The majority of participants (16) were aged between 60 and 75, this was the chosen focus due to the complexity of the transitions they face during this period. 60 year-olds entering a transition phase and 75 year-olds having gone through most typical major transitions, and hence being able to reflect upon what worked and what did not over a longer term. Two 'extreme users' (Dong et al., 2005) of 80+ were included as per the HHCD approach, which looks at extreme user groups to inform the mainstream, these individuals represented a potential 'destination point' for 60-75 year olds.

Research was conducted with people purposely drawn from the following groups:

- Across the socio-economic spectrum, going beyond a focus on the rich or the poor
- Mix of male and female across the 60-75 age range
- Involve samples from a representative range of ethnic groups found in UK
- Different health worries and situations
- Different points in retirement (i.e. about to retire, semi-retired, fully retired)
- Different family circumstances (i.e. divorced, single, near family, distant from family)
- Different geographic locations and circumstances, as environmental factors will play a role

1.3 Core tasks and timescales

The start point for this project derived from a one day scoping workshop held at the HHCD with Nesta, with four researchers from ArtCenter College of Design in Pasedena also participating. 10 design researchers in total attended this one-day session, which in addition required four days of preparation and three days of analysis. From this a full proposal for the four-month study was generated, which was presented as follows:

Month 1: Context setting: desk research and literature review in order to refine topics and create hypotheses. Initial consultation with individual users to focus topics. Start to design the research methods and recruit users. Talk to experts in the field.

Output for month 1: Set of frameworks and hypotheses for testing in the field written up. Users recruited. Design research methods established for creation of engaging topic guide. Desk research complete.

Month 2: User research: test/investigate hypotheses with upto 18 older people and their families using design ethnography techniques. These could include observation, individual/group interviews and some novel techniques that encourage families to interview one another or discuss in groups. Overall, 1-2 days will be spent with each family – the majority of time is spent designing methods and recruiting participants which can be time-intensive. The user insights will be collected and curated to inform themes and design directions to be explored in the next phase of workshop.

Outputs for month 2: Six experiences captured and qualitative data gathered as video, audio, images, user quotes etc.

Month 3: Gather the research into comprehensible themes. Plan and deliver co-creation workshop. Workshop will discuss core issues and develop new narratives. The workshop will require intense levels of staffing and support to ensure that they are productive and informative. A team of six people will run the workshop, act as visualisers, capture the data and help to process afterwards. The workshops will last between 3-4 hours, starting with a shared lunch for the participants and researchers. Although London-focused, the workshop participants will be selected to represent a mixed sample of gender, culture and socio-economic background.

Outputs for month 3: Design ideas and further research resulting from the workshops in the form of communication pieces (e.g. video, audio, drawings, themes and ideas). A list of key questions, actions and design concepts will be developed to act as supporting evidence of need.

Month 4: Fully synthesise data and create dissemination outputs. Write up and sort research and outputs into a report and/or other novel output to be mutually agreed.

1.4 Research Approach

The research endeavored to investigate and capture a range of views, but was not intended to be statistically representative due to the numbers involved (18 participants in total). It was intended to highlight various patterns and, most importantly, to provide a platform for individuals to share the stories of different everyday lives, and to work with these participants to design effective communication pieces around their experiences.

This design research study was carried out by the HHCD based at the Royal College of Art in partnership with Nesta. The project used design ethnography (Salvador, 1999) methods to empathise and engage with a range of people, to record their experiences and aspirations, and to capture responses to design provocations (Norwegian Design Council, 2010). It then went through a process of discussion and co-creation to deliver ideas and outcomes. 18 older people based across the UK participated in research over a 3-month period. As a qualitative study large samples groups were not the aim, instead considering a smaller group of more targeted individuals was considered more appropriate (Formosa, 2009), but diversity was sought in individual circumstances in terms of age, gender, culture, family, wealth etc. Time (one month) was allocated for the more particular requirements for recruitment, ensuring participants were representative of a broad snapshot of markedly different experiences. The design research study examined experiential aspects of retirement from an emotional and functional perspective such as personal approaches and adjustments along the journey from pre- to post-retirement.

The initial internal working session in addition to a wealth of previous connected research carried out in the area by the HHCD was used to identify initial interest areas. This informed the design of a 'narrative booklet' - a development on the Cultural Probe (Gaver et al., 1999) delivered to participants to facilitate reflection and recording of experiences around life and guide follow-up interviews. The booklet took advantage of visual communication and aesthetic to encourage more extensive responses, and inspire reflection - it was playful, prompting, and at times provocative – the intention being to engage the participants to be open and reflective as they completed out each task. The application of 'design skills' in this instance being in the delivery of a platform for expression, in terms of a visually compelling booklet, that was created to encourage participation.

The first phase of the engagement involved delivering the booklet to 18 pre-selected people that brief discussions had already been carried out with to explain the nature of the research. This presented a range of creative tasks relating to their retirement attitudes and experiences (Figure 1). Their responses were followed up one to two weeks later with interviews held at each participant's home, which allowed them to elaborate upon their answers and discuss their responses further.

Figure 1 – Narrative booklet containing creative tasks framed around the retirement experience

2 Information capture through 'narrative booklets'

The design of the booklet was a critical component of the research, not only was it be sent ahead prior to face-to-face meetings, it was also the primary means of data capture of individual experiences and the bridge for follow up interviews (Figure 2). The material generated from these was intended to elicit unique individual experiences of retirement and develop genuinely representative characters and storylines based on the individuals and themes established from the engagements.

Figure 2 - Follow up interviews

The booklet's 20 pages of exercises intended to creatively engage participants in self-reflection, and provide a platform to externalise experiences and hopes in relation to the process of retirement.

As participants progressed through the booklet, tasks prompted them to be increasingly reflective and expressive. The first page began with simple questions asking for personal details such as age and profession. It continued onto more reflective questions from which anecdotes and histories could be expressed. Some questions were designed to help establish rapport and work as conversation prompts in the later interviews. Other questions went beyond 'written' responses prompting participants to, for example, literally draw how they felt other people perceived them. Participants were asked to capture different aspects of their lives; talk about their dreams; describe their worries; draw their passage through life and so on. This allowed specific topics to be explored as well as unexpected themes to emerge.

Provocation exercises such as 'My 3 Biggest Difficulties' (Figure 3), gave people the opportunity to express frustrations such as health-related issues – 'current injury to hip'; social relationships – 'relating to my son's girlfriend'; and lifestyle – 'changing some habits of a lifetime that get in the way'.

Figure 3 – 'My 3 Biggest Difficulties' responses

The 'I Dream of' (Figure 4) exercise openly prompted people to go beyond the everyday and talk about dreams and aspirations. This gave perspective on their lives at an aspirational and emotional level. Some spoke of more immediate self-improvement such as 'being this energetic, dynamic creative person', whilst others expressed lifetime goals such as 'making a mark before I die.'

Figure 4 – 'I Dream of' responses

3 Follow up interviews

It was suggested to participants that they complete the workbooks over a three-day period prior the interview at their home carried out by one of the project researchers. Casual and informal, the semi-structured interviews typically lasted between 2-4 hours, and were based around the material people had self-recorded in the booklet. This allowed the contents to be directly discussed and qualified with the participants whilst still fresh in their minds. For example, the 'Piece of Your Life' (Figure 5) exercise asked people to write a personal reflection about their life along an illustration of the rings of a tree. This was an open prompt allowing participants to self-select the segments of their life that they felt were important to express. The reasoning behind their answers was more thoroughly qualified during the visits as they were asked to read through the piece and explain why this was what they most wanted to communicate.

Figure 5 – 'Piece of Your Life' responses

The information gathered helped to identify recurring issues and emerging themes across the group, which formed the basis of the initial 'narrative timelines'. These timelines were a series of communication pieces intended to capture and communicate the individual experiences in an efficient and empathic way.

4 Development of themes

The research identified that people take to retirement in different ways. Some embrace it, some ignore it and others simply do not retire. In many cases different approaches were taken and adapted in an ad-hoc way dependent upon the individual's life and situation. Retirement often happened in a way that was not predicted, some having positive experiences and others more challenging ones. These complexities were captured to aid understanding of the variety of potential experiences.

Life after retirement had some common themes, with life and time being largely structured around three key areas: leisure, people and task. This aligned with previous research undertaken by the partner on the project (Khan, 2013) The participants' focus on these varied immensely but all were a common thread that ran throughout the data produced by the research.

These themes formed a framework around which seven characters and their associated timelines were developed. They are defined as follows:

Leisure: This relates to time spent on non-work related activities such as hobbies, vocational pursuits or simply relaxing. It is about recreation and reflection. This theme is illustrated by the following participant quote -

> *"I spend my time doing things that interest me. I started a degree in sociology. It was just something for me. It was something I had always wanted to do."*

People: This looks at relationships, companionship and connections with people. This could be with family, friends, networks, special interest groups, social groups or situations. This theme is illustrated by the following participant quote -

> *"I love people. At times when I worked I was too busy, but you have more time when you retire to connect. And I think you're more approachable. You're safe."*

Task: This relates to things people are obliged to do. Day-to-day activities and focused duties that can be considered 'work' rather than 'leisure'. In retirement this may be a more casual or voluntary role. This theme is illustrated by the following participant quote -

> *"I like tasks, things with a beginning and end, that need to be done. Sometimes to help others – that's satisfying."*

5 Development of timeline framework

Although the event of retirement is a single moment in time, the fuller experience reaches beyond this single moment. It was apparent from the research that the build-up to this moment and the progression after was interconnected and had a bearing on the participants' current lives. In order to capture and communicate the fuller retirement journey the research was compiled around 'preparation' prior to retirement and 'adaptation' post-retirement:

Preparation: The period before retirement mainly concerning varying degrees of planning that can take place. This included rethinking daily routines and structures.

Adaptation: The period after the retirement moment focusing on the implementation of new plans or the adjustment of previous routines. This involves much more than a simple change of work patterns.

6 Co-creation workshop

A workshop was then prepared to explore and corroborate the identified themes established during the first phase of research, and to further develop the characters and timelines through co-creation tasks responding to the initial draft timelines. During the workshop initial findings and themes were visualised in a presentation and accompanying co-creation workbook that was used to engage a

group of six retirees partnered by six design facilitators in a number of exercises. This built upon the information gathered from the original booklets and interviews, and helped crystallise findings. The main purpose of the workshop was to ensure initial findings were supported by those that contributed to earlier research, and to gather material to further detail and develop the narrative timelines. In addition, the workshop was used as a pilot test of the initial drafts of the narrative timelines, the participants were asked to carry out a series of tasks based around the timelines that had been developed. They began by interrogating the experiences portrayed to ensure they were considered accurate and believable, based on their own experiences and those of people they knew, before moving onto other tasks. One of the tasks was to address recurring statements that emerged about retirees in the interviews. This selection of statements drawn from the earlier interviews presented as the 'Myths of Retirement' (Figure 6), and the participants were asked to provide their input on the statements and opinions, drawing firstly from their own experiences and secondly from the experiences presented to them through the timelines.

Figure 6 – Myths of retirement co-creation task

Research outcome

The main outcome of the project was seven retirement tales embodied in and communicated as 'narrative timelines' (Figure 7) based on the individuals involved in the research, directly presenting the voices and concerns revealed through the research.

The timelines aim to provoke conversation, assist interrogation and challenge assumptions for anyone involved in addressing retirement. The timelines present a more realistic view of the different ways in which people transition through the retirement moment. They look at what is easy, what is challenging, and how such situations are approached. These seven 'characters' were divided across the three themes of People, Leisure and Task (Figure 8). For example, within the 'People' theme was 'Mother Hen', who found fulfilment in looking after her family but neglected herself as a result; within the 'Leisure' theme was 'Deep-ender', who was forced out of the workplace and into retirement unexpectedly and undeservedly; within 'Task' is 'Surprised' who had to retire in his 50s due to alcoholism and having now found stability is struggling to find fulfilment.

Figure 7 – Overview of seven distinct retirement timelines

Figure 8 – Characters grouped by theme

One 'character' in each area made a positive transition into retirement and 'found their feet' whilst the other finds it difficult. This aimed to give a truer representation of the range of older people's experiences and go beyond the imaginary persona or retiree stereotype to show a range of very different real-life experiences.

The characters draw on the experiences of the participants and use individual quotes and anecdotes gathered from the research. Although the characters are written based on individuals, they are

depicted using illustrative non-specific photographs as the aim is to use them to provoke response and provide perspective on an individual experience rather than focus on a individual person.

Each 'character' is depicted within a retirement journey (i.e. a timeline) typically presenting highlights from 10 to 20 years to capture their situation pre- and post- retirement. Direct user quotes were used throughout the journeys in order to bring these timelines to life and ensure they were representative of the people involved in the research.

The timelines were physically embodied (Figure 9) as scrolls of upto two metres length, which could be easily transported and unrolled for consideration in workshops and similar occasions. More recently the timelines have also been compiled into an interactive pdf that can be easily scrolled through on tablet devices, the intention of compiling them in this format is for ease of distribution and use.

Figure 9 – Retirement scrolls and Ipad interactive pdf

One example from the narrative journeys was the retirement tale of Nigel. His journey starts at the age of 54 when he is happily married and a successful professional (Figure 10). When his wife dies when he is 55 and he falls into alcoholism (Figure 11).

Figure 10 – Nigel timeline segment 1

Figure 11 – Nigel timeline segment 2

This example is amongst the more 'messy' in that, using the participant own words, he 'didn't retire as such' but instead 'chucked it' (Figure 12). The timeline continues to elaborate on his experience and recovery over a period of 10 years, until he eventually finds his feet and begins to evaluate his position in life, his anxieties and his concern over how he can again contribute to society (Figure 13).

Figure 12 – Nigel timeline segment 3

Figure 13 – Nigel timeline segment 4

7 Discussion and conclusion

The research in this project answered many questions; however, in addressing a complicated issue it also highlighted new areas that need future focus and exploration. For example, an unexpected result of the distribution of the booklets to participants was demonstrated in several cases where the booklets became a tool to instigate and mediate difficult conversations around retirement with family members and close friends, allowing topics that had never broached before to be discussed. These included issues such as legacy, personal fears and even unvoiced irritation with another family members perspective. During the interviews many people commented that the booklet added another dimension to their responses and helped them unpick new perspectives. This aspect of the research highlighted potential for further work exploring ways to use design enable retirement discussions, and allowing family and friends to reflect upon the motivations and support decisions made during retirement journeys.

The narrative booklet was considered an effective means of engaging participants and supporting follow up interviews. The material generated in combination with the co-design workshop informed the creation of seven narrative timelines that were successful in telling seven very different retirement tales. The intention to communicate complexity over a timescale, helped take the material further than static and fictional personas (Portigal, 2008). The material was embedded with the real stories, viewpoints and comments of the participants, which made the timelines compelling and went some way towards evoking a level of empathy (McGinley and Dong, 2011) with the individuals being represented.

The pilot test of the narrative journeys in the co-design workshop assisted in the generation of creative and compelling ideas and creative outputs. The 'retirement journeys' were further explored in a four-person session of academics and an innovation manager from a major charity to explore how they might be used in future workshops. Potential future uses identified were in workshops, think-tanks, ideation session and in brainstorming scenarios where the direct voices of diverse retirees are usually missing. This aligns with the hopes of the project, the timelines do not aim to replace real people but offer a tool to stimulate conversation, envision scenarios and virtually test situations. The timelines were considered successful in succinctly presenting textured human stories to an audience that do not need to be fluent in ethnography or design thinking. It effectively communicates the needs and the aspirations of retirees into frontline consideration by providing engaging textual and graphic representation that inspires new thinking and stretches perspectives.

They can be used by anyone as part of a body of material to create more relevant and people-centred ideas, products, services, systems and environments that relate to retirement.

The research has limitations, the timelines developed were specific to the retirement project, they depicted seven retirement journeys selected from 18 participants to highlight as broad a range of experiences as possible. However, the set could potentially be expanded to include many more interesting and diverse retirement experiences.

There is another obvious limitation in that the timelines are framed around the specific subject matter - retirement, this was intended, as the topic of the research. However, it is considered an effective approach to focus on significant life events, and future timeline development for other projects could similarly use this kind of focus as this approach proved useful in stimulating response and conversation - everyone had an opinion, which in turn contributed to the development of rich and informative timelines.

The approach was effective in engaging people in considering their varied life experiences, broadening conversations in the research. The finished timelines have been used in a number of workshop sessions to explore the user experience around retirement with policy makers, insurance companies and the general public. In these sessions they have acted as a tool to help people interrogate ideas and identify opportunities for change.

This project identified ways to move beyond the static persona, and attempted to capture a 'messier' lived experience. There are of course limitations to the depth that can be captured around a lived life experience in a communication piece, even with a longer period of experience being examined; however, these timelines go some way towards moving into a more dynamic representation, a pursuit which the researchers on the project continue to investigate.

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Evaluating Inclusivity Using Quantitative Personas

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Exclusion assessment is a powerful method for assessing inclusivity in a quantitative way. However, its focus on capability data makes it difficult to consider the effect of other factors such as different ways of using a product. We propose addressing this by combining exclusion assessment with quantitative personas. Each persona represents a group of people with similar capabilities, and is enhanced with other personal information. The capabilities of each persona are compared against the product demands to assess whether they (and thus the group they represent) could do a task. The additional persona information helps to determine how they approach and conduct the task. By examining personas that cover the whole of the target population, it is possible to estimate the proportion of that population who could complete the task. We present a proof-of-concept study using personas created from Disability Follow-up Survey data. These were used to assess the task of carrying a tray of food across a cafe, taking into account how using mobility aids restricts hand use.

inclusive design; exclusion assessment; persona; assistive technology

1 Introduction

The British Standards Institute (2005) defines inclusive design as "the design of mainstream products and/or services that are accessible to, and usable by, people with the widest range of abilities within the widest range of situations without the need for special adaptation or design" (p. 4). To achieve this, it is important to understand the range of capabilities, needs and situations in the population as a whole.

It is also useful to assess how a product or service measures up to this definition, determining how many and what kinds of people it is usable by (and conversely, how many people are unable to use it). This can help to identify the need for further work and to prioritise issues. It can also be a powerful tool in convincing designers and managers that they need to make improvements to products (Goodman-Deane, Waller, Bradley, Bradley and Clarkson, 2018).

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Exclusion assessment aims to achieve this. This method uses population data on users' capabilities to estimate how many of them would be unable to complete the series of tasks needed to use a product or service effectively. However, the focus on capability data can make it difficult to consider the effect of other factors affecting product use, such as different user goals, needs, ways of using a product and use scenarios. All of these vary from person to person based on more than their capabilities.

In this paper, we propose a method of combining exclusion audits with personas to facilitate the consideration of factors like these.

1.1 Exclusion assessment

Exclusion assessment is based on the idea that product interactions place demands on users' capabilities. Users may be excluded from using a product if any of its demands are higher than their capabilities. For example, a product with very small text requires a high level of vision capability. People with lower vision capability will be excluded from its use.

The method uses data on people's capabilities on a population level. The standard method uses data from the 1996/97 Disability Follow-up Survey, conducted by the Office of National Statistics (Grundy & Great Britain Department of Social Security, 1999). Although the data is now rather old, it is still the best source of coherent population-level data covering a range of capabilities and different levels of capability loss (Waller, Langdon & Clarkson, 2010). Using this dataset allows the method to take into account a range of capabilities and to account correctly for people with more than one type of capability loss.

The exclusion assessment method (Waller, Langdon & Clarkson, 2010; Cambridge Engineering Design Centre, 2017b) involves first breaking down the use of the product or service into a series of tasks, using task analysis. For each task, the assessors examine each capability in turn, determining what level of that capability is needed to complete the task. This is rated on a scale for that capability, which is based on the measurement scales in the Disability Follow-up Survey. These demand ratings are then compared with the capability of the people in the survey sample to determine how many of them would not be able to complete the task. As the survey is population-representative, this can be used to calculate how many people in the British population as a whole (in 1997) would not be able to complete the task. By doing this for all the tasks in the task sequence, it is possible to estimate how many people would be unable to use the product or service. The Exclusion calculator software (Cambridge Engineering Design Centre, 2017) helps to facilitate this process and performs the underlying calculations.

Exclusion assessment has been used successfully in both research and commercial contexts, along with other methods, such as user trials (e.g. Clarkson, Cardoso & Hosking, 2007). They can be useful in identifying usability issues and potential improvements (Goodman-Deane, Ward, Hosking & Clarkson, 2014).

However, exclusion assessment is typically only used for one task analysis at a time. It *can* be used when there is more than one way of using a product to achieve a single goal (Waller, Bradley, Langdon & Clarkson, 2013) but this gets increasingly complicated with increasing numbers of alternatives. It is also difficult to take into account other user information (not about capabilities) that may also affect how people use a product.

In this paper, we propose a way of combining exclusion assessment with quantitative personas to overcome some of these issues.

1.2 Personas

Cooper (1999) defined the first model of the personas tool. He described personas as fictional profiles of users that represent the patterns found in qualitative research. In the years since, personas have been developed and used in different ways. They have been shown to be effective in focusing the design process on user needs and goals and in improving communication among the

design team (Miaskiewicz & Kozar, 2011; Grudin & Pruitt, 2002). Personas allow the incorporation of a wide variety of different kinds of information about users, including capability data and information about lifestyle and social networks. However, there is little consensus over exactly what kinds of information should be included (González-de-Heredia, Justel, Iriarte & Beitia, 2017).

Personas have the potential to be particularly effective in inclusive design because of their power to help designers to think about users who may be very different to themselves. However, few persona sets consider the capabilities and/or the aging process of the personas. These are discussed below.

The Designing with People website (Helen Hamlyn Centre for Design, undated) provides ten profiles that represent people with disabilities. These profiles include information such as: name, age, medical condition, assistive aids, things that they can and cannot do, a typical day, the five most "important" things in their life, and a message they want to give to designers. They differ from typical personas in that they describe real individuals. They were chosen "to represent a spectrum of capability across the UK population". The stated goal of this project was "to give the designer a more holistic portrait of the individual than can be supplied by reading capability data alone". As such, this shows the potential of personas to include a wider range of information, but the profiles are not suitable for quantitative evaluation because the set of personas does not attempt to cover the entire population. In addition, there is no information given on how many people each profile represents.

Another set of profiles is provided by TACSI, The Australian Centre for Social Innovation (Burkett & Jones, 2016). As with the Designing With People set, these are descriptions of real users rather than fictional. They were based on interviews with "a diversity of baby boomers" seeking to understand "how they see this idea of 'ageing well'" (p. 1). Burkett and Jones (2016) describe ageing as a systemic event not a personal event. As a result, the profiles include information on aspects such as: family, housing, income, social network, vulnerability factors, major life events and resilience factors. The descriptions are qualitative and aim to give the designer a holistic view of the person's background and situation. These personas do not include detailed information on capabilities and so are not suitable for assessing usability.

In contrast, the descriptions proposed by Reeder, Zaslavsky, Wilamowska, Demiris and Thompson (2011) are personas in the more usual sense of the term. They are fictional descriptions with a quantitative basis. They were produced using cluster analysis of data from a small study of people aged 85 and over. The personas include information on age, education, health conditions, experience with computers and social support. They also contain ratings of general health, functional status and cognition. However, the rating scales used are not specific enough to facilitate product assessment. For example, the cognitive status of the personas is described as "minor cognitive changes" and "moderate cognitive changes". This set of personas was focused only on the "oldest old" segment of the population and thus only included two personas.

Wöckl et al. (2016) created a larger set of thirty personas to represent the diversity among older people in Europe. These personas were created from a survey data of 12,500 older people in different European countries using partitional clustering. They include a wide range of information including general health, limitations in Activities of Daily Living, economic situation, social activities, psychological well-being and a range of capabilities. The capabilities include hearing, eyesight, cognitive function and memory. However, like the personas in Reeder et al. (2011), the scales used to describe capabilities are not specific enough for product assessment. For example, eyesight is described as "good, less than good, glasses, cataract". In addition, most of these capabilities were not included in the initial cluster analysis which means that it is unclear how well they represent the cluster as a whole.

The most similar system to that proposed in this paper is HADRIAN (Marshall et al., 2010), which uses descriptions of 100 real people. Unlike the previous examples, these profiles include detailed data on capabilities, as well as preferences and experience with a range of daily activities. Indeed, the aim of HADRIAN is to assess exclusion and identify problems and solutions. When assessing a

task, each of the individuals in the database is run through the task in turn to determine whether or not they would be excluded by it. However, the set of people is "clearly not representative of the more general population" (Marshall et al., 2010, p. 258). Indeed, the authors explain that there was a "deliberate decision to skew the data towards the older and disabled" (p. 258). This makes it difficult to determine how many people these problems would affect in the population as a whole. More recent work on HADRIAN has investigated correlating the capabilities of the individuals in the database with data on the population as a whole from the Disability Follow-up Survey (Marshall et al, 2016). This provides some useful insight but currently only considers one capability type at a time

2 Proposal

We propose using personas to evaluate how many people will be able to use a product or service. To do this, the personas need to have certain characteristics, each of which is discussed in more detail below:

- Appropriate information content: The personas need to include the right type of information to determine whether each persona would be able to use the product;
- Quantitative basis: We need to know approximately how many people are represented by each persona;
- Representativeness: Each persona needs to represent a group of people in the population with sufficient accuracy for the assessment.

Once suitable personas have been created, they can be used to evaluate a task by stepping through the task for each persona in turn. This is described further in Section 2.4.

2.1 Appropriate information content

The personas need to include the right type of information to determine whether each persona would be able to use the product. Typically, this means determining whether they could carry out particular task steps with the product. The information required may be different from the kind of information that is useful for building empathy and impact. For example, giving each persona a name is vitally important for persuading designers to engage them. However, it is not useful for determining if that persona can use a product.

To determine if a persona can use a product, we use the model in an exclusion audit (see Section 1.1), where a person is excluded from using a product if any of the product's demands are higher than their capabilities. Therefore, assessing if a persona can use a product requires information on the persona's capabilities. Exactly which capabilities are relevant will depend on the type of product being assessed. Which capabilities can be used will also be limited by the datasets available.

An advantage of using personas to do the assessment is that multiple kinds of information can be included in them. As well as user capabilities, there are other factors that also influence product use, such as the social context and prior experience. It may be useful to include some of these in the personas.

2.2 Quantitative basis

In order to evaluate how many people will be able to use a product or service, it is necessary to know approximately how many people in a selected user population are represented by each persona. To do this, the personas must be based on quantitative data about the target population.

Once a dataset is chosen, a statistical method such as factor analysis or cluster analysis can be applied to identify groups in that dataset that can form the basis of personas. An example using cluster analysis is given in Section 3.3.

2.3 Representativeness

Each persona needs to represent a group of people in the population with sufficient accuracy for the assessment. It needs to be close enough to all the members of the group that it is possible to say with some certainty that if the persona can use the product, then the members of the group will be able to as well.

There is a trade-off between the number of the personas and their accuracy. The smaller the groups, the more similar their members are to each other, and the more representative their personas can be. However, smaller groups also mean more groups. If the number of groups and personas is too large, then doing an assessment using them becomes unmanageable.

It is important to note that the ideal number of personas for doing an assessment is very different from the ideal number to use throughout the design process. For example, Cooper (1999) recommended creating between three and twelve personas, and Pruitt and Grudin (2002) suggested between three and six. When using personas throughout the design process, the set needs to be small enough for the design team to keep the whole set in mind. However, this is not necessary for an assessment where a bigger concern is how representative the set of personas is.

When performing an assessment, there is no need to keep the whole set of personas in mind. A designer can work through the assessment for each persona at a time. Therefore, a much larger set is feasible. However, it is still possible for the set to become so large that the method becomes unwieldy and frustrating. We estimate that more than 50 personas would be difficult.

2.4 Using the personas for evaluation

Once suitable personas have been created, they can be used to evaluate a task. This can be done by stepping through the task for each persona in turn. For each, the evaluation looks at the ways that persona would be likely to attempt the task. The persona's capabilities are then compared with the demands of the task steps to determine whether they would be able to complete them. Other information can also be taken into consideration such as the use of mobility aids. This process is described in more detail using an example in Section 3.5.

If a persona cannot complete the task, then it can be assumed that the group he or she represents cannot complete it either. By examining a range of personas that cover the whole of the target population, it is possible to gain an estimate of the proportion of that population who could not complete the task, and thus an estimate of population-level exclusion.

This information can then be used by a design team to identify the particular tasks involved in using a product or service that cause the most exclusion. It can also help to identify why those tasks are particularly problematic, and thus help to develop ways to improve the product or service and reduce exclusion. An example of how exclusion calculations can be used in this manner is given in Goodman-Deane et al (2014).

3 Proof-of-concept

This section presents a proof-of-concept study, based on the analysis in Demin (2009). It demonstrates how a set of quantitative personas for evaluation could be created, using cluster analysis on the data from the Disability Follow-up Survey. Some of the personas are then used to assess a task in Section 3.5. In a full study, the task would be analysed for all the personas in the set. However, just a few examples are shown here as a proof-of-concept.

3.1 Information content

The personas were based on data about user capabilities so that they could be used for assessing product use. The study used a subset of the capabilities typically used in an exclusion audit: vision, hearing, dexterity, reach & stretch and locomotion. It omitted the scales for thinking and communication because they were less relevant to the particular products being assessed and because of a lack of transparency in these scales.

Note that this analysis uses earlier versions of the scales than are currently used in the exclusion calculator software (Cambridge Engineering Design Centre, 2017). Each capability was described using more than one subscale. For example, locomotion included walking, managing stairs, bending and balancing. There were sixteen separate subscales in total, each scored 1 (low ability), 2, 3 or 4 (full ability).

Once the personas were constructed, additional information was added to round out the personas as described in Section 3.4.

3.2 Data set

The personas were constructed using data from the 1996/97 Disability Follow-up Survey, for compatibility with the exclusion assessment method (Waller, Langdon & Clarkson, 2010). The method and survey are described in more detail in Section 1.1.

The full dataset contained 7,168 people. The study in this paper was conducted as part of an assessment of assistive equipment. Therefore, sift criteria were applied to the dataset to identify just those individuals who were on the borderline of being eligible for the provision of assistive equipment. To be included, participants had to have a capability loss in the range in Table 1 for at least one capability. This indicated a level of capability loss that might make assistive technology helpful. They were excluded if they had a higher rating for any capability, indicating that their capability loss was sufficiently severe that they would automatically receive help. The particular boundaries were chosen based on the requirements for different kinds of disability assistance.

Table 1 Summary of sift criteria. The severity of capability loss had to sit between the lower and upper thresholds for at least one capability.

Capability	Lower threshold (inclusive)	Upper threshold (inclusive)
Vision	4.5	5.5
Hearing	2	5.5
Dexterity	3	7
Reach and Stretch	3.5	5.5
Locomotion	3	5.5

Application of these sift criteria identified 2,225 people within the dataset who were borderline for assistive equipment provision.

3.3 Clustering

K means cluster analysis was used to identify and group individuals in the dataset based on their type and level of capability loss. This method was chosen due to its simplicity and speed for running on a large dataset.

When a set number of clusters is entered, this method creates that number of clusters from the data. The data was initially explored by inputting various numbers of clusters between 10 and 600. In each case, the Euclidean distance of points from their cluster centres was calculated by the equation:

$$\sqrt{\sum_{capabilities} (capability - capability_{clustercentre})^2}$$

At 35 clusters, the average distance between each point and its cluster centre was approximately equal to one point on the capability rating scales. This gives reasonable accuracy for exclusion analysis, while being a small enough number of personas to manage. So 35 clusters were chosen.

3.4 Describing personas

For each cluster, a representative was chosen that was close to the cluster centre. The representative was described using the capability scores from the DFS data as shown in Table 2.

The number of people in the British population represented by a cluster was calculated as follows:

- Each of the 7,168 people in the Disability Follow-up Survey had a multiplier associated with them. This multiplier indicated how many people that person represented in the British population as a whole. This multiplier was calculated by the organisation that completed the original survey.
- The multipliers for all the people in a cluster were added up to give a number for the cluster as a whole. This number indicates the number of people in the British population who were represented by that cluster.

Table 2 Example of the capability scores for a persona. The scores are only shown for capabilities that are less than "full ability" (i.e. less than 4 on the scale).

Cluster Number: 3		
Number of survey participants in this cluster: 4		
Number of people in the British population represented by this cluster (1997 statistics): 5,060		
Capability	Capability score	Description of capability level
Walking	3	Can walk 200 yards without stopping but not 400 yards
Fine-finger manipulation (both hands)	3	Can pick up a safety pin with each hand but cannot tie a bow in laces without difficulty
Strength (both hands)	3	Can pick up and carry a pint of milk in each hand but not a bag of potatoes
Hearing sound	3	Can hear a telephone ring but cannot follow TV at a volume that others find acceptable
Hearing speech	2	Can hear someone talking in a loud voice in a quiet room but cannot use an ordinary telephone

Other information was then added to the information in Table 2 to turn it into a persona: name, age, photo, some personal and social information, and information on medical conditions and assistive equipment used. The information was based on the assessors' knowledge of the likely situations of participants with these kinds of capabilities. Examples of these personas are shown in Figure 1.

It is important to note that this additional information was not used in the initial cluster analysis. As a result, only the capability information in the personas is statistically representative of the clusters. The other information can help to inform the assessment and design of a product, but is not necessarily accurate for all members of the cluster. It may be possible to include further information into the cluster analysis so that this information is also statistically representative. However, this example uses just the capability data as a proof-of-concept.

Bob (78)

Cluster 3
Number of survey participants in cluster: 4
Number of GB people represented (1997): 5,060

Bob is retired and lives with his wife. He likes spending time with his grandchildren, watching TV and swimming. He uses a basic mobile phone to communicate with friends and family.
Bob has Spondylitis, angina and age-related hearing loss. He wears a hearing aid.

Capability	Score	Description
Walking	3	Can walk 200 yards but not 400
Fine-finger	3	Can pick up a pin with each hand but not tie a bow without difficulty
Strength	3	Can pick up a pint of milk in each hand but not a bag of potatoes
Hearing sound	3	Can hear a telephone ring but not follow TV at a volume others find acceptable
Hearing speech	2	Can hear someone talking in a loud voice but not use an ordinary telephone

Barbara (58)

Cluster 27
Number of survey participants in cluster: 41
Number of GB people represented (1997): 64,000

Barbara is single and works part-time from home. She likes going to the cinema and sewing but now finds sewing difficult due to her arthritis.
She uses a computer in her work and to communicate with friends and family. She also orders groceries online.
Barbara has rheumatoid arthritis. She uses a walking stick.

Capability	Score	Description
Walking	3	Can walk 200 yards but not 400
Stairs	3	Can manage 12 steps but with difficulty
Balance	2	Cannot balance without often holding on
Bending	2	Can bend to touch knees but not to the floor
Reach (one hand)	3	Can reach one hand to head but not above head
Reach (both)	1	Cannot reach both hands in front without difficulty
Fine- finger (one hand)	3	Can pick up a pin with one hand but not use a pen without difficulty
Fine- finger (both)	3	Can pick up a pin with each hand but not tie a bow without difficulty
Strength	2	Can pick up a mug of coffee in each hand but not a pint of milk

Figure 1 Persona examples

3.5 Using the personas for evaluation

As an example, we examined whether the personas can complete a simple task: carrying a tray of food across a café. To do this properly, it is important to consider the use of mobility aids that may restrict the availability of the hands. This is difficult to do in a standard exclusion analysis Waller et al, 2010) because the demand on each capability is assessed separately.

In the task, the environment is a large café. There are several other customers but the café is not crowded. The tray is initially on a serving counter, and is to be carried to a table 15m away. The user must navigate round other tables. There is enough space to be able to use mobility aids including a wheelchair. The tray is too large to be carried with a single hand, is well balanced and weighs about the same as a pint of milk.

Table 3 gives the task analysis for this task. A fuller task analysis would include pulling a chair out and sitting down, but this example focuses on the core tasks for the purposes of the proof-of-concept.

The basic demands involved in each task step were assessed to the nearest 0.5 using the exclusion assessment method (see Section 1.1). The results are shown in Table 3. These were then compared to the personas in Figure 1. Both Bob and Barbara (personas 3 and 27) have higher levels of capability for each scale than the corresponding demands. Therefore, according to a standard exclusion audit, they should both be able to do the task and so be *included.*

Table 3 Task analysis for carrying a tray of food to a table 15m away. Only non-zero demands are shown.

		Non-zero demands (1=someone of low capability would be unable to do this task, 4= someone of full capability would be unable to do this task)				
Task step	Task description	Vision (recognition)	Walking	Balance	Reach (one hand)	Strength (two hands – each hand takes half the weight)
1	Pick up tray	0.5	0	1	1	1
2	Hold tray and move to table	1.5	0.5	0	0	1
3	Place tray on table	0.5	0	1	1	1
Overall		1.5	0.5	1.5	1	1

However, Barbara needs to use a walking stick to walk across the room. This takes up one of her hands, leaving only one available to hold the tray of food, but the tray is too large to hold in a single hand. As a result, she cannot complete the task and so is *excluded.*

Barbara represents cluster 27. If she is assessed as excluded from the task, then so are the 64,000 people in the population that she represents (see Figure 1). If this analysis is repeated for all 35 personas, then it is possible to add up all the people represented by all the excluded personas to get an estimate of the number of people in the population as a whole who would be excluded from completing the task.

The exclusion figure is higher than that obtained from an exclusion assessment because it takes into account the impact of using a mobility aid on carrying out the task.

In a full analysis, exclusion would be estimated for multiple tasks involved in using the café. These could be compared and, if the exclusion associated with carrying a tray was particularly high, then effort could be put into addressing it. The analysis above reveals that part of the cause of the exclusion is the difficulty of carrying a tray while using a mobility aid at the same time. Ways of reducing the exclusion might include providing a tray that can be carried in one hand, providing a trolley on which the tray can be placed or providing a table service.

4 Discussion

4.1 Data used in the cluster analysis

The proof-of-concept used data from the 1996/97 Disability Follow-up Survey because it is the dataset used in the general exclusion assessment method. In addition, it is one of the few population-level datasets providing detailed data on a wide range of different types of user capabilities. However, this dataset is now rather out-of-date. It may be possible to update the data from this survey by adjusting for changes in population demographics over the last 20 years. Alternatively, the method described in this paper could be used with other datasets that provide suitable information about the user characteristics of interest on a population level.

Note also that the proof-of-concept only used capability data in the cluster analysis. The information on mobility aids was added based from the assessors' knowledge of participants' likely situations. Making assessments based on the use of mobility aids is therefore a bit of an extrapolation – probably a reasonable extrapolation but not statistically representative. As a result, it is not entirely accurate to use the multipliers for each cluster to determine the total number affected in the population. If we want to use the multipliers, we should really include mobility aid information in the initial analysis. This similarly applies to any other additional information used in the assessment.

4.2 Clustering methods

The proof-of-concept used cluster analysis to identify groups for the personas, but other methods are also possible. Brickey, Walczak and Burgess (2012) identified several persona grouping techniques. Many of these are manual methods and so are not suitable for quantitative analysis of

large survey samples. However, there are several promising semi-automated techniques, including factor analysis and principle component analysis, as well as cluster analysis. In addition, Persad et al. applied Topological Data Analysis to capability survey data, identifying 14 clusters describing the capability distribution in the sample (Persad, Goodman-Deane, Langdon and Clarkson, 2018).

4.3 Number of personas

The proof-of-concept study examined a subset of the total population and identified 35 personas. Even more personas would be needed to cover the whole population with the same degree of accuracy. However, such large numbers of personas may become difficult to use. Even going through the use of a product for each of the 35 personas in the proof-of-concept is tedious and time-consuming, and it may be unlikely that a designer would do this in practice.

Further work is needed to determine whether it is possible to do a reasonably accurate assessment with a smaller number of less representative personas.

Alternatively, the full set of personas could be produced, but a full audit only conducted for a few of them. Perhaps the assessor could perform a standard exclusion audit and then look through the set of personas, highlighting any for whom there are likely to be additional issues. Further assessment is only done for these personas, not for the whole set. Even for these, the full assessment may not be necessary in every case. There are likely to be some personas for whom it is obvious that they could not complete the task, or perhaps would not even attempt the task. These could just be marked as "excluded" without having to look through all their capabilities or steps in the task analysis.

It is may be possible to identify subsets of personas in advance that should be considered for particular kinds of products or tasks, so that the assessor does not have to do this step him/herself. This smaller set of personas could also be used in the ways more typical of personas in general – for awareness raising, empathy building and maintaining a user-centred focus throughout a project. It could also be useful for helping designers to visualise the diversity of the target user group.

4.4 Ways of using this kind of personas

The example in Section 3 showed how these personas could be used to examine a situation where one capability affects another. In contrast, standard exclusion assessments assume that capabilities are fixed. For example, if someone can use both hands, the assessments assume that they can use them in all situations. However, this is not always true. In particular, use of a mobility aid means that someone can only use one hand when walking.

This applies to other capabilities as well. For example, someone with poor balance capability may be able to use both hands without difficulty when seated. However, if the task requires standing, especially on an unstable surface (e.g. a moving bus), they need to use one or even both hands to hold on.

Similarly, someone with reduced vision capability may have reduced concentration capability if the task requires a high level of vision. They may need to spend some of their concentration trying to read text that is on the edge of their ability.

These types of personas may also be useful in situations where different users are likely to do tasks in the different ways, e.g. using coping strategies to overcome some capability loss. While exclusion audits can examine situations with multiple task analyses (e.g. Waller et al., 2013), this gets increasingly complicated with increasing numbers of variations in ways of doing the task.

This is particularly relevant to digital products, where there are often multiple ways of achieving a goal. In fact, when it comes to digital products, it is often less a case of whether people can or cannot do individual specific tasks, but how they go about trying to achieve the goal in the first place – what set of tasks they choose to perform. It is hard to determine this based on a list of their capabilities, but the additional information in a persona can allow an assessor to make reasonable assumptions about what they would do.

Another issue when examining digital exclusion is that a sizeable segment of the population would rather not do certain tasks, such as use a new piece of technology or a computer. For example, faced with the choice between using a digital camera or failing to get a photograph of a special occasion, they may choose the latter. They may technically have the capabilities to do the task, but are essentially excluded due to a variety of reasons, such as a lack of self-efficacy. For example, the OECD (2016) found that 9.6% of working age adults opted not to use a computer in an assessment situation, even though they reported some prior experience with computers.

5 Conclusions

In this paper, we have proposed combining quantitative personas with exclusion assessment. This would facilitate the consideration of other factors (in addition to capabilities) when considering how many and who can use a product or service. We have discussed what kinds of personas would be necessary to do this in practice. A proof-of-concept example demonstrates that it is possible to create this type of personas and to use them in an assessment.

To our knowledge, this is the first time that a set of quantitative personas has been created with the level of accuracy about user capabilities necessary for product assessment. The proof-of-concept also shows how users' use of mobility aids can be taken into account when estimating exclusion. This is not possible in a standard exclusion assessment.

The paper highlights issues that need to be explored and different ways that quantitative personas could be used to improve exclusion assessments. These are all areas for further work and research. For example, further work could explore the use of different datasets and clustering methods, and different ways in which these personas could be used.

In particular, the personas in this paper are a proof-of-concept. As such, they were based on a subset of the full survey sample, focusing on those people who were borderline for assistive technology provision. The analysis was also based on an old version of the capability scales. The scales have since been revised to be simpler and easier to manage (Waller et al., 2013). In particular, the scales for hand function now allow an assessor to examine what people can do with their dominant and non-dominant hands or with their left and right hands, which is helpful when looking at some types of product use. The thinking scales have also been improved. Further work could develop personas for the full dataset, using the new scales. It could also include additional non-capability information in the clustering. It would be useful to produce a full set of personas and compare the exclusion results using this set with those from the exclusion calculator (Cambridge Engineering Design Centre, 2017).

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Numeral Legibility and Visual Complexity

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To enhance the peripheral legibility of numerals we designed three versions of the digits from 1 through 9 by modifying the complexity of each numeral (equivalent to their digit skeleton) while controlling for variations in other physical parameters. Observers identified the different versions of the digits in random three-digit strings, presented within their peripheral visual field. Our results showed that the digit '1' should have a narrow design without a crossbar at the bottom, the digits '3' and '9' should benefit from open apertures, and the digit '7' should have a straight leg and no serif at the horizontal bar. The data further demonstrated that crowded digits presented in the periphery of the visual field generally profit from a short morphological skeleton. The findings can improve the identifiability of numbers for readers with normal visions as well as for readers with central visual field loss.

typefaces, numerals, legibility, inclusive design

1 Introduction

If a reader misreads a number on a road sign, a medicine information leaflet, or an aircraft display, the potentially flawed action which follows can have severe consequences. With this in mind, it is important to realise that few studies in the research literature concern numeral legibility. By identifying visual factors influencing numeral legibility, we seek to add new knowledge that could benefit both visually impaired readers and readers with normal vision. The findings could help type designers create legible digits, and could also help graphic designers determine which typeface to choose when maximum legibility is a priority. Among possible limiting visual factors, we were interested in studying the effect of the length of the numeral skeleton on numeral legibility. This is based on previous studies showing the effect of letter skeleton length (potentially measuring letter complexity) on peripheral letter legibility (Bernard & Chung, 2011; Wang et al., 2014).

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Figure 1: The skeleton of a letter or digit is the basic structure of the character. In this illustration, the letter skeleton varies while other parameters, such as stroke weight and width, are identical among the tree letters.

Whilst identifying a letter within a word, the reader will draw on a mental library of all the words he or she has been exposed to before (Legge, Klitz, & Tjan, 1997). This means that when a reader encounters an illegible letter, he/she can draw on information from adjacent letters and from the sentence structure, and thus make an educated guess of what the letter might be (Pelli & Tillman, 2007). This is rarely possible when the target is a digit. In such situations, there will be little or no additional help from the surrounding digits or the structure of the text. It is therefore essential to prevent one digit being mistaken for another (Figure 2). This pertains especially to specific visual conditions that make numerals difficult to identify. For instance, letter/numeral recognition is harder for small print sizes near the acuity limit because of human optical and neural limitations. When readers cannot use their central vision (such as patients with age-related macular degeneration (ARMD)), symbol recognition can be difficult, even for large print sizes. This is due to visual crowding (Pelli et al., 2004), a phenomenon which impairs symbol recognition when a symbol is surrounded by other symbols in the peripheral visual field. As previously explained, patients with ARMD, unfortunately, cannot rely on the general context to improve their limited numeral recognition performance.

Figure 2: Based on word and sentence structure, it is possible to guess the missing letters in the top row. However, there is no way to guess the missing number in the bottom row.

The so-called alphanumeric category effect (Hamilton, Mirkin, & Polk, 2006; Jonides & Gleitman, 1972; Polk & Farah, 1998) describes the fact that in a different-category target search, subjects tend to have a longer reaction time when detecting a letter among letters than when detecting a letter among digits, and vice versa. This suggests that digits and letters are, to some degree, independently processed. Yet, there are indications that this difference is related to habit. As readers often perceive letters and digits under separate circumstances, it might be more difficult to process them when they are presented collectively. This idea is demonstrated by Polk and Farah (1998), who found that the alphanumeric category effect is less evident among Canadian postal workers, who have a daily routine of sorting postal codes of mixed letters and digits, and by Jonides and Gleitman (1972), who found that results were affected by whether observers perceived 0 as a digit (zero) or as a letter.

If the phenomenon is due to habit alone, the identification of letters and digits should be equally difficult. That is, however, not the case. There is substantial evidence suggesting a numeral identification advantage, with studies demonstrating that it is easier to identify digits than letters (Schubert, 2016). Further, the vast amount of literature on pure alexia showed that digit naming can be less impaired than letter naming in certain patients (Starrfelt & Behrmann, 2011). In fact, cases of digit naming impairment with intact letter naming impairment have yet to be reported (Rath et al., 2015).

One reason for this could be related to the difference in the visual properties of letters and digits. To investigate this hypothesis, Starrfelt and Behrmann (2011) visually overlapped lowercase letters and

digits in the typefaces Times and Arial. They suggested that as there are more letters in the alphabet than digits, letters have a larger number of possible competitors, and hence, single symbol identification should be more difficult for letters than for digits. Schubert (2016) focused on scenarios where letters and digits are mixed. She used uppercase letters and digits of four different typefaces, separating the character features into different units such as 'slant', 'curve' and 'orthogonal'. While overlapping two characters, she considered position and relative size and found no indications that digits have more distinctive forms than letters. However, a curve within a typeface can vary highly between characters (Figure 3).

Figure 3: The four typefaces applied in the study by Schubert (2016). To demonstrate that curves within a typeface can vary significantly between characters, the curve of the '2' has been rotated and scaled to fit the curve of the 'D'.

It is also possible that the numeral identification advantage is related to a difference in letter and digit structure that cannot be detected by measuring the physical overlap of shapes. While uppercase and lowercase letters originate in the Roman capitals and the Carolingian minuscule, numerals are Hindu-Arabic. This difference in origin has left a mark on the basic structure of letters and digits. Roman capital letters were originally cut in stone, and the letter shapes are therefore dominated by straight horizontal, vertical, and diagonal strokes mixed with clear circular strokes. The vertical stroke survived in lowercase letters, through the cursive tradition of connecting the downstroke with the upstroke of the following letter. About 62% of lowercase letters and about 65% of uppercase letters have a vertical stroke. Compared to this, only 20% of digits have a vertical stroke (Figure 4). It appears that the downward-upward stroke in lowercase letters contribute to a steady rhythm when the letters are put into words and sentences (Johnston, 1913).

Figure 4: 1) The cursive writing hand that connects downward and upwards strokes. 2) The vertical strokes of lowercase letters. 3) The vertical strokes of uppercase letters. 4) The vertical strokes of numerals. Demonstrated in the typeface Garamond Premier Pro.

The oft-repeated saying that 'type is a beautiful group of letters, not a group of beautiful letters' (Carter, 2004), suggests that letters should be designed to be parts of words, not individual units. That is the essential difference between letters and digits. Since each digit represents a number, their functions are independent of other symbols. That is not the case for letters. Except for rare exceptions (for instance, the 'a' and 'i' in the English language), single letters are only abstract symbols with no numerical value or semantic meaning. It is when letters are flanked by other letters that they fulfil their purpose by forming words. Following this, matters related to word readability and the flow of reading are less relevant in the study of numerals. Research into letter legibility can, however, also provide useful information for optimising the legibility of numerals.

2 Experiment: the skeleton structure of the digits

Previous research into the foveal and peripheral legibility of numerals have aimed at reinventing the shapes (Lansdell, 1954), improving the shapes of seven-segment numerals (Van Nes & Bouma, 1980), or at comparing the digits of different typefaces (Berger, 1944; Fox, Chaparro, & Merkle, 2008; Hind, Tritt, & Hoffmann, 1976; Smuc, Windhager, Siebenhandl, & Egger, 2007).

Within typeface legibility research there is a tendency to seek answers by comparing different typefaces in psychophysical experiments. The problem with such an approach is that it is difficult to isolate one visual feature from another, as different typefaces have different proportions, weights, contrasts, and styles (Beier, 2016). That makes it difficult to interpret the findings of such studies, as there are too many typographical variables at play at once. Here, we decided to focus on visual complexity, a factor that has been shown to influence letter legibility. As several studies have suggested a link between the visual complexity of symbols and their skeleton length, we chose to investigate the effect of the skeleton length of a numeral on its legibility. We measured peripheral legibility, a way to investigate directly how we could improve numeral recognition performance in patients with central field loss.

2.1.1 Subjects

Five subjects (two females and three males) with normal or corrected-to-normal vision aged from 21 to 38 years participated in this study. The subjects were students and post-docs from the Aix-Marseille Université. They were paid 10 euros each for their participation in the experiment. The research followed the tenets of the Declaration of Helsinki and was approved by the Ethical Committee for Protection of Human Subjects at the Aix-Marseille Université. Written informed consent was obtained from each subject after the nature and purpose of the experiment had been explained.

2.1.2 Apparatus

Stimuli were displayed on a 21-inch CRT color monitor (ViewSonic P227f, refresh rate = 120 Hz, resolution = 1152 x 854 pixels) driven by a Windows computer running custom software developed in Python with the Psychopy library. The subjects sat in a comfortable chair with their eyes at a distance of 40 cm from the monitor in a dimly lit room (screen visual angle: 50.8° x 37.7°). An eye tracker (Eyelink 1000 Tower Mount distributed by SR Research Ltd., Mississauga, Ont., Canada) was connected to our system to control the gaze fixation of the subjects. Numerals were displayed in black (luminance: 0.3 cd/m2) on a light grey background (luminance: 60 cd/m2).

2.1.3 Design of the numerals

For this experiment, we isolated the variables under investigation by altering one visual feature at a time. By keeping the test material within one typeface, we can ensure that the findings are related solely to the matter under investigation. For this purpose, we extended the typeface DejaVu Sans to contain three variations of each of the numerals from 1-9.

Figure 5 shows the different versions of each numeral. For the numbers 1 and 8, one aspect of interest was the effect of character width; Fox et al. (2008) found an advantage of a wider ‘1’, and Berger (1944) and Smuc et al. (2007) both recommended narrow versions of ‘8’. To control the variables, the only difference between 1a and 1b and between 8v and 8x is the width. We were further interested in the effect of a cross bar on the numbers ‘1’ and ‘4’; the open and close counter of the numbers ‘2’, ‘3’, ‘5’ and ‘9’; the x-height of the number ‘6’; and the cross sections of the numbers ‘2’ and ‘7’.

ID	a	b	c	d	e	f	g	h	i
digit	1	1	1	2	2	2	3	3	3
varia ble	narrow	wide	cross bar	open count.	round spin	close count.	open count.	diagon. top	close count.

ID	j	k	l	m	n	o	p	q	r
digit	4	4	4	5	5	5	6	6	6
varia ble	close top	open top	cross bar	open count.	close count.	square loop	regular bowl	small bowl	large bowl

ID	s	t	u	v	w	x	y	z	A
digit	7	7	7	8	8	8	9	9	9
varia ble	straight leg	bended leg	serif at top	soft cross	sharp cross	wide	open counter	close counter	straight loop

Figure 5 : The different versions of the digits originate in the typeface DejaVu Sans. Each of the numerals 1, 2, 3, 4, 5, 6, 7, 8 and 9 have been created in three different variants, each having only one visual feature different from another version of the same number. The variables relate to one of the focus areas described above.

2.1.4 Experimental Protocol

Each subject ran a single experimental session (total duration of the session: about 1 hour) to test his/her ability to identify each of the 27 digits in a crowded environment (digits surrounded by other digits) while using his/her peripheral vision. The session was divided into 6 experimental blocks of 100 trials each, 3 blocks of trials presented in the lower visual field and 3 blocks of trials presented in the right visual field. Figure 6 schematically describes the temporal course for each trial: observers were asked to fixate a dot centred on the screen. Gaze location was measured to control for steady fixation on the fixation target dot. When the subject was ready for the trial, he/she pressed the button on a hand-held joypad. This triggered an offset correction and initiated the trial: at 10° eccentricity in the lower visual field, a string of three digits (three digits chosen randomly among the 27 possible ones with a standard inter-digit spacing) was briefly displayed for 150 milliseconds. The subject's answer (three numerals) was stored by the experimenter. We did not ask the subjects to identify which versions of the numerals were displayed. No pre- or post-masks were displayed before and after each display. The print size for each subject was obtained in a pre-test session so that the recognition rate was approximately 50% for the middle digit (print-size average: 0.78°, range: 0.74°–0.83°[1]). On average, each numeral was presented 67 times for each subject. Approximately 5% of the trials were discarded because of incorrect fixation. Note that similar to the figure example, different versions of the same numeral could be part of the same string.

[1] 0.74° represents 20 pixels with our viewing distance and screen resolution.

Figure 6 : Description of the experimental protocol: The subject fixated on a dot, pressed a button to display the string of 3 digits and then named the presented numeral.

2.2 Statistical analysis of the individual digits

Statistical analyses were performed using the R language and environment (Team, 2013). For each numeral from 1 through 9, we investigated the effects of the different versions on recognition performance by using generalised linear mixed-effects models (function glmer of the lme4 package). A model was run for each numeral (from 1 through 9). Random effect was the subject factor. Fixed effects were the version of the numeral (version 1, version 2, or version 3) and the position within the letter string (left, centre, or right letter). The dependent variable was the letter recognition error variable (0 or 1). P-values were based on conditional t-tests.

2.2.1 Individual digits results

Figure 7 shows the different recognition rates for each version of each numeral. First of all, numeral recognition rates can vary considerably across different numerals. For instance, the numeral '1' has an average recognition rate of 86% (average across the three different versions) whereas the numeral '8' has an average recognition rate of 56%. This is due to letter confusion that exists only for some numerals. For example, on average, the digit '8' is confused with the numerals '5' or '6' 20% of the time, whereas the numeral '1' is confused with the numerals '5' or '6' less than 2% of the time, on average.

Figure 7 : Recognition rates for the different versions of each numeral 1–9. A star on the left represents a significant difference between version 1 and version 2 of the corresponding numeral. A star on the right represents a significant difference between version 2 and version 3 of the corresponding numeral. A centred star represents a significant difference between version 1 and version 3 of the corresponding numeral.

For each numeral, our linear mixed-effect models show a significant effect of the relative position of the digit (p<0.00001 for each model): The digit at the centre of the trigram is less often correctly identified, compared to the digits on the left or on the right of the trigram (53% recognition on average for the central digit vs. 87% on average for the outside digits). This is because the magnitude of crowding depends on the number of flankers (Chanceaux, Mathôt, & Grainger, 2014). More importantly this shows the significance of the differences between each pair of digits based on the different linear mixed-effect models. The pairs that are significant (across a same numeral) are also shown in Figure 7. Interestingly, our analysis shows that some versions of the numerals '1', '3', '7' and '9' are significantly easier to identify than other versions.

Table 1: P-values for numeral-pair comparisons. Significant differences are highlighted and marked with a star (p-value<0.05). The yellow versions are the most legible.

	a	b	c
a		0.046*	0.0019*
b	0.046*		0.27
c	0.0019*	0.27	

	d	e	f
d		0.51	0.43
e	0.51		0.15
f	0.43	0.15	

	g	h	i
g		0.32	0.00085*
h	0.32		0.018*
i	0.00085*	0.018*	

	j	k	l
j		0.13	0.99
k	0.13		0.12
l	0.99	0.12	

	m	n	o
m		1.00	0.42
n	1.00		0.42
o	0.42	0.42	

	p	q	r
p		0.24	0.79
q	0.24		0.15
r	0.79	0.15	

	s	t	u
s		0.039*	0.045*
t	0.039*		0.96
u	0.045*	0.96	

	v	w	x
v		0.22	0.07
w	0.22		0.58
x	0.07	0.58	

	y	z	A
y		0.040*	0.018*
z	0.040*		1.000012*
A	0.018*	1.000012*	

2.3 Complexity analysis

Previous research – focusing on the recognition of crowded symbols in the periphery – has showed that symbol complexity (theoretically, the number of visual features of a single symbol) has a deleterious effect on the recognition of adjacent letters (Bernard & Chung, 2011). Visual complexity can be measured following different methods that are strongly intercorrelated (Wang, He, & Legge, 2014). Here, we decided to use the length of each digit skeleton for a given print size of 20 pixels (see Figure 8). This was done by using a custom-written Matlab program and templates for our different digits. Complexity values for each symbol are shown in Table 2.

Figure 8: Symbol complexity. The complexity of each character is quantified by the length of each digit's morphological skeleton (example with a height of 41 pixels). The longer the string, the more complex the character.

For each presented digit (for instance the digit '2' within the trigram '123'), we studied (1) the effect of the complexity of the digit (i.e., the complexity of the digit '2') and (2) the effect of the complexity of the two adjacent digits (the sum of the complexity of the digit '1' and the complexity of the digit '3'). To do so, we ran a new generalised linear mixed-effect model to study the effects of both kinds of complexity on recognition rate. Random effects were the subject factor and the numeral factor. Fixed effects were target complexity, flanker complexity, and the digit's position within the digit string (left, centre or right letter). The dependent variable was the digit recognition error variable (0 or 1).

Table 2: Complexity values for the different versions of digits 1-9.

Digit	Complexity	Digit	Complexity	Digit	Complexity
a	30	j	54	s	37
b	33	k	49	t	37
c	47	l	63	u	41
d	44	m	51	v	58
e	48	n	52	w	54
f	46	o	54	x	63
g	48	p	53	y	53
h	51	q	51	z	56
i	53	r	54	A	51

2.3.1 Complexity results

The data show a significant effect of the complexity of the displayed target ($p<10^{-4}$), and a significant effect of the complexity of the displayed flankers ($p<10^{-3}$) on target recognition rate. The effect is stronger for target complexity (–0.5% per skeleton pixel) than for flanker complexity (–0.2% per skeleton pixel). To summarise, we found that for a given digit, the recognition rate significantly increases when the complexity of the digit decreases and the complexity of the adjacent digits decreases. Finally, the effect of trigram complexity (sum of the complexity of the three letters, i.e., the sum of both types of complexity) on trigram recognition rates is shown in Figure 9. It clearly exhibits the negative effect of digit complexity on recognition rate based on the definition of six different ranges of complexity: [111:120], [121:130], [131:140], [141:150], [151:160] and [161:170]. There are at least 40 trials per subject for each complexity range.

Figure 9: Effect of trigram complexity (sum of the length of the skeleton for the three digits) on numeral recognition rate. Recognition rate is averaged across subjects.

3 Discussion

In the following, we will compare the present findings (summarised in Figure 10) with data from other kinds of experimental designs and discuss the implications.

Figure 10: The characters of the top row were all found to be significantly more legible than the corresponding characters in the bottom row.

3.1 The digit '1'

Our results showed that the narrow version of the digit '1' was more legible than the wider versions. The finding contradicts previous research by Fox et al. (2008), who investigated the legibility of single characters of 20 different typefaces and recommended a large surface area for the '1', so that the character is both tall and wide with a distinctive arm and a crossbar. While our focus is on three-digit strings, Fox et al. studied single characters. Furthermore, in our study the digits could only be misread for other digits, while the Fox et al. study also included letters and symbols as possible confusion material. We argue that except for the reading of codes, in most reading situations involving digits, possible confusion characters will be other digits. Hence the findings of Fox et al. cannot necessarily be translated into normal reading.

Our finding that narrowness benefits the digit '1', is supported by a previous study into reading distances, which found that serifs on the top and bottom of the stem resulted in a greater number of misreadings between the letters 'i' and 'l' (Beier & Dyson, 2014). In another distance study, the results indicated that a serif on top without a large cross bar at bottom made the character more legible compared to one version *with* a cross bar and another sans serif version. However, the same study also concluded that narrow letters such as 'l', 't', and 'j' benefit from slightly wider designs, yet not too wide (Beier & Larson, 2010).

It is possible that when characters we expect to be narrow lose their uniqueness as narrow, they become more difficult to identify, even though they might be easier to spot. Furthermore, while the alphabet includes several narrow letters that potentially can be misread for each other, there is only one narrow digit. Hence, the narrower the digit '1' the fewer misreadings for other digits.

3.2 The digit '7'

The digit '7' was significantly more legible without a serif at the horizontal crossbar. The effect of serifs has been a central focus point throughout the history of legibility research. However, many of these studies lacked both internal and external validity as they often look for answers by comparing different typefaces (Lund, 1999).

By applying a method of Rapid Serial Visual Presentation of words, Morris et al. (2002) found that a sans serif version of the typeface Lucida was more legible in very small sizes at distance than a serif version of Lucida, the typefaces were designed for the study to control all other variables than the serif. The study by Beier and Dyson (2014) applied a similar approach of controlling other variables and found that single letters with serifs at the vertical extremes were more legible at great distances than sans serif letters (see Figure 11).

The different results confirm the notion that legibility-related findings identified under one reading condition cannot necessarily be translated into another reading condition. In other words, the higher error rate found in our study for the digit '7' with a serif might not be found if the same character is tested at greater reading distances or presented in isolation.

Figure 11: By measuring the maximum distance for the identification of single characters, Beier and Dyson (2014) found that serifs at the vertical extreme enhanced legibility.

3.3 Digits '3' and '9'

For the digits '3' and '9' our data indicates that versions with open apertures are more legible than versions with more closed apertures. This finding confirmed a widely voiced opinion by many type designers, who speak advocate the design of types with open inner counters, as they view this as a way to improve legibility (Kinneir, 1978, 1980; Unger, 2007). The central function of the open aperture is demonstrated by an experiment reported by Fiset et al. (2008). Here the researchers blurred different parts of the letters and found that subjects were better at identifying letters when the stroke endings were visible. For example, the stroke endings defining the open part of the 'c' are essential for distinguishing it from the letter 'o' (Figure 12). Following this, we can conclude that the open apertures of digits '3' and '9' help to differentiate the characters from similar digits such as '8' and '6'.

In 2007, a team of researchers conducted an investigation in connection with the development of the road traffic typeface 'Tern' (Trans-European Road Network) (Smuc et al., 2007); in this study they compared the distance legibility of a range of different European traffic typefaces. Based on the

data, the team recommended against closed counters and suggested that the digits ‘6’ and ‘9’ should have a curved tail.

Figure 12: By blurring different parts of the letters, Fiset et al. (2008) found that letters where the stroke endings were visible were the easiest to identify (our illustration).

There are strong indications that open apertures benefit reading both within the peripheral visual field and for distance reading. However, that may not be the case when characters are seen in isolation. Recently, Larson and Carter (2016) published parts of the experimental research they had undertaken while developing the typeface Sitka. For a brief exposure within the central visual field, their findings suggest that letters with more open counters performed best when flanked by other letters; however, the study also found indications to suggest that letters with slightly closed counters performed best when viewed in isolation.

3.4 Complex and simple skeletons

The data revealed that strings of numerals with simple morphological skeletons were more legible than strings of numerals with more complex morphological skeleton (Figure 9) when numerals were presented within the peripheral visual field. This influence of symbol skeleton complexity on recognition rate was first demonstrated by Bernard & Chung (2011), who tested the typefaces Times Roman and Courier and the script typefaces Edwardian and Aristocrat at an eccentricity of 10° in the peripheral vision. They found that letter identification error rate increases with flanker complexity, up to a certain value.

This is an interesting finding in relation to the design of legible characters and numerals for subjects who cannot use their central vision. Yet, it somewhat contradicts the approach applied by several renowned type designers whose focus on ensuring differentiation between characters may result in added features, such as cross bars and tails (Herrmann, 2012; Johnston, 1913; Spiekermann, 2007). For the London Underground typeface, Johnston created a loop in the lowercase ‘l’ to differentiate the character from the capital ‘I’ (Walter, 1986). This resulted in a more complex letter skeleton, which in theory would lower legibility. However, the issue is not straightforward. As mentioned above, Beier and Larson (2010) found that at greater reading distances, a tail on the ‘l’ results in fewer errors.

Further, a two-storey ‘a’ and ‘g’ also have more complex letter skeletons than single-storey versions. However, Beier and Larson (2010) established that the two-storey ‘a’ is more legible than the single-storey ‘a’, as the latter produced a high number of misreadings, being confused with ‘o’ and ‘q’ (Figure 13).

Figure 13: Beier and Larson (2010) found that with brief exposure and at distance reading, the two-storey ‘a’’ (left) was more legible than the single-storey ‘a’ (right).

It appears that simple letter and digit skeletons generally improve legibility; however, this is only the case when the simplicity does not result in character shapes that are easily misread for others. Numerals are a great example of a set of symbols whose complexity can be significantly reduced: there are only 10 different symbols, and thus fewer confusion pairs compared to the Roman alphabets with their 26 or more characters. Based on the findings of this paper, we recommend the

design of digit skeletons that follow the typeface of the top row in Figure 14, while the bottom row shows a typeface with less legible designs.

Figure 14: The digits in the top row were collectively more legible than the digits in the bottom row.

4 Conclusion

The purpose of this study was to identify the most legible digit skeletons for readers relying on their peripheral field of vision. The experiment produced significant findings for four out of the nine numbers tested. The results showed that the digit '1' should be narrow without a crossbar at the bottom, the digit '3' may either have open apertures or a triangular upper part, the digit '7' should be designed with a straight leg with no serif at the vertical bar, and the digit '9' should have open apertures with the bowl being somewhat straight and not too round.

The results further showed that a simple morphological digit skeleton facilitates greater peripheral legibility than more complexed skeletons by (1) increasing its own legibility and (2) increasing the legibility of adjacent digit skeletons. Based on previous research, it is argued that this is only relevant in situations where the simple digit skeleton will not result in a greater number of misreadings for other characters.

As the stimuli were designed for this specific experiment we were able to isolate the variable of digit skeleton for investigation, a methodological approach that improves the external validity of the findings and generates a set of usable 'rules of thumb' that can be easily implemented in the design of new typefaces.

Our results are highly relevant for the design of numerals that would be of specific benefit to individuals with central field loss, such as age-related macular degeneration. It has also been suggested that improved peripheral letter legibility could benefit reading performance for subjects who are able to use their central vision when they read running text (Rayner & Pollatsek, 1989). Thus, our findings could also benefit normally sighted individuals.

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Beyond Accessible Aisles? Psychosocial Inclusivity of Shopping Experience: an ethnographic investigation

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Purpose: Although the importance of non-physical inclusivity has been recognised in inclusive design, the current understanding of psychosocial aspects in inclusive design is currently limited, disjointed and unstructured. This study reports a study of supermarket shopping experience of older individuals, designed and conducted to explore the concept of psychosocial aspects in older individuals' supermarket shopping experience by identifying any possible psychosocial components. Empirical investigation i.e. non-participant observation was conducted with eight participants aged 60 and over. The results from the observational investigation were analysed and validated via multiple coding steps and multiple coders. Findings suggest four major dimensions including 'cognitive', 'emotional', 'social', and 'value' factors. These four factors define and affect psychosocial inclusivity of older adults' supermarket shopping experience. Each factor is further detailed with a series of sub-themes, and key aspects in regard to each dimension are highlighted.

psychosocial inclusivity, inclusive design, accessibility, supermarket shopping, shopping experience, older individuals, observation

1 Introduction

An ageing population with more active roles in society and significant disposable income, related to an increasingly vocal community of individuals with disabilities, have been leading to the growing visibility of social inequality, isolation, and need for inclusivity beyond physical accessibility (Hedvall, 2013; Nickpour et al., 2012; Gaver & Martin, 2000; Demirkan, 2007; Imrie & Hall, 2003; Demirbilek & Demirkan, 1998). Theses numerous social issues can be seen to impact the daily lives of individuals who often lack social support and contact and who may suffer from unemployment, low economic status and discrimination (Salles, 2013).

Inclusive design is an approach for addressing these issues to move towards greater equality and diversity (Da Silva, 2013; McCarron et al., 2013; Suzman & Beard, 2011; Stephanidis & Emiliani, 1999). The purpose of inclusive design as a design philosophy is to provide better life opportunities

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for as many people as possible via the design of accessible services, products, and environments (Fletcher, 2011; Coleman et al., 2007). British Standards Institute (2005) defined the concept of inclusive design as "the design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible ... without the need for special adaptation or specialised design.". This paper adopts the British Standards Institute (2005) definition as an operational definition of the term 'inclusive design'. However, there is an argument that the application of inclusive design as a holistic and positive approach has been rather limited although it is generally recognised as good practice (Persson et al., 2015). Further, it can be noted that complex global socio-cultural challenges and life-style changes are highlighting issues of design exclusion beyond those which are purely physical or access related. The wider world of design has moved beyond 'physical' and has witnessed the emergence of new metaphysical fields including emotional design (Norman, 2005), pleasurable design (Jordan, 2002) experience design (Hassenzahl et al., 2010; Pullman & Gross, 2004; Hekkert et al., 2003), human-centred design (Giacomin, 2014; Brown, 2009) and meaning-centred design (Giacomin, 2017; Verganti, 2013). However, inclusive design has remained largely focused on the more physical and tangible aspects of functionality, usability and accessibility (Steinfeld, 2013). These are referred to as 'physical aspects' in this paper.

The emphasis on physical aspects in the field of inclusive design is also reflected in the existing regulations and policies in developed countries. These mainly focus on barriers to physical access (barrier-free access) (Persson et al., 2015; ANSI, 1998) in relation to the development and provision of infrastructure and technologies (Lim & Nickpour, 2015). It is now often noted that additional exploration, evaluation and development are needed in order to achieve holistic and genuine inclusivity within our increasingly complex and diverse societies (Frye, 2013; Hedvall, 2013; Nickpour et al., 2012; Gaver & Martin, 2000; Demirkan, 2007; Imrie & Hall, 2003; Demirbilek & Demirkan, 1998). Considering inclusive design's origin, history and context, it is perhaps not surprising that non-physical aspects in inclusive design are currently scarce, neither systematically explored in the existing literature (Lim & Nickpour, 2015), nor in applications of inclusive design (Steinfeld, 2013). In this study, therefore, these non-physical aspects of inclusivity including psychological and social aspects are referred to as 'psychosocial aspects'.

The 'psychosocial' is usually described as a context-dependent and multidisciplinary concept. The term 'psychosocial' is defined as "the close relation between psychological factors (emotion, behaviour, cognition) and the socio-cultural context" (Psychosocial Working Group, 2003). It has been used mostly in medical and psychiatry journals since the 1950s, and since the 1990s its usage has increased (Roseneil, 2014). Psychosocial issues have been widely studied in psychology, social sciences, and the humanities (Roseneil, 2014).

Existing literature on inclusive design focusses mainly on accessibility and physical aspects of experience, thus there appears to be an opportunity for integrating further research which addresses the psychological and social aspects of inclusion. Table 2 provides a core set of definitions of the term 'psychosocial' and the most commonly used term, which is 'psychosocial intervention', identified through a review of the relevant literature from fields, including psychology, sociology, healthcare, ergonomics, and design.

Table 1 Frequently cited definitions of the term 'psychosocial'

Term	Definition	Context	Key notion
Psychosocial	"Relating to the interrelation of social factors and individual thought and behaviour" (Oxford English dictionary, 2017)	General	Social factors/ individual thought/ behaviour
	"The close relation between psychological factors (emotion, behaviour, cognition) and the socio-cultural context" (Jordans et al., 2010)	Mental health (Improving quality of care for children)	Socio-cultural context/ emotion/ cognition/behaviour
Psychosocial intervention	"Factors pertaining to a person's ability to deal effectively with the demands and challenges of everyday life. This involves a person's ability to maintain a state of mental well-being and to demonstrate this in adaptive and positive behaviour while interacting with others, his/her culture and environment." (Andersen et al. 2014)	Health care (Study of pain- identifying a relationship between psychosocial aspects and chronical musculoskeletal pain)	Mental well-being/ adaptive and positive behaviour/ culture/ environment
	"Including practices that have the purpose of improving the patient's psychological, social and behavioural functioning (Thirsk et al., 2014)."	Health care (Improving patients' psychosocial functioning)	Psychological/ social/ behavioural/ improving functioning
	"Cognitive behavioural therapy for patients, family intervention for family members and case management for patients and families" (Ruggeri et al., 2013)	Mental health (Improving quality of mental health care)	Cognitive behavioural therapy (CBT)/ family intervention/ case management
	"Improving quality of life and maximizing function in the context of existing deficits. Such interventions use a wide range of approaches including behaviour-oriented, emotion-oriented, cognition-oriented, and stimulation-oriented approaches and are carried out by a wide range of health and social care practitioners." (Vernooij-Dassen et al., 2010)	Psychogeriatric (Improving quality of life and care of people with dementia)	Quality of life/ maximising function/ behaviour-oriented/ emotion-oriented/ cognition-oriented/ simulation-oriented
	"To produce some beneficial effect on psychological distress or emotional adjustment of patients" (Rodgers et al., 2005)	Health care (Improving quality of life and care)	Psychological destress/ emotional adjustment
	"being any intervention that focuses on psychological and/ or social factors rather than biological factors" (Ruddy & House, 2005)	Mental health (Improving quality of care)	Psychological/ social
	"Any programme that aims to improve the psychosocial well-being of people." (Psychosocial Working Group, 2003)	Complex emergencies (Improving psychosocial well-being)	Well-being
	"Studies employing intervention techniques designed to utilize cognitive, behavioural or social mechanisms of action" (Cooke et al., 2001)	Psychogeriatric (Improving psychosocial intervention for care givers)	Cognitive/ behavioural/ social/ mechanisms of action

As an initial step, an operational definition of the expression "psychosocial inclusivity in design" was required. Following a review via the search keywords psychosocial, sociology, healthcare, and ergonomics, a set of definitions of psychosocial were assembled into a database which served as the basis for a thematic analysis. This resulted in an operational definition of 'psychosocial inclusivity' in design which was adopted for the purpose of the current study:

"provision of equal opportunities for better quality of life to as many people as possible by considering psychological social factors"

Having established an operational definition of psychosocial inclusivity which is appropriate for design applications, the remaining sections of the paper included empirical investigation performed in order to identify possible components which contribute to the psychosocial inclusivity construct. To achieve this purpose, two research questions were established:

a) Do psychosocial aspects affect older individuals' supermarket shopping experience?

b) What are the possible psychosocial components that need to be considered for better inclusivity in shopping?

2 Methodology

2.1 Choosing an ethnographic context for the study

2.1.1 Participant demographics

The two key beneficiaries of inclusive design are older population and individuals with disabilities (Hedvall, 2013; Nickpour et al., 2012; Gaver & Martin, 2000; Demirkan, 2007; Imrie & Hall, 2003; Demirbilek & Demirkan, 1998). In this paper, older individuals were selected as a key audience. The World Health Organization (WHO, 2007) defines 'older person' as an individual above "chronological age of 60 or 65". This is also the retirement age in most developed countries, e.g. 60 years for females and 65 years for males in the UK are state pensionable age (Mein et al., 2000). The United Nations (UN, 2007) refers to the older population as aged 60 and over. In this study, WHO terminology and definitions were adopted to refer to the target group i.e. 'older person/people' above 60 years of age, alongside similar terms such as 'older individuals', 'elderly people', 'senior citizens' and 'older adults'.

2.1.2 Activity and context

Inclusive design is applied in diverse contexts e.g. the design of transport systems; premises; built environment and facilities; education; products and goods; services (Casserley & Ormerod, 2003). Within the contexts, a practical implication for psychosocially inclusive design is often evaluated via 'Instrumental Activities of Daily Living' (IADL: housework; preparing meals; taking medication managing money; shopping for groceries or clothing; use of the telephone or other forms of communication; transportation within the community). IADL are essential activities for independent living (Spector et al., 1987), particularly by older individuals (Katz, 1983; Lawton & Brody, 1970).

Within IADL, it has been argued that shopping is the activity that is strongly affected by both physical and non-physical aspects including individuals' socioeconomic status (Pechey & Monsivais, 2016; Ministry of Agriculture et al., 2014; Ishikawa et al., 2013); health and physical conditions; and geographic availability (Ishikawa et al., 2016; Yakushiji & Takahashi, 2014; Aggarwal et al., 2014; Pettigrew et al., 2005; Chow et al., 2014; Rose & Richards, 2004; Aylott & Mitchell, 1998). Shopping is also frequently related with other daily activities e.g. money management, personal transportation, and preparing meals (Spector et al., 1987)

Furthermore, older individuals' supermarket shopping is considered as one of the most important contributors to choice of diet and independent lifestyle (Lang & Hooker, 2013; Thompson et al., 2011). Physical aspects of store environment e.g. parking access, the availability of food products in appropriate sizes, accessibility of products on the shelves, and queues at checkouts (Moschis et al., 2004; Hare, 2003; Hare et al., 2001; Goodwin & McElwee, 1999; Dychtwald, 1997; Moschis, 1992) have been discussed as significant issues that impact supermarket shopping experience of older individuals. While physical inclusivity issues are evident, combinations of health, psychological, and social factors such as social isolation, mental illness (Davies & Knutson, 1991), social interaction (Moschis et al., 2004; Leventhal, 1997), and entertainment (Tongren, 1988), the attitude of staffs also significant issues that affect the older individuals' supermarket shopping experience.

These have been suggested that supermarket shopping affects older individuals' physical, psychological and social well-being (Amarantos et al., 2001). These aspects of well-being are related to quality of life of human, which is defined by Felce and Perry (1995) as "a multi-faceted concept comprised of subjective evaluations of material, physical, emotional and social well-being". In this study therefore, supermarket shopping was chosen as the ethnographic context since it involves a rich mixture of not only physical but also psychosocial considerations.

2.2 Choosing method for the study

A Non-participant observation (fly-on-the-wall observation) (Robson and McCartan, 2016) which is the one of the human centred design tools (Giacomin, 2014) was selected as an empirical investigational method to identify any psychosocial aspects of the supermarket shopping experience which emerge in the real-world.

2.3 Sampling

Ishikawa et al. (2013) argued that supermarket shopping reflects both personal preference and correlates with the individuals' socio-economic circumstances. The three main marketing categories relative to best known UK supermarkets are presented in Table 2. The supermarket brands are presented based on their marketing distinction of high, middle, or low -cost supermarkets (Pechey & Monsivais, 2015), and their market share and number of stores are provided for reference (USDA Foreign Agricultural Service, 2016).

Table 2 supermarkets in the UK categorised by target customers

Category by cost	Supermarket	Market share (2016)	Number of stores (2016)
High-cost	Waitrose	5.4%	350
	M&S	4.3%	914
Medium-cost	Tesco	28.2%	3,493
	Sainsbury's	16.0%	1,312
	Asda	15.6%	626
	Morrisons	10.4%	569
	The Co-operative	6.5%	4,000
Low-cost	Aldi	6.2 %	620
	Lidl	4.6%	630
	Iceland	2.1%	864

Additionally, in 2015 over 99.7 percent of the UK households (24,828/24,879) used medium-cost supermarkets including Tesco, Sainsbury's, and Asda (Pechey & Monsivais, 2015) as part of their major shopping. Also, the market share (76.70%) and the number of stores (8,688) of this category are more than double compared to those of other two categories.

Therefore, older individuals (n=8) who use the medium-cost supermarkets at least once in a fortnight were chosen as participants for the observational investigation. The participants are consisted of three males and five females. Prior to starting the investigation, a research ethics approval was sought and granted by the research Ethics Committee of Brunel University. The ethical and consent forms were provided at the beginning of the investigation.

3 Data collection and analysis

3.1 Observational study protocol

Non-participant observational investigations were conducted to identify any psychosocial aspects by observing older individuals' real-time supermarket shopping experience. As a familiarisation stage, an initial interview was carried out for approximately 30 minutes at the beginning of each observation session at the participant's home. The actual observation session began from the participants' outward journey to the supermarkets. After completing the observation, a final

interview of was conducted in each participant's home for approximately 30 to 60 minutes which sought further information and feedback.

3.2 Observational study data analysis

The data from the observations were analysed by two coders (one final year PhD researcher in design and one design researcher with over 15 years experience) using qualitative data analysis methods including the domain and taxonomic coding, process coding, and NVivo10 software. The analysis process followed the 'six phases of thematic analysis' (Braun & Clarke, 2006): familiarisation with the data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; producing the report. The analysed data was reviewed by a design researcher with over 15 years experience. The '15-point checklist of criteria for good thematic analysis' (Braun and Clarke, 2006) was adopted for reviewing the final results of the data analysis.

4 Results

Findings from the observational investigation were categorised under four main groups which are 'Psychosocial aspects'; 'Physical aspects' (physical factors e.g. accessibility, usability, efficiency, etc.); 'Shopping' (supermarket-related factors e.g. store items, facilities and environments, surrounding facilities, etc.); 'General background' (individual's socio-demographic characteristics, physical condition, etc.). The results pertaining to the concept of psychosocial inclusivity, which is the 'Psychosocial aspects' category, and the discussion of the interpretations are presented below.

4.1 Psychosocial aspects

The psychosocial aspects category includes four main themes: *Cognitive factors*, *Social factors, Emotional factors,* and *Value factors.* The four main themes along with their associated subthemes are presented in Table 3. The themes, sub-themes and codes are ordered according to their frequency of occurrence which was extracted from the thematic coding database of the observational investigation.

Table 3 Psychosocial aspects of supermarket shopping of older individuals

Theme	Sub-theme	Code (number of occurrences)	
Cognition factors	Cognitive judgement	Preference of	Supermarket products and services (n=38)
			Life style, social, public related, etc. (n=7)
		Familiarity (n=30)	
		Helpfulness (Supermarket products and services [n=15])	
	Self-awareness	of Health (n=9)	
		of Age (n=1)	
Emotional factors	Positive emotion (Positive affect)	Enjoyment (n=32)	
		Pleasure (n=32)	
		Satisfaction with Supermarket related product and service (n=32)	
		Sense of independence (n=1)	
	Negative emotion (Negative affect)	Frustration (n=11)	
		Tiresomeness (annoyance) (n=5)	
Social factors	Support and Service	Support from other people (n=6)	
		Social service (n=1)	
	Social activity	Hobbies (class, club etc.) (n=19)	
		Volunteering activities (n=5)	
	Socialising	Interaction with others in the super market (n=32)	
		Having guest (entertaining, hosting etc.) (n=2)	
	Public attitude	Public awareness and language (n=7)	
		Generational difference (n=1)	
Value factors	Satisfaction	Sense of belonging (n=14)	Life-satisfaction (n=3)
		Social and public related satisfaction (n=12)	Reliability & Trust (n=1)
	Happiness (n=12)		
	Self-esteem	Self-satisfaction (n=5)	
		Self-confidence (n=3)	

4.2 Cognitive factors

The 'Cognitive' factors theme consisted of two sub-themes which are 'Cognitive judgement' and 'self-awareness'. The 'Cognitive judgement' sub-theme in turn consisted of the codes of *Preference (supermarket products and services; Life style, social, public related, etc.); Familiarity; Helpfulness (supermarket products and services). '*Self-awareness' sub-theme included *Self-awareness of health* and *Self-awareness of age.* The codes of each sub-theme were presented in the Table 3.

Messick (1994) and Lazarus (1991) argues that the notion of 'Cognition' is a broad and over-arching concept among various areas of application. The general definition of the term cognition is "the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses." (Oxford English Dictionary, 2017). On the other hand, Messick (1994) defined the term 'cognitive styles' as "characteristic modes of perceiving, remembering, thinking, problem-solving, and decision making, reflective of information-processing regularities that develop in congenial ways around underlying personality trends". This definition was used to describe the cognitive factors in this study. The 'Cognitive factors' theme contains behaviour, attitude, and thinking of participants in their supermarket shopping experiences. the most frequently mentioned sub-themes and codes by the participants *were Preference* of supermarket products and services (n=38*) and Familiarity (n=30)*. Indicative examples of participant comments include:

> *[Preference] "Yes I got a later date on it. […] If I got the one it's gonna be expired by tomorrow, I would only use part of it, and it's going off a bit before I consume that, so I always hang around for the one with the most time left on it […] Yes, I only use even top*

300 ml top like that I only ... that allows me five days. […] If it's few days left before it's expired, it's not very nice. It's gonna be passed expire date." (Male, 72)

[Familiarity] "I know the layout of the supermarket and locations of the items very well, so it's useful." (Male, 72)

4.3 Emotional factors

'Emotional' factors theme consisted of two sub-themes 'Positive emotion (Positive affection)' and 'Negative emotion (Negative affection)'. 'Positive emotions' sub-theme included *Enjoyment; Pleasure; Satisfaction with supermarket products and services; Sense of independence.* 'Negative emotions' sub-theme included *frustration; Tiresomeness (annoyance and losing interest)*.

'Emotion' is a broad over-arching concept, hence there is a lack of consensus in the existing literature on the definition of the term emotion (Mulligan & Scherer, 2012; Cole et al., 2004; Kleinginna & Kleinginna, 1981; Chaplin & Krawiec, 1979). English and Ava (1958) proposed the definition of emotion as "a complex feeling-state accompanied by characteristic motor and glandular activities; or a complex behaviour in which the visceral component predominates.", and this was used in this paper. Within the definition, the participants' senses or feeling related codes caused by their mood, relations with others, or circumstances were categorised in this theme. *Enjoyment* (n=32), *Pleasure* (n=32), *Satisfaction with supermarket products and services* (n=68), and *Frustration* (n=11) were amongst the most noticeable codes encountered during the older individuals' supermarket shopping. Examples of participants' comments include:

[Enjoyment] "Oh, quite often! I mean today we didn't, no chatting today at all. I didn't see anyone I knew, and I didn't see anyone else to speak to … oh we often do … especially, perhaps about cat food […] we are all doing the same things, we know what we are doing. And I will talk about it because we do." (Female, 80)

[Pleasure] "Uhm well, I enjoy going there physically because often especially in the winter, the sun is going down, and the so very nice sky, and the yes they got the trees there and as I said little leaves coming out from the bottom, and they are so pretty." (Female, 81)

[Satisfaction] "I like the bargain. And finding everything I am looking for is exactly in the same place it was in last week. That's quite satisfactory […] Well, when they move things. […] when you find an assistant, they are all very very helpful, really nice. They spend time to help you." (Female, 81)

[Frustration] "I mean I'll drive around here to go shopping and bits. But I don't enjoy it. So I'd rather go on the train if I go anywhere. Um, I think there's a bit of an old age thing really. […] I'm, not losing my confidence but I'm, I'm very, I'm not slow but I don't know. I just feel that I, I could cause an accident because perhaps, no, I don't know. Anyway, I don't, I don't enjoy it anymore so." (Female, 74)

4.4 Social factors

The 'Social' factors theme consisted of four sub-themes: *'S*upport and Service', 'Social activity', 'Socialising', and 'Public attitude'. The 'Support and service' sub-theme included S*upport from others*; *Social service*. The 'Social activity' sub-theme included *Hobbies (classes, clubs, etc.); Volunteering activities. The* 'Socialising' sub-theme included *Having guest (entertaining, hosting etc.)*; *Interaction with others in the super market*. The 'Public attitude' sub-theme included *Public awareness and language; Generational differences.* The codes of each sub-theme were presented in the Table 3.

Kaslow et al. (2007) have proposed that the concept of 'social factor' as "physical environment, external stressors, family environment, interpersonal relationships, social support and isolation, role models, social expectations, value system, sociocultural factors, and culture.".

Social factors strongly influence on individuals' quality of life including human well-being (Larson, 1996) and have interdependency with physical, emotional, and mental factors. 'Social factors' in this study referred to any support, services, activities, public awareness and attitude which can affect participants' thought, feeling, and behaviour in their shopping experience. The codes of *Interaction with others in the supermarket* (n=32), *Hobbies* (n=19), and *Public awareness and language* (n=7) were the most repeatedly mentioned by the participants. Indicative examples of participant comments include:

> *[Interaction with others in the supermarket] "I don't want to do online shopping because I like to go and see things and people." [Female, 80]*
>
> *[Hobbies (classes, clubs, etc.)] "Tomorrow there is my coffee morning group. Yesterday, I had to miss my scrabble group because it was my granddaughter's graduation in the Sussex. […] Tuesday is different scrabble group. Monday is I call a day off. Sunday, I go to a church in the morning, and friend comes to see me most Sunday afternoon." [Female, 80]*
>
> *[Public awareness and language] "But it just makes it easier for the general public as well. Because it's difficult when you're in there on a scooter for them to get around you, and very often they don't see you. I mean I wear a lime green jacket which you'll see when we go over. And very often people, they'll walk into me and they'll say, 'Oh, sorry! Didn't see you there.' And my scooter's quite big as well!" [Female, late 60]*

4.5 Value factors

The 'Value' factors theme consisted of three sub-themes; 'Satisfaction', 'Happiness', and 'Self-esteem'. The 'Satisfaction' sub-theme included the codes *of Sense of belonging*; *Social and public related satisfaction; Life-satisfaction; Reliability and Trust.* The 'Self-esteem' sub-theme included the codes of *Self-satisfaction* and S*elf-confidence.* The codes of each sub-theme were presented in the Table 3.

The concept of 'value' is a multi-faceted and wide-spanning notion used in diverse fields such as physics, music, chemistry, ethics, mathematics, marketing, and business (Gil Saura et al., 2008; Zeithaml, 1988). Diener and Suh (1997) have proposed three bases: continuous choice; judgement of satisfaction; judgment with reference to cultural norms or value system, that an individual can identify what is valuable or not to them. In this study, the Oxford English Dictionary (2017) definition: "principles or standards of behaviour; one's judgment of what is important in life." was used as reference. Therefore, participants' feelings and thoughts regarding their shopping experiences as well as themselves were extracted in this theme. The codes of *Sense of belonging* (n=14), *Happiness* (n=12), and *Social and public related Satisfaction* (n=12) were the most repeatedly raised by the participants. Indicative examples of participant comments include:

> *[Sense of belonging] "[…] I always try to go to the counter to see people I know that I recognise would be pleased to say you know "you've had a haircut, nice today." "did you have a nice holiday?" or maybe it's 5 o'clock evening, "you are going home soon are you tired?" […]" (Female, 85)*
>
> *[Happiness] "Going to the supermarket with my partner is the happiest thing" (Female, 73)*
>
> *[Social and public related Satisfaction] "Because I go to supermarket, I see more neighbours and talk to them and also get local information. It's amazing" (Female, 85)*

5 Discussion

This study aimed to address two research questions: a) Do psychosocial aspects affect older individuals' supermarket shopping experiences? b) What are the possible psychosocial components that need to be considered for better inclusivity in shopping? These research questions were

addressed through the empirical investigation i.e. observations. The psychosocial aspects of older individuals' supermarket shopping that emerged from the data were named *Cognitive, Social*, *Emotional* and *Value* factors. Many of the components for psychosocial aspects have been identified via various previous research. However, specific details of these themes including code are not well established in the existing literature. This could also explain that psychosocial aspects are less explicit and visible, and thus more elusive and complex in terms of its definition, measurement, and improvement.

Cognitive factors: The results suggested that older individuals' shopping experience is influenced by a number of 'cognitive' factors which can be grouped under the sub-themes of 'Cognitive judgement' and 'Self-awareness'.

The results confirmed *Preference* (supermarket products and services), and *Familiarity* (Pechey & Monsivais, 2015; Vyth et al., 2010; Vannoppen et al., 2002; Arora & Stoner, 1996) as codes of the sub-theme 'Cognitive judgement' as noted by previous researchers.

However, Self-awareness of health and age, which had not been identified in the previous researches, were identified as an additional sub-theme in this paper. In one instance, the participant who made the different choice of supermarket due to awareness of her back pain.

Emotional factors: The results suggested that older individuals' supermarket shopping experience is affected by both physical and 'emotional' factors including feelings of pleasure and frustration.

Existing literature on supermarket shopping emphasises *emotional reaction* as an important factor mainly considered by supermarkets for marketing purposes. It was stressed that the emotional reaction as one of the key drivers for consumer decision making (Ambler et al., 2004).

This study stressed a richer scope of considerations through identifying the positive or negative emotions experienced by older individuals during their supermarket shopping activities. In one instance, an older shopper stressed strong negative emotions of *Embarrassment*, and *Self-consciousness* in the process of renting a mobility scooter for use in store. The participant needed to que for a considerable amount of time and had to speak to customer services and security in order to borrow a mobility scooter and its key for use in supermarket. In such case, the supermarket aimed at physical inclusion through providing mobility assistance and improving accessibility, convenience, and usability for shoppers. However, the shopper experienced psychosocial exclusion, feeling embarrassed, uncomfortable and self-conscious due to the unnecessarily complex process of renting a scooter. This suggests that focussing only on physical inclusivity in supermarket stores can lead to experiences of negative emotion for the older shoppers.

Social factors: The results suggested that older individual's shopping experience is influenced by 'social' factors such as gaining motivation for shopping; feeling positive or negative emotions; and choosing supermarket products and services, stores or transportation. The social factors were found to involve four sub-themes of: Support and service, Social activity, Socialising, and Public attitude.

In the previous literature, socio-economic status was already stressed as an important social factor (Pechey et al., 2013; Appelhans et al., 2012; UK Department for Environment, Food and Rural Affairs, 2011; Giskes et al., 2010; Darmon and Drewnowski, 2008; Aylott & Mitchell, 1998).

However, several social related sub-themes including 'Support and service', 'Social activities', 'Socialising', and 'Public attitude', were newly identified through this study, possibly for the first time. On various occasions, participants stressed how their shopping experience was mainly driven or significantly affected by social factors e.g. going to supermarket to see or meet people, spending time with partner, or shop for neighbours physically unable to shop. This emphasises why design for social inclusivity beyond physical inclusivity should be a key consideration.

Value factors*:* The results suggested that older individual's supermarket shopping experience is influenced by certain values (happiness, satisfaction, and self-esteem) which have a important

influence. In one instance, feelings of 'happiness' when seeing the sunset on the way back from supermarkets or shopping with a partner appear to be difficult to separate from the particular shopping interactions and events.

The existing literature re-confirmed results Life-satisfaction and Self-satisfaction. Literature supports the association between shoppers' shopping experience and their well-being at supermarkets and malls (Grzeskowiak et al., 2016; Wagner, 2007; Lavin, 2005). Additionally, satisfaction with the state of health is considered as one factor that influence older individuals' shopping behaviour (Ishikawa et al., 2016).

However, results suggested further sub-themes including 'happiness' and 'self-esteem' as relevant values and several new codes were also identified. The satisfaction with the participants' life or society through their shopping experiences were implied (e.g. choosing fair trade items; having trust in services or products in the store; or feeling a sense of belonging by engaging with others). This emphasises the association between quality of shopping experience and certain values which considering 'core values' of older individuals can lead to better shopping experiences.

In addition to considering each component (i.e. Cognitive, Emotional, Social, and Value) individually, the data collected from this study proposes the need for evaluating the psychosocial components in cognition because of the obvious correlations identified in the data. Various statements collected from the data base as part of the study involved joint concept, with codes from more than two themes being used to explain the same need, thought, or desire. This is specifically important when designing for psychosocially inclusive supermarket shopping experiences for older individuals so as to adopt a convergent, holistic, and connected approach. Therefore, the dimensions can be used by design professionals and academics or third parties to consider the concept of psychosocial aspects in design of better supermarket shopping experience. The results also can be developed as a complete set of toolkit or framework by conducting further research

5.1 Limitations

A methodological limitation of the current study was the sampling and data collection. Due to recruitment difficulties, there was a gender imbalance in participants (Male: 3 and Female: 5). While there is not one specific sample size which is generally preferred by the research community, due to the various factors which should be considered in study design (Robson and McCartan, 2016), the total sample size of eight individuals might be considered to be small from some points of view.

The scope of this paper was limited to older individuals' shopping experiences. When it comes to the wider concept of inclusive design, further key contexts and IADL beyond shopping need to also be investigated in order to thoroughly explore the concept of psychosocial inclusivity. The current findings from this paper provide only initial dimensions in order to extend the concept of psychosocially inclusive design but can also be considered a preliminary step.

6 Conclusions and Future work

6.1 Conclusions

The findings from this study suggest: (a) the importance and significance of psychosocial inclusivity supermarket shopping of older individuals and in design and (b) a partial list of components for psychosocial inclusivity in design which can be extended via further studies.

In this study, the older individuals' supermarket shopping was selected as a first context in order to explore the nature and also the role of psychosocial inclusivity in design. The investigation was performed by using the human centred design method of observation with a total of eight older individuals. Through the investigation, several psychosocial aspects of supermarket shopping of older individuals were identified and categorised based on their implications or meaning using thematic coding analysis, under the four major themes which are 'cognitive', 'emotional', 'social', and 'value' factors (Table 3).

6.2 Future work

This study is part of a research project aiming to explore the notion of psychosocial inclusivity in design by identifying a definition and set of dimensions of psychosocial inclusivity in design. In this study, the partial components for the dimensions of psychosocial inclusivity in design were identified based on the older individuals' supermarket shopping experience. Further contexts should be studied so as to provide universal practicality and validity of the results. Validation, refinement and detailing of the four dimensions and their sub-themes is the subject of on-going research which is being performed using ethnographic interviews and creative workshops in the personal mobility and built environment contexts, conducted with people with disabilities chosen from a diverse demographic group.

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Seeking for Diversity among Young Users: the case of children's photography

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User-centred design practices in the design of products for children's use has become common, especially in the field of technology design. Although young users are now considered as essential and reliable actors to inform the design space, design research with children still remains focused on the design process itself, and children's role in it. In an attempt to steer away the discussion from how children are included in design to how they are represented in design, our paper focuses on understanding and communicating plurality of the experience among young users to inform and expand the early design phase. For this purpose, we present an overview of the child-centred design practices, discuss how designers of children's products may benefit from an experiential approach for a holistic understanding of the user space; and finally, we present our study on children's photography to illustrate how a commitment to understanding children's perspectives can contribute to eliciting, and representing user diversity through personas to guide the design of meaningful products for young users.

child-centred design, children's photography, user experience, persona

1 Introduction

Children of the developed countries are growing up in a technology-immersed environment. From the moment they start purposeful interactions with their physical surroundings, they get in touch with interactive toys, game consoles, smart phones, tablet computers, and numerous educational and gaming applications. Designing interactive technologies for them has become a separate research field (Markopoulos, Read, Hoÿsniemi, & MacFarlane, 2008), which brought about intense methodological research on how to design for and with children, accumulating a body of adapted or novel methods, from user testing (Read, 2008) to participatory design (Fails, Guha, & Druin, 2012). Designing for young users can be a challenging task due to intergenerational differences, which potentially leads to a mismatch between adult-designers' conceptions of child-users and the real-life product experiences of children. One source of information designers often refer to when designing for children is the age-based developmental characteristics described by the pioneers of

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developmental psychology (Bruckman, Bandlow, & Forte, 2007; Hourcade, 2007). Although biological differences of children from adults can be a useful source to begin comprehension of the needs of young users, developmental approach is based on presuppositions and generalisations about characteristics of children at a certain age (Christensen & Prout, 2002). It focuses on general characterisations about what children can and cannot do, hence overlooks the differences among them.

Another issue that has been occupying the research agenda is how to involve children in the design process. The role of children based on the extent of their contribution in design has long been discussed in the field (Druin, 2002; Yarosh, Radu, Hunter, & Rosenbaum, 2011), and how this contribution corresponds to different phases of design (Barendregt, Bekker, Börjesson, Eriksson, & Torgersson, 2016). Putting emphasis on the methods and degree of involvement was criticised by Iversen, Halskov, & Leong (2010), suggesting that the focus of inquiry should be on integration of children's values in design, rather than how and to what extent they take part in design activities. Although useful in guiding the design process, the strong focus on the age-based developmental characteristics and methodological inquiries to involve children evident in the HCI tradition prevents us from understanding the diverse interests and expectations of children from designed artefacts, which is needed in the early stages of product design to diversify and expand the design space with possibilities, leading to different design concepts.

Moving from this concern, we propose a change of focus in the inquiry from the process of design and methods of children's involvement in it, towards a comprehension of how products come to being in children's lives. We believe such a perspective will help free us from our vested conceptions of childhood, and notice the plurality of product experience among children, which can be a useful source to enrich the design space. For this purpose, we start with a review of the methodological approaches to designing for and with children. Then, by investigating how representations of children and child-users are relevant in design space, we discuss the experiential approach in design and its possible implications in design research with children. Finally, we present and discuss our field study on children's photography experience to illustrate the potential of an approach that seeks for plurality of experience to enrich the possibilities for designers.

2 Methodological approaches to designing for children

The ways children differ from adults in terms of their interactions with technology has always been a focus of interest in design research and practice for children. From the perspective of designers, who do not have prior experience, the first thoughts come to mind would perhaps be what their interests are, and what they are capable of. Adult-designers are way past their childhood years; hence, referring to past personal experience, a common tactic employed by designers when attempting to understand the needs and concerns of the target users, becomes even less reliable than it is with adult-users (Antle, 2006). This is where developmental psychology has taken part in informing designers of children's products. Developmental characteristics of children have a considerable impact on how they interact with their physical environment. This idea inspired a body of research borrowing theoretical knowledge from developmental psychology to ground guidelines and recommendations for designers. For example, Bruckman et al. (2007) focus on Piaget's theory of intellectual development to illustrate how cognitive and physical characteristics of children impact their interactions with technology. Similarly, Hourcade (2007), who builds his guidelines on the developmental theories of Piaget, Montessori, Vygotsky and Gardner, match developing cognitive and fine motor skills of children with hardware and software interaction. Gelderblom & Kotzé (2009) point out that relying on developmental psychology alone not necessarily results in developmentally appropriate designs, though it decreases the amount of usability testing needed. As much as awareness of developmental characteristics is a way of acknowledging children's differences from adults, if not supported with other sources, it remains to be a generalising approach which overlooks the differences among children.

Druin's (2002) framework on children's role in technology design is perhaps one of the most influential works changing the course of research and practice. Describing the user, tester, informant and design partner roles for children, she introduces *cooperative inquiry* as long-term, sustained collaborations. In cooperative inquiry, children become equal partners of an intergenerational design team together with adult designers, developers and other stakeholders throughout the product development process, during which they participate in several user research, idea generation and elaboration, and prototyping activities. Although it shares or adapt several methods and techniques of participatory design practices with adult-users, intergenerational design teams with child-users offer a more progressive approach to design collaboration in terms of the level and sustainment of user participation. Early involvement of children in design has gained considerable attention in the past years, with a significant interest in methods of inquiry (Read & Markopoulos, 2013). For example, a review of the 2002-2010 proceedings of the ACM conference on Interaction Design and Children[1] shows 37% of the papers concentrated on investigating or comparing methods of design and evaluation with children (Yarosh et al., 2011). Same study shows that 31% of the papers reporting on the design of a system for children involve children as design partners. These numbers undoubtedly reflect only one publication venue, hence not generalizable. However, a common interest in children's role and methods of involvement among interaction design and children community is evident, as similar works continue to be reported by scholars. For instance, Druin's framework was utilised in a review study to describe how families are included in the design of technologies (Isola & Fails, 2012). Similarly, Barendregt et al. (2016) suggested "role definition matrix" as a guide to characterise the contribution of children based on the design phase, and the activities in relation to the designer.

A growing body of research on methods of inquiry is vital for any maturing research field. On the other hand, the emphasis on children's role gives rise to a focus on the design process and the resulting product, rather than understanding children's perspectives and translating them into design solutions. A similar concern was raised by Iversen et al. (2010) towards current participatory design practices with children. Pointing out to the dominant discussions focusing on the methods and degree of children's participation, they assert that the original premise of participatory approach, which is to incorporate user values into design, has gone unnoticed. Although it can be inferred that participation will de facto result in integration of children's agenda into design output, the embedded nature of the research and design with a strong focus on developing the product in question leaves these issues less explicit and untraceable.

An inquiry into children's lives can be a valuable source of inspiration for meaningful design solutions addressing their latent needs and concerns. Generative methods are suggested to be useful particularly in the 'fuzzy front-end', when there is no well-defined brief, the design space is ambiguous, and user input can inspire major design directions (Sanders & Stappers, 2008). Although not as popular as design partnerships in the early design phase, use of generative methods in design research with children is not uncommon. For instance, Gielen (2008) reported contextmapping activities with children to collect information about 'fears' through cultural probes and mappings, timelines and writing letters in generative sessions; investigating the aspects of outdoor play by collages and stickers; and finally, exploring 'water play' with cultural probes and brainstorming activities. In a study aiming to capture the daily experiences of children using prosthetic legs, Hussain (2010) employed write/draw tasks, role playing, and photo-documentation techniques. Such activities are useful in co-constructing knowledge and insights into daily experiences of children, hence boosting empathy and inspiration necessary for designers.

One reservation about contextmapping could be regarding the translation of the rich information into design briefs, since contextmapping activities not necessarily focus on a product, but the

[1] Gathering since 2002, IDC is the only academic conference series fully focusing on designing interactive systems for children. In 2013, the same community began to publish International Journal of Child-Computer Interaction.

general context within which it will be used. According to Töre Yargın's (2013) model of effective communication of user research findings with design teams, guidance is as important factor as inspiration in design process. She bases her framework on the practical and organisational needs of designers, and how they utilise user information during product development process. According to her work, guidance not only supports empathy with the user, but also provides feedback when taking major design decisions. For this purpose, she recommends researchers to concretise user perceptions and behaviours by matching them with related product attributes, highlighting instances of product interactions in a natural setting, and representing diversity among users in order to promote both inspiration and guidance for designers. Long-term design partnerships, as well as contextual exploration through generative methods, require direct contact of designers with children, which may not always be feasible. Therefore, these recommendations are meaningful especially in an industrial setting, where division of labour forces a separation of user research from design practices (van Veggel, 2005). When this is the case, capturing and communicating the richness and complexity of the user context becomes important (Sleeswijk Visser, 2009). The field of designing interactive technologies for children is dominated by the human-computer interaction tradition. Hence, a large number of studies concentrate on engineering and evaluation of a single solution (Jensen & Skov, 2005), and evaluative studies to iterate and improve the designed system still remain to be the dominant form of contribution received by children (Yarosh et al., 2011; Authors, 2016). Although the importance of early involvement of children is often acknowledged in the literature, its impact on expanding the design space by leading to the generation of multiple diverse ideas is relatively less explored (Sluis-Thiescheffer, Bekker, & Eggen, 2007). Similarly, the importance of seeking for differing perspectives of children lies under the need for diversification of the design concepts in accordance with their suitability to the different needs and expectations of child-users.

3 Constructing the child-user

When we design products and systems for adults, we consider their differing needs and expectations based on several factors such as demographics, cultural differences and personal backgrounds, in order to diversify or target our design solutions. However, child users are usually characterised by their developmental traits based on age, or the requirements defined by the institutional actors such as schools or families, who mostly mediate their ownership and use of products. For example, a considerable number of user research studies with children focus on education and 'edutainment' technologies (a term describing playful systems with learning goals). Hence, the 'learner' identity is in the forefront, and meeting the pre-defined learning goals often becomes the merit of successful designs.

A quick glimpse at the consumer products designed for child-users in comparison to adult-user counterparts demonstrates not only adult-designer conceptions of child-users, but also the encompassing contemporary socio-cultural constructions of childhood. To illustrate, we compared the formal product language inscribed in digital cameras designed for adult and child-users (Figure 1). Designers often reflect adult conceptions of children on products, which presumes they would appreciate the use of bright colours, cartoon-like bulky and roundish forms, and that they would identify themselves with famous, pop-culture characters. Although this might be partly relevant due to a shared cultural understanding among the individuals living in the same society, it not necessarily means that they point out to a taste innate to childhood. They rather represent our contemporary cultural norms, which, for instance, contrasts with the behaviourist approach to childhood and learning theories dominated the Western culture until recently, constructing children as "blank vessels" to be filled by responsible adults with required skills, tools, knowledge and experiences (Bruce, 2011).

Figure 1 Examples of cameras designed for adults (left) and children. Product images retrieved from Amazon.co.uk[2]

Mayall (2000) suggests we should regard children as a social group and childhood as a culture, in order to understand their unique knowledge coming simply from the experience of 'being a child'. Children, like adults, live in a certain cultural world; they have shared values and concerns, as well as their diversities. These factors, along with product characteristics and the context of use, have an impact on children's interaction with and expectations from products. This perspective in a way corresponds to the experiential approach in design, the focus of which is to present a holistic understanding of the issues playing a role in user experience by taking into account product, use context and subjective factors. Designers can only control the features of the product, such as form, function and interaction modalities. According to Hassenzahl (2004), this is only the *intended* use proposed and communicated by the designer. The way users perceive and engage with the products, and the emerging consequences through this engagement, always occur in the actual use situation. The context refers to not only the momentary situations such as the physical conditions and the emotional state of the user at the time of interaction, but also the underlying personal, social and cultural factors that effect how the product is experienced (Desmet & Hekkert, 2007). The user experience literature suggests that better comprehension of the aspects of experience is vital to inform the design of pleasurable products, and facilitate experiences meaningful for users. Even though we cannot design experiences per se, we can adjust *design expressions* to be able to influence the experience through formal and behavioural qualities of design by understanding what really matters for users (Fulton Suri, 2003). Hence, an awareness about the constituents of experience beyond the actual product itself will better inform designers about users' world, and guide the design process accordingly (Hekkert & Schifferstein, 2008).

Examination of the frameworks of user experience points out to an interplay of the product, user, and the use context, and the larger social-cultural world in which the interaction occurs. A holistic comprehension of children's perspectives requires not only an inquiry into the personal and contextual factors that influence how children interact with products, but also conceptualisation of the subjective judgements regarding how children give meaning to product features based on past experience, concerns, and aspirations. The former can be examined by observation or self-documentation techniques (e.g. cultural probes), whereas subjective constructions can only be elicited through self-report techniques, such as interviews and questionnaires. Although the use of these techniques are not uncommon in research with children, we would like to explore the potential of a research methodology devised to elicit and communicate the plurality of children's expectations from designed artefacts. In the rest of the paper, we present our study on exploring

[2] Images retrieved from the first-page results of the Amazon.co.uk search under 'Digital cameras' product category, filtered 'Up to 7.9 megapixel cameras' for a fair comparison within compact cameras by excluding products for professional use. Cameras designed for children are searched as "for kids" within the same product category and filtering.

children's photography experience, and discuss design implications through persona-like characterisations we constructed from our findings to communicate the diverse product experiences of children.

4 The case of children's photography

Photography is an extra-curricular activity, independent from learning objectives of an educational setting. Although children usually are not camera owners, they are familiar with the concept of photography from their social environment, and to some extent experienced with devices having image capturing functions such as smart phones and tablet computers. Additionally, cameras mediate a multi-faceted experience with both subjective and social aspects. In this respect, we considered photography as a fruitful experience to investigate. The study described in this section is a part of the first author's doctoral research on methodological inquiries into holistic capture of children's product experiences to inform early design process.

4.1 Methodology

We recruited participants via announcements sent to the e-mail listings of the campus housings, and a neighbourhood association located near the campus region. We scheduled meetings with the parents who responded to our call. 26 children (m=14, f=11) aged 7 to 9 years old participated in our study (7 years old=10, 8 years old=9, 9 years old=7).

In data gathering, we used three different cameras. The selection criteria was to present the diversity of the product line, while still keeping the range relevant to children. *Vtech Kidizoom* is designed for children aged between 3 and 8. It has a playful menu with draft filters, game menu, and parental controls. Image quality controls are limited, while the design effort seems to be concentrated on after-photo effects to enhance the 'fun factor' of the user experience. *Nikon Coolpix S33* and *Panasonic DMC-XS1* are compact, 'point-and-shoot' cameras, a term used in photography to refer to the ease of use, but at the expense of limiting the technical capabilities. Panasonic is designed for the use of adults, whereas Nikon comes with two built-in menus, one for adults and one for children.

We constructed a two-step methodology to investigate how children make sense of different camera designs to understand their expectations, and how these products come into existence in a social context. In the first step, we conducted individual interviews with children to discover their constructions about cameras based on their anticipations of product language. Before each session, we administered a parental questionnaire to collect information about the participant's daily experience with technological products. The questions consisted of a list of consumer electronics, asking the ones available in the household, the ones the child had experience with, and an open-ended column for indicating the nature and purpose of use. Twenty-one participants have access to camera at home. 12 of them have not used a camera before, however 6 of these participants have used smart phone or tablet for taking pictures. Interviews consisted of a comparative procedure: we introduced children pairs of product images and asked for perceived differences, we asked which one is the preferred attribute, and why this is important for them. We continued comparative questioning until they cannot come up with new constructs, and then we moved to the next image pairs to repeat the procedure. Each interview lasted 20 minutes in average, and the sessions were video recorded for later analysis.

The second part was conducted as photography workshops. We scheduled five workshops with the participants of the interviews, each consisted of 3 to 7 children. To give a flexible structure to the sessions, we instructed children to experiment with at least four types of photography, namely portrait, texture, nature and architecture. Each child had a chance to use all three cameras for at least 15 minutes, taking pictures at both indoors and outdoors locations of the faculty. Since we wanted to capture both product and social interactions of children, we designed 'magic hats' with action cameras attached on them to record the sessions through children's perspective (Figure 2).

We explained children that these hats will record everything they see, and asked them to keep them on until the photography session ended. Due to technical issues and limited number of equipment, we could record the camera use of 20 participants. Each recorded photography session lasted approximately 45 minutes.

Figure 2 The use of 'magic hats' in observations (left) and how it records the session

We transcribed interview recordings in a spreadsheet and applied content analysis (Krippendorff, 2004) by coding the constructs children mentioned based on product attributes (e.g. black & white > realistic). Then, we thematically categorised these constructs to define the dimensions as perceived by children. For the photography sessions, we coded the videos by noting and describing both individual interactions with the camera, and the moments when the camera initiates social interaction (e.g. exploration of the menu, laughter, sharing).

5 Patterns of diversity in children's photography

Our inquiry unravelled many dimensions related to children's perception and use of cameras. Although several usability issues have also been identified, we will not focus on them for the following reasons: (1) the interviews reflect user concerns based on perceived product attributes, but do not give insights regarding the actual use, (2) observations provided information on usability issues, but they are mostly raised by lack of experience, and seem to be common to our sample rather than being sources of diversity, (3) and we want to highlight the inspirational information to inform the design of diverse product concepts, rather than usability improvement. Therefore, we will present the differences in attitudes regarding expressive qualities of the products, interaction with cameras, and approach to photography.

5.1 Product language

Based on the judgements of the participants, we identified an axis defining the extent the product language meets their expectations from what a camera should look like. The axis extends from *camera-like* to *toy-like*. Note that both ends are positive and negative at the same time; meaning children show affinity towards one end in comparison to the other. This binary is supported by their judgements on product expression, aesthetic appeal, and age appropriateness (Figure 3).

Product expression is described by the associative judgements, comparative to the 'world of cameras'. The borders of this world can be extended towards other product lines that are found relevant by children, such as tablet computers and game controllers. In this sense, product expression is closely related to past experience, as it provides an associative framework for children to assess the product language based on similarities with and differences from their existing mental categories. The more the product is perceived to be realistic, high-tech and contemporary, the more it resembles a camera. On the other hand, the features that are judged to be imaginary, comical and salient makes the product rather toy-like, a quality also favoured by a number of children. *Aesthetic appeal* refers to what children find visually pleasant and appealing. Its major difference from

product expression lies behind its connection to 'taste'. Some children prefer monochrome colour and simplistic form for the sake of modesty, whereas others favour colour and flamboyance, which makes the product's presence felt.

Figure 3 Summary of the constructs related to product language

Product expression and aesthetic appeal indirectly point out to another distinction regarding for whom the product is supposedly suitable. We name this dimension *age appropriateness*, following the genuine assessments of children for products to be "suitable for kids", "for adults", and "for babies". Such judgements imply that children identify a certain self-image through associations with product language. Therefore, it is not only about how they perceive themselves, but also how they want to be perceived by the others. These implications reflect the constructions of designers about 'child-friendliness', which is evident in their conscious effort paid to the expressive qualities of the products. The reaction of children implies that the message is received, however not always embraced. Child-friendliness in designer terms might be interpreted by some children as "childish" or "for babies", as much as it can be interpreted as "fun" or "cheerful".

5.2 Product interaction and approach to photography

Analysis of the observation material revealed insights into both personal and social aspects of the use context. We observed two main aspects of diversity: children's approach to photography, and their interactions with cameras. Approach to photography lies in a continuum from *professionalism* to *playfulness*, whereas the latter describes the level of tinkering with what the camera has to offer. We investigate these aspects in relation to the following dimensions emerged from our analysis: exploration of the camera (or, lack of it), quality of the photography, laughter, and sharing (Figure 4).

Exploration refers to the interactions with the camera interface, and it is a trait observed in both professional and playful approach. In *professional exploration*, the child tries to find out the ways to improve the quality of the photography. We observed children seeking out functions such as zoom in/out, flash, preview and delete. Zoom and flash is used to improve *photo quality* when experimenting with capturing different photographs of the subject. Another effort to enhance the quality of the photography is trying out different angles and framings when working with a subject. We also observed some children wanting to see the resulting pictures, and delete the ones they don't like. However, such sensitiveness was not common to all participants. Some children completed the whole session simply pushing the shutter button, with no apparent enthusiasm to explore the functions offered by the camera. Lack of exploration can be a result of lack of interest, as much as it can be due to lack of knowledge, fear for doing something wrong, and not feeling comfortable to ask for help.

Figure 4 Summary of themes based on observation analysis

We use the term *playful exploration* to describe the behaviour of fiddling with the camera functions with playful motives. Giggling while over-zooming to the subject or previewing the picture of a friend making a silly face, and getting joy from discovering the funny filters are examples of playful interactions with and through the camera. *Laughter* is when such playful interaction becomes more observable. We identified several moments when product interactions led to laughs and chuckles, both in individual and social settings. In the most extreme cases, the camera only serves as a tool to initiate play, such as a chasing game. Such moments are when interaction with the product decreases to a minimum level, and some children end up taking just a few pictures by the end of the session.

Sharing is another dimension observed in both professional and playful approach. It is an indispensable part of photography, which makes it a social experience. Children were observed to show the pictures they took to their peers or us after paying evident effort to capture the desired frame. This is to either get approval, or because they take pride in taking a good photograph. The ones that have a more playful approach tend to capture “silly” or bizarre pictures such as a close-up photograph of a friend or spinning pictures while twirling the camera. If they think the resulting pictures are funny, they want to show them to their friends, which usually results in laughter. Although different approaches to photography have both unique and common dimensions, the manner and the motives lie behind them can be different.

6 Design implications

In order to communicate the differences of preferences and behaviours among our participants, we translated them into personas-like representations. Persona is introduced by Cooper (1999) in interaction design field as a way of communicating the goals and concerns of a user in a hypothetical but concrete way. Antle (2008) proposed child-based personas framework to generate realistic abstractions of child-users. In her framework, Antle suggests childhood needs, developmental abilities and experiential goals as sources of constructing child-user personas. Although more common in designing for adults, the use of child-based personas have also been reported (Moser, Fuchsberger, & Tscheligi, 2011; Wärnestål, Svedberg, & Nygren, 2014). We propose personas as an effective and empathetic source of inspiration for designers to communicate the diversity of interests and interaction styles of children. Our user representations are brief, concrete summaries to demonstrate the product-related concerns and behaviours of the participants, rather than detailed personas. When constructing the persona characters, we utilised the differences in children’s approach to photography (professional vs. playful) and the level of interaction with the cameras (explorative vs. focused). Crossing of these aspects allowed us to define four different

personas, and we also embedded the perception of product language (camera-like vs. toy-like) into this model corresponding with them (Figure 5). We also compared the parent questionnaire responses to the behaviours of children observed in photography sessions for additional interpretations.

Expressive qualities of the product form can communicate the approach to photography. Making use of the camera-like vs. toy-like binary through explorations on product language can emphasize the self-image preferred by children. The more the product resembles a "real" camera, the more professional it will be perceived. A professional look will communicate that the user/owner of this camera should be taken seriously, like grown-ups. Possible strategies to achieve a professional look is to avoid the use of bright colours, and salient forms which are unexpected for a camera. Visual features following contemporary consumer electronics would also contribute to the serious look some children seek for. On the other hand, as the product drifts away from the culturally shared signs of what a camera should look like, it will be easier to integrate playful connotations into the product language. A playful look would perhaps contribute to the self-image, such as accentuating fun or feeling special by owning and using a product designed specifically for themselves (and *not* for adults). Children who prefer a toy-like product language are more ready to embrace eccentric and comical forms, and the use of radiant colours, which we usually don't expect in a grown-up camera.

Figure 5 Personas constructed based on the findings of the study

The Adventurer is ready to explore the technical potential of the camera to test what they can do to improve the quality of their photography. Perhaps they laid their hands on a camera before, or they had a chance to observe others using one. This previous experience will encourage them to push their boundaries, and increase their expectations from the technical capabilities of a camera. When

designing for The Adventurer, attention must be paid to accessibility of the basic functions related to photo quality.

The Earnest is best characterised by their meticulousness in capturing a good photograph. They have little interaction with their social environment, take their time to decide on the framing, and repeat if they are not happy with the result. Despite their sensitiveness to the quality of the photography, they don't explore the camera functions to see how they can improve it. This may be due to their lack of knowledge or interest; in both cases, they can benefit from simplistic interfaces to encourage them to make the most of the camera functions without the fear of getting lost in the menu.

For *The Gamer*, camera and photography is a medium for play. Their motivation for exploring the camera is mostly playful, with little attention to quality of the photography. They take delight in browsing the menu without photography-related purposes, and display joy by giggling when something unexpected pops up on the screen. Although it doesn't mean that they don't have any interest in taking pictures, they would welcome any opportunity to spice up the photography with a little humour. True to their name, The Gamer enjoys video games in free time, hence they are familiar with game-related interfaces.

The Player has little interest in the camera or taking pictures. They enjoy the playful social interaction with peers, in which the camera or photography has a minor role. The sociality of the experience is so central for them that they can end up with taking no pictures at all, unless it has significant value in play. They would appreciate products which could initiate and reinforce playful social interaction, and would embrace playful camera applications which give room to humour and laughter they can share with their friends.

We constructed the personas to inspire diverse design concepts. Although we utilised our findings and observations from the field study by adopting a data-driven approach, we do not propose that each child would strictly fit into one of these personas. For example, even though one dominantly shows the character of The Adventurer, they may act like The Player for a brief moment of social interaction. Hence, different personas may not only lead to different design concepts, but also different modes and applications of the same camera. In this sense, the personas represent both the diversity of interests among the sample, and differing interests of the same user.

7 Conclusions

The focus of our paper was to examine the potential of a methodological approach, which puts forefront eliciting and communicating the differences in perceptions and behaviours of child-users, to enrich the possibilities in early design ideation. For this purpose, we presented an overview of the child-centred design practices, discussed the benefits of an experiential perspective to our methodological inquiry and how it relates to plural constructions of child-users, and presented our study to demonstrate how such a perspective can contribute to challenge our vested understandings about children and their product experiences.

We are aware that our study poses certain limitations. For example, our choice of cameras undoubtedly effected children's interpretations of the product language. Different set of cameras could have yielded different set of constructs, yet the range of products should be decided based on research questions unique to specific studies. Additionally, even though we wanted to simulate a natural use context, it is still a controlled environment, therefore is not representative of a real-life experience. Also, the duration of the observations allowed us to see the issues raised in short-term user-product encounter, but more comprehensive insights can be gathered in a longitudinal study that examines long-term usage.

We discussed design implications through persona-like characterisations to represent differing needs and expectations of children. We only focused on the issues demonstrating diversity among our sample, and tried to remain faithful to the findings of our study by avoiding any fictional information. Therefore, our characterisations are far from complete, detailed personas. However,

we believe it is an efficient way to illustrate how designers can benefit from a methodological approach that seeks for plurality of experience in order to expand early design ideation phase with user information, hence lead to diverse design concepts. In the future, we would like to assess this approach in terms of its usefulness in generation of multiple concepts in the actual design activities.

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Smart Citizenship: designing the interaction between citizens and smart cities

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Based on the study of recent research regarding the development of smart cities, this paper develops a critical reflection about the reasons why not every citizen in a smart city can be considered a smart citizen. We point out some of the primary causes and the role of design to help to develop possible solutions. The paper uses the concept of the network society and actor network theory in order to understand the infrastructure of smart cities and develop an analysis of the changing role of citizens into smart citizens. We propose that there is a need for new methods to generate sustainable and inclusive social engagement to solve collective urban problems. Moreover, it is speculated that smart citizenship will be an important part of the future of smart cities. In this context, design plays an important part, framing the way actors understand and interact with each other in the city ecosystem, and enabling citizens to shape the future of their cities.

smart cities; smart citizenship; open design; metadesign

1 Introduction

New forms of social organization, sometimes involving the use of technology, can reframe the interaction between government, citizens and business to be more collaborative. Smart cities may be one of the new forms of technology that can support this kind of change.

A smart city uses technology to improve the urban infrastructure in order to develop a more efficient and collaborative city. The concept of the smart city emerged during the last decade as a fusion of ideas about how information and communications technologies might improve the functioning of cities, enhancing their efficiency, improving their competitiveness, and providing new ways in which problems of poverty, social deprivation, and poor environment might be addressed (Harrison et al., 2010). From this perspective, efficiency can improve quality of life. This concept is related to one of the characteristics of the organization of the network society, which is the decentralization of operations and control, in which the effectiveness of networks is increased (Castells, 2000). Therefore, the role of citizen may need to change to the role of smart citizen.

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If cities are the key element for a more sustainable and efficient future, citizens are the key element in cities. However, some studies and projects related to smart cities subjugate the role and the importance that citizens can possibly develop, concentrating their efforts instead on the role of technology. Hollands (2008) affirms that IT working alone cannot improve urban environments. For this reason, social elements, like human capital, should develop a more active role, or even become the starting point of this process, creating (smart) civic inclusiveness.

The creation of new kinds of social organization and civic inclusiveness has been challenging more diffused design approaches, like design thinking and human centered design. Local communities are finding new ways to use existing online social networking systems to create offline local communities. Open source, P2P and new digital fabrication technologies enable new forms of relationship between users, designers and artifacts. Under these conditions, design can be characterized as the mediator in the process of co-creation, supporting the ecosystem in which the process of social value creation happens. Design activity becomes open and critical, supporting open spaces and practices, in which it is necessary to take an open (meta) design approach.

In order to develop the concept of the smart city, it is necessary to understand the differences and conflicting perspectives, principles and objectives of the various city's stakeholders (government, citizens, and companies). However, a better comprehension of the citizens' role is essential to unfold the infrastructure of urban environment' networks, which must include the articulation of interactions between human and non-human actors. Using this approach, the future of smart cities will be more sustainable in terms of both participation and engagement.

In addition to helping people better understand, develop, and mediate the interactions between human and non-human actors, design can also develop an important role in shaping the space where these interactions can happen. Moreover, by framing the interaction and space, design construed as open (meta) design, has the potential to help the movement towards smart citizenship.

With the purpose of explaining the main causes of why not every citizen in a smart city is a smart citizen, this paper will briefly explain the concepts of smart city and smart citizen, emphasizing their key elements and particular attributes. Based on these foundations concepts, it will be provided a discussion will be provided about the problematic around citizens' engagement, since it is difficult to sustain long term relationship in participatory actions. In the same sense, the paper discuss what is open (meta) design, and how the actor network theory analysis and the decentralization of human in design process is a way to understand the smart city ecosystem and improve it towards a more sustainable, open and inclusive urban infrastructure. Finally, the paper discuss what could be a transitory model from citizenship to smart citizenship, in which design can enable citizens to shape the future of their cities, transforming the relationship between people and other elements that are part of the urban ecosystem.

2 Smart Cities

The use of technology, especially the internet of things, big data, and information and communication technologies (ICT), in order to improve urban life, can be one way to characterize a smart city. As with the non-stop growth in technology use, the number of projects related to smart cities is growing exponentially around the world. For example, the Government of India (2016) has a project to build 100 smart cities and rejuvenate 500 more. Despite the number of new smart cities initiatives and researchers devoted to the concept, the definition of what constitutes a smart city can diverge in relation to several aspects, including the level of development, resources, engagement of citizens and willingness to change (Albino, Berardi & Dangelico, 2015).

Singapore is considered one of the most successful example of smart cities. The island has a huge number of sensors and cameras, which do not only control the traffic, but also the cleanliness. However, Singapore goes beyond the wireless connectivity and sensors, and has an open data platform related to data collected by sensors located on the island for sharing all the information

that is collected. Furthermore, almost all of Singapore's government services are available and accessible online and citizen-centric mobile health, municipal and transport apps were recently rolled out. Therefore, Singapore is one of the unique cases in which the city provides residents with behavioural feedback that helps them to reduce their energy and water consumption and drive down costs. In addition, the government analyses the data generated by these sensors to improve the design, planning and maintenance of these and future public housing estates.

Most studies and self-nominated smart cities argue that the use of technology enables real-time analysis of the urban environment, new forms of governance, and provides material (data) for envisioning a more efficient, sustainable, competitive, productive, open and transparent city. The use of technology should support learning processes, knowledge exchange, technological development and the rise and application of innovation to improve the urban space and facilitate people's lives (Komninos et al., 2013; Woods, 2013). Thus, a smart city can be related to the use of information technology to assist the building process of transforming a city into a sustainable and inclusive territory, based on citizens' needs and creativity.

It is clear that the concept of a smart city is far beyond the application of technologies to improve urban environments. Cities can only be smart if there are intelligence functions that are able to integrate and synthesize data to some purpose, such as ways of improving the efficiency, equity, sustainability and quality of life in cities. In other words, the provision of intelligence functions is what will make this possible in the most effective and equitable ways. Some of the self-nominated smart cities and researchers have faced criticism for being too concerned with hardware rather than with people (Saunders & Baeck, 2015). To overestimate technology's importance is to forget that a smart city is an intrinsic and well-connected network environment, that relies upon the interaction of its many elements to achieve sustainable development.

Like the concept of the term smart city, its key elements and a possible methodology to study and research it has different and, sometimes, divergent approaches and definitions. Even though the technology is an enabler for the development of smart cities, it is not necessarily the most critical factor in defining a smart city (Paquet, 2001). Concerning the key elements of a smart city, Albino, Berardi, & Dangelico (2015) claim that "people" are the missing component. Although, it is people who shape the cities through continuous interactions while making the most of the growing potential of collaborative technologies (technologies that enable greater collaboration among urban communities, citizens, government, and companies) (Albino, Berardi & Dangelico, 2015), little has been said about smart citizens.

The fact that someone lives in a smart city does not mean that she/he is a smart citizen. A smart citizenship can be identified when people become active stakeholders, engaged in long term relationships in the process of planning, developing, testing, implementing and evaluating urban decisions, actions and policies. The "smartness" is not only related to the use of technology: it is the participation, engagement and how it changes the citizen's attitudes concerning the urban environment. Moreover, becoming a smart citizen is not just about being a data provider, but it is to use data and translate it into actions to improve the urban ecosystem. Thus, the connectivity, which is exponentiated in the urban network infrastructure, can enable small (bottom-up) initiatives to have an enormous impact on the ecosystem.

3 Smart Citizens

The technology in smart cities is not always synonymous with equitable access or democratization. Many cities have auto-nominated themselves as smart cities for self-promotional purposes. Moreover, government, when joined to private companies, has been shaping and controlling the use of technology and the data produced through its use. Further, some of the largest and most commercial business in hardware, software and infrastructure sectors, such as IBM, General Electric, Cisco Systems, Hitachi, and Siemens have been developing projects related to smart cities. In addition to the development of new technologies to improve the urban space, these companies also

have research departments specialized in studying the different aspects and key elements of a smart city (Sadoway & Shekhar, 2014). As a result, the majority of the concerns and actions implemented are related to the interests of big and controlling corporations.

That new form of control leads to top-down initiatives and can produce a social domination and exclusion. Thus, there is a problematic in the definition and employment of smart cities, in which the modes of urban governance have clearly been "(…) shaped and steered by large and influential commercial players in hardware, software and infrastructure sectors" (Hollands, 2008, p. 314). Moreover, the misuse of the smart city label, only for commercial purposes, can enhance this discriminatory process. Commercially-driven "Smart Cities" can be too much focused on providing returns to shareholders, neglecting previous findings that these ephemeral solutions, based on the technology use, are "wicked-problems" (Sadoway & Shekkar, 2014). However, the smart city environment and the proper use of technology can transform the industrial capital domination into a new form of organization focused on knowledge (Hollands, 2008). A smart city organization based on knowledge can result in a more participatory and inclusive environment.

Since people play a fundamental role in the development and the success of smart cities, they should have a more leading and participative role in all smart cities actions. Although top-down initiatives led by governments and big tech companies may aim to improve citizens' lives, bottom-up actions and technology democratization should be a common practice as a way to engage citizens and enable them to become smart citizens. Bottom-up initiatives, together with open and participatory approaches, can create the sense of community necessary not only to engage citizens, but also to provide the necessary tools to empower them. Kitchin (2014) affirms that technology can be used in cities to empower citizens by adapting those technologies to their needs rather than adapting their lives to technological exigencies.

Although this form of participation called "empowered participatory governance" (Abers et al., 2003) shifts the role of the citizen from a passive actor into an engaged citizen involved in the public domain (Schaffers et al., 2012), there is always unintended consequences in which some citizens will be included, while others will be excluded (Turnhout et al., 2010). Moreover, citizens' motivation to engage can be different, while some of them can have a natural motivation to participate in shaping their environment through a sense of place (Horelli, 2013), others can be less interested in this kind of participation.

In this context exists a gap that could be filled by open design practices. Design has been researching and practicing open and participatory approaches, and using open technology in order to engage different stakeholders to solve, or to try to create, possible solutions to social problems. Forlano (2016) explains that design could fill this gap, mediating top-down plans and interests in order to meet bottom-up actions and needs. Design, when working strategically and using open and participatory practices, is more about problem setting than problem-solving. In other words, it means that design deals with the complexity of the inter-relationships that happens in the ecosystem in which it is involved. Given this capacity, design can strengthen the smart cities ecosystem where it is currently weakest, concerning its elements and interactions, and especially the role of citizens.

Furthermore, it is important to point out that the majority of the studies about smart cities usually do not talk about maker spaces. The maker culture, even outside the context of smart cities, has been changing the role of citizens in the urban spaces, providing workspaces and tools to empower them. In the maker spaces, citizens can create their own things, decentralizing the traditional manufacturing system. Fab Labs and maker spaces offer access to low-cost digital fabrication equipment, and they are becoming increasingly common in the post-industrial cityscape (Van Abel et al., 2011). In summary, technologies, practices and communities of makers have been evolving rapidly in the last few years. Design is highly connected to this evolution, creating and developing methods and platforms for collaboration and sharing.

Advocates of do-it-yourself (DIY) approaches, hackathons and fablabs – in other words the maker movement, have argued that without the building blocks of open ICT infrastructures and platforms for smart citizens (Townsend, 2013; Diez, 2014) including open access, open source software and net neutrality (decentralization), the construction of the smart city and its social economy will be highly unlikely (Sadoway, 2012). In this regard, it is possible to argue that open and decentralized practices, like open design, can help in developing not only smart cities, but also smart citizens. Moreover, design can shape the rise of smart citizens avoiding more exclusion due to the differences on the access of technology.

4 Unfolding the infrastructure of smart cities: ANT and decentralization of the human in design

Sensors, hubs, cameras, location-based services, transports, sewers, water, electricity, heat, communications systems, roads, buildings, museums, parks, restaurants, shops, billboards, lights, skyscrapers, bridges, cell towers and people: these are some of the examples of the elements that compose the network infrastructure of a smart city. The functionality of an ecosystem is highly dependent on the connection and integration of all these multiple systems. In fact, no system, as part of a bigger ecosystem, can work in isolation (Albino, Berard & Dangelico, 2015). In other words, the effectiveness of a smart city network can be measured in terms of how well connected are the different elements.

Regarding the network of a smart city, the authors Allwinkle and Cruickshank (2011) claim that smartness is a way to be sufficiently innovative to connect “villagers” to “neighbors” based on creative partnerships in natural communities, facilitating the generation of collective knowledge. Moreover, the infrastructure of these networks can become a platform for innovation and creativity, in which the different aspects of the urban environment – social, environmental, economic, and cultural are developed through enabling technologies (Allwinkle & Cruickshank, 2011). Therefore, the networked form of organization is an opportune and qualified environment for smart cities and for the emergence of smart citizens.

The study of smart cities’ infrastructure is essential, since successful smart cities should combine the best aspects of technology and infrastructure to find new models of participatory operation. To illustrate, Forlano (2016) and others have discussed Latour’s work on actor network theory, which describes how society is constructed by the collective organization of human and non-humans, in which agency can be delegated, especially from a human to a non-human, as well shared among multiple entities. Actor network theory seems to be relevant to better understand urban networks because it changes the way the materiality of the objects is analysed. Moreover, it is not only citizens who shape technology; instead, technology can shape citizens and the multiple interactions that happen in their network (Niederer & Priester, 2016).

Regarding the fact that technology and objects have the power to affect other elements of the network; it is possible to say that non-humans also have agency. In this perspective agency is anything that modifies a state of affairs. Moreover, agency is not provided by humans because they cannot control the non-humans, and the non-humans have their own agency. Thus, agency arises from the relationships, the interactions and how things are brought together, and this is how a social organization network is created.

Social can be a way to describe a connection between things. In Latour’s perspective (2005), the social comprised of collectives, it is not only just about people but is also about things that are brought together and build a relationship with one another. Thus, it is possible to say that the social is constructed. Therefore, some design researchers have been arguing for the decentralization of the human – in other words, a non-anthropocentric approach (DiSalvo & Lukens, 2012; Forlano, 2016). The human is one element among others in a vast ecosystem, and non-human elements also develop an important role. In this large system of interactions, all elements have legitimacy, based on the plurality of the system (DiSalvo & Lukens, 2012). This approach seems to be effective when

the study of the interactions is more relevant than the simple knowledge about the different elements in isolation.
Human centered design (HCD) is one of the most diffused design approaches, widely applied and commoditized. Many areas use the HCD approach as a way to solve problems, understanding what humans want and need. Although some fields have had success applying HCD, it has limitations when disruptive and sustainable solutions are expected, or when the complexity of the ecosystem in which the project takes place is a prime consideration. Thus, HCD practices can be accused of complicity in increasing the number of disposable solutions, and the scenario in which the problems that we are solving today will return as problems to be solved again in the future. The decentralization of the human in design is a way to break the dichotomy between human versus technology. Moreover, it can be a way to break the assumption that "(…) possibilities for framing and solving problems are bounded only to human imagination and capabilities" (Giaccardi et al., 2016, p.377).
Smart citizens should be aware that the social is constructed based on the relationship of different network's entities. Smart cities – together with Design – should consider working on the development of possible entities' articulations, to enable new forms of relationships for the social improvement.
Design has been operating as a facilitator in many activities and spaces, developing an expertise in navigating among inter and multidisciplinary fields and creating more participatory and inclusive spaces. About these possible articulations, Forlano (2016) points out that designers can be mediators, calling attention to the importance of the non-human stakeholders, empowering them with values, ethics and politics. As mentioned before, this is related to a non-anthropocentric idea, in which all entities have the same power to modify the network.
The use of actor network theory to study smart cities is a way to develop a more holistic view, in which all actions have an effect, and these effects are exponentiated due to the network infrastructure. Thus, to visualize and to make tangible the connections that exist in a network, the different actors' interactions and the possible future interactions, can be a possibility for having both smart cities and smart citizens working together to have an open system to allow smart citizenship. All this should lead to transforming the urban environment as a platform, in which municipalities, citizens, and business could act and interact with each other. These platforms should be open spaces in which the knowledge exchange is a fundamental piece. The relevant knowledge is not only personal, but it is also related to data produced by the people, and it must be used for the people. This platform is neither about top-down initiatives nor bottom-up ones; it is a circular and systemic approach in which all the elements are intrinsically connected. Ideally, in this ecosystem all data should be open, and the use of technology should enable all stakeholders to understand and use open data.
The openness demands a decentralized approach, in which it is possible to integrate different stakeholders, including the human and non-human. It also enables design to shift the focus from one user to a local community – which can also be online, and from isolated "solving specific user problems" projects to design whole complex systems. From the moment that design starts to take into consideration all entities, and the complexity of different interactions and their connectivity in the ecosystem with which it is involved, new forms of design practices arise – like open design. Although open design is not a new practice, it changes some of the current paradigms of design practice, like authorship, the use of human-centered design and the idea that every design project should end with a commodified outcome, such as a product or a service. However, one of the most important changes required is to the role of the designer.

5 Open (Meta) Design

The development of open design is connected to the rise of computers and the internet, just as in other fields influenced by the open movement, such as open source software, open science, and

open technology (De Mul, 2011). The introduction of digital technologies has enabled new forms of organization and distribution of resources, or it has modified obsolete forms (Goetz, 2003). Therefore, new spaces and conditions for practice are developed regarding the openness of projects, participatory practices, the sharing of knowledge and information, and collaborative interactions.

Open design is more than just a new way to create products, or a new design method. As a process, and as a culture, open design also changes relationships among the people who make, use and look after things (Van Abel, 2011). Since open design breaks the boundaries between different entities, it is possible for non-designers to become "designers", allowing end users to share projects and access to digital fabrication technologies to manufacture the products they want locally (Menichinelli, 2016; Stappers, Visser, Kistemaker, 2011). Therefore, open design supports the development of new forms of value, expanding existing relationships, power and responsibilities between suppliers, consumers, and competitors in a given ecosystem.

From this perspective, the designer has to become a metadesigner, shaping environments in which unskilled users can design their own objects. The metadesigner resembles the scientist who no longer creates a linear argument, but instead develops a model or simulation that enables the user to explore and analyse a particular domain of reality, or a successful game designer who designs a game space that facilitates meaningful and enjoyable play (De Mul, 2011).

Meta-design is a broader concept with several meanings and no single definition; here we refer to Giaccardi's (2003) overview of the topic. Meta-design is not an established design approach and practice, but rather an emerging design culture (especially related to interaction design) that intersects with net art. The interest on the meta-level shifts the focus from objects to process, from contents to structures, from design as planning to design as seeding or emergence.

Regarding the idea of thinking and/or reflecting critically about the discipline, meta-design can be considered critical and reflexive thinking about the boundaries and scope of design, aimed at coping with the complexity of natural human interaction made tangible by technology, with the goal of transforming this complexity into an opportunity for new forms of creativity and sociability (Giaccardi, 2005). Similar to open design projects, meta-design does not require a final and tangible product or service as an outcome. Thus, meta-design is able to develop a free space for creativity and reflection. Moreover, in those meta spaces, designers can move away from the simple goal of developing a product or a service and be more critical about their activity and their creations.

6 The development of Smart Citizenship

According to the Merriam-Webster dictionary, citizenship can be described as "the status of being a citizen or the quality of an individual's response to membership in a community". Therefore, citizens should want (but also to have the empowerment necessary) to develop an active part of the discussion for local, national, and even international issues. Based on that definition of citizenship, governance should be about the people, their lives and values and constant evolution. Moreover, all the entities of the networks that constitute the urban ecosystem, should be transparent, participative, and open.

A smart citizenship should consider the use of technology to enhance the power of communication and to create a more participatory ecosystem. A Smart Citizenship framework situates citizens, civic organizations, and open and participatory processes as drivers or steering devices for ICT-linked applications and praxis (Sadoway & Shekhar, 2014). Moreover, in the smart citizenship process, the use of technology and ICT should be used to facilitate, complement and support civic engagement, instead of drive or be a conditional factor for it (Sadoway & Shekhar, 2014).

Smart citizenship should also not be dependent on companies and government if the tools are available, like open technology and a smart cities environment. All the entities of the urban ecosystem must be able to keep track of policies, decisions, and their results. In other words, smart citizenship is the feasible use of innovation to minimize, or even extinguish, the divergence between

citizens' inputs and political output, which is called as democratic deficit (Sevinc, 2016). Thus, this approach can be considerate a disruptive way to exercise citizenship.
Several initiatives have been developed around the world. Although they are not characterized as smart citizenship projects, the development of smart citizenship is one of their primary goals. Thus, in order to develop a "civic-cyber space", it is necessary to have the engagement and involvement of different social stakeholders (e.g. civic hacktivists, local associations and community groups), which goes beyond the participation of scientists, engineers, and coders (Sadoway, 2012). Moreover, it is also necessary to adapt and develop new forms of interaction, new platforms and infrastructure that could support this emerging phenomenon.
One example is the Fab City Global Initiative, which aims to empower citizens to be the designers and the owners of their own destiny. The expected result is an increase in citizens' resilience, and the establishment of a more ecological system, as consequence of the reduction in materials and energy consumption. The idea of the Fab City aims to transform the way people live and interact in urban spaces, using fab labs and other maker spaces as a global infrastructure for knowledge sourcing. This concept was created by the MIT Center for Bits and Atoms, the Institute for Advanced Architecture of Catalonia and the Fab Foundation (Fab City Global Initiative, 2017). In this context, a smart citizenship is practiced through an open decision-making process, collaborative learning, and knowledge exchange that happens in a Fab City. Furthermore, smart citizens are not invited to engage or participate; rather, it is the openness of the environment that empowers them to act. Nowadays, the Fab City Global Initiative movement counts the following members: Barcelona, Boston, Somerville, Cambridge, Ekurhuleni, Kerala, Georgia, Shenzhen, Amsterdam, Toulouse, Occitane Region, Paris, Buthan, Sacramento, Santiago de Chile, Detroit, Brest and Curitiba. To become aware of the size of this initiative, 15 more cities will join in the next two years, and a further 25 during the years of execution of the project, with a total of at least 56 members by 2021.
A smart citizenship proposal is related to a systemic approach, not just bottom-up initiatives. Thus, it is a circular flow in which transparent and open participatory practices are able to arise. Smart Citizenship is to turn in action the ideas of urban ecosystems' entities in order to improve the system. Since all data in this ecosystem must be open, the use of technology should allow and enable the stakeholders to use open data in a feasible way.
Therefore, it is possible to speculate that smart cities of the future are related to development of smart citizenship, and in that sense they can be compared to living laboratories for innovation (Veeckman & Van Der Graaf, 2015) using open (meta) design practices. Although these laboratories enable the development and improvement of technologies that take into account equity, fairness and improve quality, their goals are only achievable through open participation, enabling the creation of shared knowledge for democratic city governance.

7 Final Considerations

The development of smart cities and smart citizens is not mutual and dependent. The concept of smart cities is not well defined because it is surrounded by different definitions and approaches, based on the stakeholders' goals and interests. However, it is the complexity and multiplicity of the different entities interaction that constitutes the smart city ecosystem. In this sense, the smart city movement is less about technology and more about improving interactions of the different entities. Although, the smart city movement working together with Design, can be able to increase citizens' engagement and help the technology democratization, there is still space for working on how to develop new models for the implementation of new ideas, and how to reframe (complex) problems in new ways of socio and economic organizations.

The use of Latour's ANT as a theoretical lens to analyse the smart city ecosystem, combined with the open (meta) design approach, can provide a framework towards the transition from smart cities to smart citizenship. Although technology has its own agency, the author claims that technology (i.e. non-humans) contains ideas and attributes from the humans who made them. Therefore, it is

necessary to accept that technology (as a non-human actor) can affect us in order to have a better and complete understanding of society's functions (Latour, 2005).

Smart Citizenship should not simply represent a new form of urban engagement based on technology use. It is about the urban environment stakeholders' empowerment and sustainable engagement in long-term relationships. To achieve this goal, strategies for meeting the complexity of the different actors' needs should be developed, and this is the gap for action on which design should concentrate its effort.

Further research is necessary to better understand the infrastructure of smart cities in practice, and to develop ways to measure decentralization as well as the engagement of different actors and stakeholders. A better understanding of decentralization, its implications and implementation, has potential to become a new turn in design practice. Moreover, a framework for the open (meta) design approach should be developed and implemented.

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Responding to Diversity Including Disability

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This paper constructs a framework for understanding how notions of disability influence the discourse on accessibility and Universal Design as well as the present understanding of the user role in Denmark. Implications are that the understanding of disability and design of architecture are not mutually opposed to one another. Instead they are closely interwoven in the fabric of designing for diversity. Through the perspectives of the UN Convention on the Rights of Persons with Disabilities, Disabled People's Organisations Denmark and the practicing Architects, the paper discusses three notions of disability. Initial findings of the PhD research project "Generating Inclusive Built Environments through User Driven Dialogue in the Architectural Design Process" along with qualitative research conducted at the Danish Building Research Institute frame former and current thinking, and discusses the scope of reviewing impairment as a condition of human variety in the architectural design process.

universal design, architecture, values, design process

1 Introduction

As modern Design Thinking welcomes design strategies that actively involve and cooperate with the user, attention to diversity of the users is growing. To some extent Design Thinking has developed into creating for people, with people. Hence a nuanced understanding of human diversity is desirable. In the Nordic Region, Co-design and User-Centered Design has become well known frames of processes to generate a wider understanding of user groups and bridge the gap between the designer and the individual user. User involvement is also used as a socio-political means to support inclusive strategies in Society, in order to embrace a broad-based community [Bayazit, 2004, Cross, 1972].

In a Danish context, the development of strategies involving users and growth of attention to diversity, also relates somewhat to processes of Inclusive Built Environment and accessible design solutions. In design practice, this has articulated new roles for Designers and Architects, in order to reconsider and transform design processes and create new platforms for social inclusion.

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The Disabled People's Organisations Denmark (DPOD) has become one of the core actors in participatory processes of accessible design solutions and Inclusive Built Environments. DPOD defines their commitment to engage in efforts that serve to encourage and protect the rights of persons with disabilities.

The reason for these organisations' active participation in design processes partly grows from an absence of interest or engagement in the professional practicing Architects. Moreover, DPOD see accessibility as a means to realise a higher level of equality for their diverse group of members; people with impairments [http://www.handicap.dk/politik/].

As design and the role of creating in the Architectural process have been taking on new forms to meet participatory design strategies and involving new participants, this particular collaborative relationship also has addressed a need for a clarification of diversity and a possible mutual understanding of Disability, as a condition of human variety [Lid, 2012].

Drawing upon studies from the PhD research project "Generating Inclusive Built Environments through User Driven Dialogue in the Architectural Design Process" and research conducted at the Danish Building Research Institute, implications are that notions of Disability, understanding of people with impairments and design of architecture are closely interwoven in the process of designing for diversity and especially for the degree of accessibility in the completed building projects.

In this paper we will construct a framework for understanding how dissimilar notions of Disability not only influence the discourse on accessibility and Universal Design (UD) we will also hypothesise how it can interrupt dialogue and hinder collaborative relationships between the user group and the Architect. The paper presents three models of disability, the Medical Model, the Social Model and Bio-Psycho-Social Model and discusses their implications in the field of architecture in Denmark from three perspectives: the UN Convention on the Rights of Persons with Disabilities, Disabled People's Organisations Denmark (DPOD) and the practicing Architects. These three actors cover the Danish discourse on accessibility and Universal Design in three levels as macro, meso and micro levels.

In the paper we present initial findings of the PhD research covering results of participating observations in DPOD and qualitative interviews with DPOD representatives and professionals from the architectural field, compare their understandings of Disability and assess the influence of their dissimilarities when collaborating in the context of Universal Design.

When we use the term Universal Design (UD), it refers to a broad spectrum of methods meant to produce buildings, products and environments that are inherently accessible to all users regardless abilities, hence also children, older people, people without impairments, and people with impairments [Imrie, 2012].

Furthermore we regard UD as a value based design approach, which is not only represented in the final design, but just as much in the design process and the elements of which the process consists [Ryhl, 2009, Ryhl & Frandsen, 2016].

Through three Models of Disability, this paper frames former and current thinking of Disability and discusses the scope of ways of reviewing impairment and its implications to how the user is perceived in the Architectural Design Process. It is debated a wider understanding of human diversity, as a strategy, can lessen architectural barriers and body-based discrimination besides enhance Inclusive Built Environments and support the self-empowerment of people with impairments [Iwarsson & Stahl 2003].

2 Perspectives and interpretations of Disability

Models of Disability can be seen as means for understanding and defining impairment and, eventually, for providing a foundation upon which Society can formulate strategies for meeting the requirements of people with impairments. These models are often met with doubts and scepticism

as it is suggested they encourage narrow perspectives, are often incomplete and rarely offer detailed directions for action [Bickenbach, et al, 1999].

Nevertheless, they can be seen as useful frames in which to advance an understanding of disability issues as well as of social perspectives and attitudes to Disability. From this, Models of Disability describe the ways in which our Society provides or limits access to social life, work, political or economic influence for people with impairments. From an architectural view, Models of Disability also reveal the ways in which our Society engages to provide or limit access to and participation in the planned and built environment.

Models of Disability offer a comprehension of the notions and predispositions of understandings of Disability and may be used to frame current understandings of Disability. Furthermore the different Models of Disability give us an insight into the movement of changing social approaches to Disability.

We should not see the Models of Disability as sequences of options in opposite positions to one another, or replacing previous understanding. The Models are used in different contexts, sometimes overlapping to gain a broader perspective.

The three different understandings of Disability can be described as:

- Disability is an attribute of the individual
- Disability is related to the environment
- Disability is linked to the individual-environment relationship.

In an overall perspective, Models of Disability are influenced by two significant philosophies. The first view understands people with impairments as dependent upon Society. This view holds potential to lead to discrimination, overprotectiveness and social segregation. The second view understands people with impairments as a part of Society, as users of what Society has to offer. This view holds potential to initiate choice, equal opportunity, empowerment and social integration [Bickenbach, et al, 1999].

As we study three different models in this paper, we will deliberate the degree to which each philosophy has been applied. The three models, the Medical Model of Disability, the Social Model of Disability and the Bio-Psycho-Social Model are noteworthy components as we touch on the different interpretations of Disability together with the understanding of accessibility and Universal Design.

2.1 The Medical Model – a medical understanding of Disability

The Medical Model describes Disability as the result from an individual's physical or mental limitations. This view limits Disability to a condition arising from disease, disorder or injury. A person is considered disabled due to individual and health -related causes. From this view, Disability is not interrelated to social constructions or physical environments. The model is at times referred to as the Functional-Limitation Model which defines the focal point of this understanding [Bickenbach, et al, 1999].

Hence the Medical Model places the source of challenges within the impaired person, and concludes that possible solutions originate from medical attention to cure the individual. This understanding of Disability has been present in health care systems as well as in general public opinion. The Model has been strongly criticised because people with impairments are not necessarily sick and cannot become able-bodied through medical treatment.

Although we should not reject the medical and therapeutic aspects, which may cure or relieve the physical or mental condition of people with impairment, The Medical Model does not offer an accurate understanding from the viewpoint of people with impairments, themselves, or from others in general. Most would reject the thought of being "abnormal" or sick. Likewise, the model applies an approach to problem solving which, although well intentioned, focuses on care, wrongness of body or being-in-the-world and eventually can provide reasoning for institutionalisation, segregation or special solutions. This model is of the dependent-upon-society philosophy.

The Medical Model - a medical understanding of Disability

The Medical Model describes disability as the result from an individual's physical or mental limitations.

Figure 1. The Medical Model

2.1.1 The expert understanding of Disability

The Expert or Professional Model of Disability can be understood as a side-shoot of the Medical Model and is a traditional reaction to Disability issues. Within its frame, professionals and experts follow a process of identifying the impairment and its limitations and taking the necessary action to improve the position of the individual, based on their professional expertise.

Critical voices argue that this understanding of Disability has tended to produce a system in which contains an inequality that limits collaboration, an authoritarian prescribes and acts for a passive client, and while doing so increases the passive perception of the client. This restricts people's opportunities to make choices, control their own lives and develop their potential.

In its extreme, this thinking is argued to undermine dignity of the individual and hinder the ability to participate in everyday decisions, the basic human right of freedom over his or her own life.

2.2 The Social Model – a socio political understanding of Disability

The Social Model arose as a critical reaction to the earlier dominant medical models of Disability which in itself is a functional analysis of the body to be enhanced in order to conform to normative values [Lid I.M. 2010].

Instead, The Social Model holds Disability as consequences of social, attitudinal and environmental barriers which prevent people with impairments from full participation in Society. The model identifies barriers, negative attitudes and exclusion by environments and Society. From this perspective, the physical environment and Society are the primary contributory factors in disabling people with impairments.

Although physical, intellectual, sensory or psychological variety may cause individual functional limitations or impairment; these do not have to initiate Disability, unless societies fail to include people regardless of their individual differences.

The philosophy of The Social Model of Disability can be traced to the Independent Living movement (Ed Roberts) and the broader US civil rights movement in the 1960s, and the specific term emerged in the United Kingdom in the 1980s [Charlton, 2000].

The Social Model is also referred to as the Minority-Group Model of Disability based on a socio political definition of Disability, which has challenged studies and research based on the functional limitations paradigm. From a socio-political viewpoint, this argues that Disability stems from failure of Society to adjust and meet the needs and aspirations of the minority group, people with impairments. Mirroring the Medical Model this viewpoint introduces a radically different

understanding of Disability: If the challenges and solutions lie within Society and the environment, Society and the environment must change. If the built environment cannot be used by persons with impairments it must be redesigned.

The implication of this understanding is that the elimination of attitudinal, social and physical barriers will enhance the lives of people with impairments, offering the same opportunities and choices as others, respected and included as equals. Taken to a simplified conclusion, there would be no Disability within a fully advanced and accessible Society.

The strength of this Model lies in its placing the responsibility and action upon Society and not the individual with impairment. And it recognises impairment as a human condition. It emphasises the requirements of Society by the group of individuals whereas the Medical Model uses diagnoses to categorise Disability, and assumes that individuals with identical impairment have identical abilities and needs.

The Social Model - a socio political understanding of Disability

The social model arose as a critical reaction to the earlier dominant medical models of disability which in itself is a functional analysis of the body to be enhanced in order to conform to normative values.

Figure 2. The Social Model.

Identifying the necessity of a different understanding of Disability, the World Health Organization formulated the following definitions in their International Classification of Impairment, Disability, and Handicap (ICIDH-1), in 1980:

> ***Impairment*** – any loss or abnormality of psychological, physiological or anatomical structure or function.
>
> ***Disability*** –any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.
>
> ***Handicap*** – a disadvantage for a given individual that limits or prevents the fulfilment of a role that is normal.

Impairments, concerned with abnormalities of body structure and appearance resulting from any cause; Impairment thus represents change of the psychological systems or anatomical structures.

Disabilities, reflecting the consequences of impairment in terms of functional performance and activity by the individual; Disability thus represents challenges of the person.

Handicaps, concerned with disadvantages experienced by the individual as a result of impairment and disabilities; Handicap thus reflects interaction with and adaptation to the individual's surroundings [World Health Organization].

A challenge with implementation of this terminology has been the expressions “abnormality” and “normal life role” and a critique of this understanding as simplified and narrow. The thinking has by now been confronted for years, and increasingly so. Critical voices argues that what is called physical or mental “Disability” is not purely a characteristic of an individual but a complex cluster of conditions, relations and activities, many of which are created by our social environment.

Critique of the Social Model, point to its failure to emphasise and meet all aspects of Disability. To embrace and meet all individual abilities and aspirations in Society is a still an unmanageable challenge. Though well intended, accessibility and Universal Design anchored in a social understanding of Disability can create the potential of overlooking bodily experiences of accessibility and barriers. Critical voices argues that the focus on Disability as entirely social constructed and environmental substance has a tendency to “forget the human body” in it´s one sided view [Hughes & Paterson 2010].

2.3 The Bio-Psycho-Social Model – a relational understanding of Disability

Today, a more multifaceted International Classification of Functioning, Disability and Health (ICF 2001) have been formulated by the World Health Organization, in attempt to meet a more relational and complex understanding of Disability.

ICF organises knowledge in two parts:

1. Components of the Functioning and Disability
2. Components of Contextual Factors

In ICF, components of Functioning and Disability include two classifications, one for functions of body systems, and one for body structures. Environmental Factors are the first components of Contextual Factors and are organised in sequence from the individual´s most immediate environment to general Environmental Factors. Personal Factors is also a component in ICF but they are not classified on account of the large social and cultural variance associated with them.

From this classification, a person´s Functioning and Disability is perceived as a relational phenomenon, a dynamic interaction between Health Conditions and Contextual Factors.

Both the Medical Model and the Social Model of Disability provide valuable insight from two very different perceptions, but none of them are offering knowledge on how Disability grows in interaction between individuals with impairments and surroundings.

Hence specific theories that guide research and understanding can shift as a result of new knowledge and theoretical development. The Bio-Psycho-Social Model built upon both the Social Model and elements of the Medical Model and describes the interplay between reduced function and Disability, a social relational understanding.

Unlike the Social Model, the Bio-Psycho-Social Model acknowledges that inability of some impairment, to adapt to Society and the physical environment, may be an influential element of their condition. Nevertheless, the Bio-Psycho-Social Model maintains that Disability grows primarily from a social and environmental failure to account for requirements of citizens with impairment. Even though a person's impairment will include some limitations in an able-bodied Society, every so often the Surrounding Society and Environment are more limiting than the impairment itself.

The advantage of this model is that it does not focus on individuals’ limitations, but takes account of abilities and potential in interaction with Society.

The development of the Bio-Psycho-Social Model is often referred to as a social relational understanding of Disability. This terminology includes even stronger, the relation between the individual and the social-environmental conditions. A social relational understanding of Disability built on participation and equal opportunity and lay emphasis on interaction between the individual and the environment.

Furthermore this social relational understanding of Disability is placing enhancement and motivations as interplay between Society and the individual and can be seen as a dynamic model of improvement and innovation. It is today a well implemented understanding of Disability in The UN-Convention, The International Classification of Functioning Disability and Health: ICF. Geneva: World Health Organization, 2001.Hence this thinking is today widely acknowledged among researchers, activists and authorities together.

The Bio-Psycho-Social Model - a relational understanding of Disability

Figure 3. The Bio-Psycho-Social Model

3 Three present understandings of Disability

In order to be brought closer to existing understanding of Disability related to Universal Design (UD) in Denmark, we bring into play, three perspectives; the UN Convention on the Rights of Persons with Disabilities, Disabled People's Organisations Denmark and the practicing Architect.

The motivation for bringing in these perspectives is that these are three influential actors in the Danish discourse and it allows us to discuss the subject through a matrix of three levels. The three actors cover the Danish discourse on accessibility and Universal Design in three levels as macro, meso and micro levels.

Matrix of three levels

Macro level	Knowledge of ethics, humanity and views on human rights. The UN Convention, mission statements of legislation and community planning.
Meso level	Technical knowledge, design of services and assistance. Implementation of plans and regulations. Knowledge of collaboration in processes.
Micro level	Knowledge of individual´s perspective, where and how barriers occur and who experiences barriers.

Figure 4. matrix of three levels [Lid, I.M. 2013] .

The three levels of the matrix hold different approaches, different agendas and different objectives and they will support our effort to create a three dimensional framework for understanding how notions of Disability influence the discourse on accessibility and Universal Design.

Macro level, embrace ethics, thinking, understandings of Disability and views on Human Rights. Macro level handles Universal Design through policy and regulations.

Meso level is an intermediate level covering planning, regulations, implementation, technical knowledge and collaborative processes. Meso level requires technical and practical knowledge to develop and implement Universal Design.

Micro level holds knowledge of individual´s perspective, knowledge of where and how barriers occur and experiences of barriers by individuals with impairments. Micro level requires knowledge of the complex interplay between individuals and surroundings [Lid, 2013].

The PhD “Generating Inclusive Built Environments through User Driven Dialogue in the Architectural Design Process” studies themes of the three levels in the matrix. The PhD framework holds objectives to identify and reflect on the role of DPOD user group and discusses their experience and competency to be dialogue partners in design processes [Micro level].

It is the project’s ambition to provide a critical reflection on the current situation and possibly suggest opportunities of development and potential for strengthening the user representatives as dialogue partners in collaborative relationships with the Architect [Meso level].

In the ambition of change and enhancement of user representation in the Disabled People's Organisations Denmark, the study draws on references from action research methodologies and involves the organisation, whilst simultaneously conducting research. The research is in some measure based on participating observation in the DPOD organization and close dialogue with its core actors of Disability Policy [macro level].

Through observations of the actual DPOD engagements for eliminating discrimination in built environments, the close relation allows practice related knowledge to be a part of the empirical source of knowledge [Nielsen & Nielsen 2016]. Empirical knowledge gained from existing research, observations and qualitative interviews with DPOD representatives and professional stakeholders from the construction industry is generating a perspective unfolding the experiences and present understandings of Disability in the collaborative relationship.

Knowledge is gained on daily participatory observations in DPOD, supported by interviews with twelve DPOD representatives and with representatives of six core organisations from the Danish building industry. The twelve chosen DPOD interviewees cover a group of impairments which are all interrelated with requirements of accessible design solutions, such as wheel-chair users, visually impaired, hearing impaired, speech-language impaired and intellectually impaired. On a later stage

participatory observations and interviews will be strengthened by case studies observing dialogue and user participation in building projects.

The methodology of interviews used in the PhD frame is semi- structured in depth interviews. This allows freedom for the interviewer and the interviewee to explore additional themes and change direction, if necessary. The method chosen, offers the opening to capture rich, descriptive knowledge of interviewee's attitudes and perceptions, and unfolding complex collaborative processes.

The questions asked touches upon notions of Disability, concepts of accessibility and Universal Design as well as the understanding of roles and responsibilities in the collaborative design processes.

The conducted qualitative research studies indicate discoveries which response to the questions of how dissimilar notions of Disability influence collaborations between users with impairments and the architectural field. Implications are that understandings of Disability and designing Inclusive Built Environments are closely interwoven in the collaborative process. Opposite views and positions hold back the dialogue. However the PhD project is still on-going, and the results presented and discussed here are preliminary.

4 Disability as understood in the architectural field

Despite examples of collaboration between the architectural field and the DPOD user group, it appears to be a challenge in Denmark to identify building projects that incorporate Universal Design values and meet the expectations of the user group. Architecture projects infrequently show an integrated and holistic approach when it comes to UD and accessible design solutions [Frandsen, et al, 2012] [Author & Frandsen, 2016].

This overall challenge stems from various obstacles of unclear interpretations of accessibility and UD, fragmented knowledge of accessibility and UD and undefined collaborative relations with the user group. Additionally, resent findings of the PhD research discover dissimilar notions of Disability in the dialogue.

The preliminary findings show at least two different understandings in the dialog between this user group and the architectural field. These dissimilar understandings appear to have a strong influence on the dialogue and even delay progressive collaborations.

Qualitative interviews with representatives of core organisations from the building industry and practicing Architects point toward the understanding that people with impairments are specific minority groups that somehow require specific attention to solve their individual Disability challenges in the Built Environment.

This understanding of Disability, by some means, parallels the Medical Models single-mindedness on the individual´s impairment and limitations. The Architect´s specific design solutions for specific people, becomes an "Architectural Cure" designed for individuals with impairments and not for all.

Responses from the interviewed Architects confirm this approach to Disability, in line with the view on diversity; *"How many disabled individuals are we talking about? Is it really fair that a small group of people with disabilities should have such a great impact on how we create architecture?"*

Understanding Disability, accessibility and Universal Design as a social aspect is not necessarily a part of the thinking or awareness of the Architect. Other research indicates a predominant focus on physical accessibility and the Building Regulations' prescriptive minimum requirements. This narrow understanding of accessibility has led to an approach, which somehow separates physical accessibility and architecture and to some extent, separates people with impairments from the rest of Society. This views result in "add-on solutions" in architecture, accessible design solutions applied in the final phases of projects. Add-on solutions do not necessarily correspond with other

architectural elements in the project neither are they responding to the manifold of bodies and varied abilities [Frandsen, et al, 2012].

Long-standing attention to the legislative interpretation of accessibility and UD, represented by rules and standards has led to critiques in the architectural field. This critical position develops from the view that the interpretation of physical accessibility and its codification in the Danish Building Regulation is a limitation of creative design processes and innovative thinking [Ryhl, 2009] [Kirkeby, et al, 2014].

We argue that these design solutions do not meet a philosophy which includes persons with impairment in Society as a part of human diversity; they are specific design solutions for specific people. From that perspective, required accessible design solutions only meet necessities of the few.

Absence of holistic Universal Design strategies and attentiveness of social relational understanding of Disability, in architectural education and practice, indicates a broader understanding of human diversity is yet to be implemented as social values and spatial quality in the architectural working method.

Importantly, this also questions functionality and efficiency of collaborative relationships with the particular DPOD user group. If users with impairments are understood as minority groups at “the outskirts of diversity” this understanding conflicts with the values of UD and the thinking of the users, themselves. Most people with impairments would reject the thought of being "abnormal" or outside social constructions [Lid, 2010] [Garland, 1996].

Qualitative interviews with representatives of DPOD member organisations and their user representatives show a general perception of being a part of Society and human diversity - being the same and different. Interview responses reveal interpretations of the Social Model of Disability; the challenges and solutions lie within Society and the environment. If the built environment cannot be used by persons with impairments it must be redesigned. This opposite position to the architectural field, suggest barriers for dialogue and hindrances for fruitful collaborative relationships.

This could point at a relational Model of Disability and the UD paradigm as a possible means to meet in ambitions to reduce body-based discrimination in social and physical constructions and support participation and daily life, not only for people with impairments, but for all.

5 The User Perspective

The Disabled People's Organisations Denmark (DPOD) defines their commitment to engage in efforts that serve to encourage and protect the rights of persons with disabilities. With the overall ambition to eliminate body-based discrimination in built environments and thereby improve independence and everyday life for persons with impairments, the Disabled People's Organisations Denmark takes

a political starting point in the United Nations Convention on the Rights of Persons with Disabilities. [http://www.handicap.dk/politik/].

The strengthening of the United Nations Convention on the Rights of Persons with Disabilities includes the approach of the Bio-Psycho-Social Model as well as Universal Design inspirations and values. The Rights of Persons with Disabilities emphasise equality, inclusion and the understanding that difference in ability is a natural and foreseeable human condition or experience.

Along with moving the perspective of limitations from the individual to the relation to the surroundings, the UN Convention not only makes clear that states should not discriminate against persons with impairments. The Convention also explains the many steps that states must take to establish an inclusive environment in order to let persons with impairment enjoy participation and equality in Society. From that perspective, physical barriers and limitations are first of all environmental and social challenges and Disability occurs when interaction fails. Although physical, intellectual, sensory or psychological variety may cause individual functional limitations or

impairment; these do not have to initiate Disability, unless Society fails to include people regardless of individual differences.

Universal Design principles are introduced in the UN Convention as means to generate Inclusive Environments which reduce barriers and limitations. UD responds to the awareness that accessible design solutions and Inclusive Built Environments should not only eliminate barriers for some, but enhance participation and experiences for everyone. Universal Design is referred to as a design strategy for urban planning, architecture and landscaping as well as strategies to meet external political and social aspirations.

Mirroring this, the social relational understanding of Disability is reflected in both the UN convention and the UD paradigm. In line with the Rights of Persons with Disabilities, UD values embrace the importance of participation and social inclusion and point out the importance of inclusive strategies as interaction between Society and individuals.

From this viewing platform, the Disabled People's Organisations Denmark (DPOD) are building the commitment and engagement to inspire and support Inclusive Built Environments, offering guidance and user perception in design and architectural processes. The organisation´s engagement is reflected at macro, meso and micro levels.

On macro level, with motivation to exert political influence DPOD´s political department embrace ethics, understandings of Disability and views on Human Rights. On meso level DPOD consultants debate political agendas with political decision makers and leave their mark on accessibility an UD through legislation and regulations.

On micro level, user representatives of DPOD share their experience of accessibility and Universal Design in collaborative relationships with Architects and stakeholders. The users representatives experience the functionality of accessible design solutions on their own body and in so doing they can contribute with experienced descriptions of design and functionality.

User representation in DPOD consists of volunteers, most often from local chapters of the main organisation, offering an individual user perspective to design and construction processes. Hence, the DPOD representatives should not be seen as professional consultants or as guarantors for the correct and legitimate design solution. The responsibility for meeting building requirements lies merely with the building owner/contractor and the professional consultants. User representation should support the professional design process, facilitating need-based knowledge and “one-to-one insight” of accessible solutions.

Facilitation offered by user representatives should be understood as a non-professional supplement disengaged of authorized or legitimate responsibilities. This understanding is confirmed and accentuated in some of the research interviews with DPOD representatives; other DPOD representatives find their role and competences unclear. A number of user representatives demonstrate how it is practically impossible to be spokesman of the large group of very different organisations.

Interviewees point out that impaired user representatives of member organisations often facilitate need-based knowledge based on their personal experience of the built environment having this particular impairment. On micro level it is a comprehensive task to facilitate and to guide on behalf of a large group of diverse people with a variation of impairments. It appears to be practically impossible to be a member of one particular user group and mediate very specific need-based knowledge and at the same time represent requirements of all DPOD members.

Findings points to an overall confusion regarding the role and responsibility of the user representatives in the architectural field and in the user group itself. As users of accessible design solutions, the DPOD user representatives are expected to possess certain knowledge of accessibility

and Universal Design. Nevertheless, as users of accessible solutions and UD, the user representatives are often mistaken for experts in accessible design solutions and building regulations.

Qualitative interviews with representatives of core organisations from the building industry and practicing Architects indicate the understanding that involving the DPOD representatives is a way of securing and approving accessible design solutions in architecture. This leads to misinterpretations of commitment and responsibility in the collaborative design process.

The experiences of misinterpretations are confirmed by the participating observations in the DPOD organisation. The narrative of "being taken as a hostage in the design process" is per se a well-known narrative in the user group and in the organisation.

The overall confusion regarding the role and responsibility of the user representatives is correspondingly present in the user group itself.

As a result, the DPOD user representatives generally appear to find support on meso level, in legislation and the current Danish Building Regulations. Interviews with the user representatives and observations in the organisation find the building legislation to be an important tool for the user representatives. Nonetheless, assuring appliance with the building legislation is not the responsibility of the user representatives, but the responsibility of the building contractors and their professional advisors.

When moving from micro level; facilitating need-based knowledge of "life with impairment" to meso level; mediating legislation and Building Regulations, the user representatives unintentionally emphasises their imprecise roles and responsibilities. Hence, user representatives by some means assume a role of professional Accessibility Consultants.

"We are very good advisors, the money which the Municipality spend on professional Accessibility Consultants is wasted. We could do this work ourselves". - DPOD user representative

Though well intended, movement between levels accentuates unclearness of roles and responsibilities as well as attention to accessibility as specific design solutions for individuals with impairments, and not for all.

This approach to user representation and focus on specific design solutions for individuals with impairments does not emphasise equality, inclusion and the understanding that difference in ability is a natural and foreseeable human condition or experience. Neither does it correspond with Universal Design strategies.

The approach creates a gap between the DPOD organisational starting point in the United Nations Convention on the Rights of Persons with Disabilities (and the UD paradigm) and the user representative´s attention to accessibility as specific design solutions for individuals with impairments. Recognising that the two parties work in different levels of the matrix, we suggest the gap can either increase from a statically understanding of Disability and accessibility or decrease from a broader understanding of human diversity, a dynamically understanding of Disability and Universal Design values.

Difference in physical characteristics of the body as a natural part of our lives and impairments viewed as a part of human diversity is useful knowledge, for the practicing Architects and the users to share. In the process of understanding Disability and translating desires into architectural form and function, the scope of reviewing impairment as a condition of human variety is useful for both groups in the collaborative relationship [Lid, 2010 Lid, 2012].

6 Perspectives: Advancing understanding of Human Diversity

Understanding of, and empathy with user groups is essential for creating new platforms for inclusion in design practice and for generating Inclusive Environments in collaborative relationships. Architects gain knowledge through education, practice and personal experience. Nevertheless, in specific

processes of designing, such as those involving participants who have significantly different needs from themselves, Architects cannot rely on past experience.

Understanding the complex implications of living a life with impairment is essential for Designers and Architects, in order to recognize, how accessible design and user friendly solutions support and inspire independence and empowerment. When living with impairment, independence and social interaction is reliant on accessibility, Universal Design thinking and functional architecture. Poorly functional design solutions and non-inclusive architecture hinder independence and opportunities to take part in ordinary life of the community on an equal level with others, due to physical barriers [Steinfeld & Smith 2012]. If we recognise that our physical environment holds the potential to be discriminatory we can do much to design and built for diversity.

Not all challenges deriving from impairments or bodily variations can be addressed, but findings of the framed PhD project point to the importance of recognising that Disability cannot be understood outside its social and physical context. As such, some of the assumptions about normality and difference, which underpin traditional thinking of Disability, are challenged.

Knowledge of modern dynamic perceptions of Disability, the relation between individuals and the social-environmental conditions plays an important role in the co-creation of Inclusive Built Environments. Implications of the PhD preliminary findings are that a social relational understanding of Disability built on participation, equal opportunity and interaction between the individual and the context is useful knowledge for users and practicing Architects.

New sorts of innovative collaborations between actors and the architectural field are suggested as possible means for a wider understanding of human diversity, including disability. Design forums, creative workshops and other dialogue processes in macro, meso and micro levels. Moving the collaborative relationship further than legislation and the current Building Regulations might open the way for new and subtle notions of Disability and Inclusive Built Environments. Rethinking Inclusive Architecture and embrace processes which include a wider range of heterogeneous users could encourage new understandings of Human Diversity as well as Disability and bring the architectural field closer to a Bio-Psycho-Social Model.

Furthermore, clear roles, well defined responsibilities and transparent positions in the matrix of levels [macro, meso and micro] point to a possible means to advance the dialogue toward an equal objective; to reduce body-based discrimination in physical constructions and thereby support participation and daily life for not only people with impairments, but for human multiplicity. Hence understanding how human diversity, accessibility and Universal Design are linked together in the notions of Disability is necessary. Given this degree of understanding, our future objective should be to develop and manoeuvre a cluster of models, which will empower people with impairments, giving them full and equal rights alongside their fellow citizens.

From this, the notion of reviewing impairment as a condition of human variety suggests a wider understanding of diversity and argues that as a strategy it can lessen architectural barriers and enhance quality of Inclusive Built Environments and equal opportunity.

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Design for Self-inclusion: supporting emotional capability

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This paper contributes to inclusive design. It seeks to extend the current definition of Inclusive Design, addressing motion, sensory and cognitive capability, by introducing emotional capability for self-inclusion as an additional component. To illustrate this perspective, the paper presents two constructive design research cases of designing for self-inclusion. One of these cases presents a finished design to support autistic children in self-inclusion. The other case presents a design exploration method to support participants in determining the emotional priorities which should underlie design interventions. The participants in this case sought to compensate a physical disability, one, a permanent one, and the other, a temporary one. The second case is presented in order to show the potential of starting from the experience of situations rather than specific design goals. The paper concludes that valuable design potential can arise from emotional and experiential insights from combined embodiment and participatory design activities.

inclusive design, emotion, constructive design research, self-inclusion

1 Introduction

The domain of Inclusive Design mostly tends to address designing for three dimensions of capability: motion, sensory and cognitive capability (Clarkson & Coleman, 2015). This is evidenced, for example, in a recent compilation of Inclusive Design contributions (Langdon et al, 2014) focusing mostly on product and environmental solutions, as well as the recent Microsoft Inclusive Design Toolkit (2015). The latter addresses visual, speech, auditory and touch capabilities and various levels of impairments in them. Where is the social, the emotional dimension of those towards whom Inclusive Design is directed? Only a few of contributions in Langdon et al (2014) address it. The term 'emotional' only occurs on five of the 275 pages, and never in relation to the state of the person to whom Inclusive Design is directed. The term 'social' occurs often, but also mostly in the context of an outside, generalised perspective. Two chapters focus on social inclusion but in relation to a specific activity or architectural environment. The term 'empower' is absent, although it has been explored elsewhere for disability (van Dijk et al, 2016). Only one chapter, by Holt, Moore & Beckett (2014) specifically addresses the experience of social, experiential inclusion and exclusion as a main topic. It does so in the context of children's play, acknowledging the significance of social barriers, yet in the solution

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space also goes on to focus on the design of the games themselves. Goldhaber et al (2014)'s chapter addresses self-exclusion mechanisms for the case of women and computing, but does not propose any concrete strategies to address it, beyond a general recommendation to encourage a flexible self-view towards learning. An experience such as 'independence', as someone's subjective desire, is only mentioned once in the compilation (Andrews, 2014, p. 211). Earlier contributions to the Inclusive Design domain were still closer to the initial needs that helped establish the domain. In Clarkson, Coleman, Keates and Lebbon's (2003) primer, Bieber (2003) presented an impassioned plea outlining her "struggle for independence". Though listing all the products and environments causing impairment, the contribution also highlights all the emotions that come with dis- or enablement: frustration, stress, but also enjoyment and satisfaction. Moore's (1985) famous self-experiment with social exclusion described its emotional repercussions evocatively.

This paper picks up on the emotional aspects of inclusion and proposes two explorations in this direction, with examples. To illustrate how emotional aspects are not currently prominently addressed in it, I first explore how Inclusive Design has been conceptualised and how it defines its aims.

1.1 Aims of Inclusive Design

Inclusive Design aims at the "integration of older and disabled people in the mainstream", "as active, participating and contributing members of society", through "products and services that delight the end-user, rather than stigmatise and alienate" (Clarkson & Coleman, 2015, p. 235 and 245). The economic and scale aspect of Inclusive Design is revealed in this older definition in the British Standard 7000 Part 6: "[The] design of mainstream products ... that are accessible to, and usable by, as many people as reasonably possible on a global basis, in a wide variety of situations and to the greatest extent possible without the need for special adaptation or specialized design." (Keates, 2004). The definition can be taken to imply that the desired (also experiential) inclusion relates to becoming more similar to others - in fact, the many others, the mainstream - through product use. If most people drive cars, Inclusive Design is about enabling someone to drive a car too, in a way that is adapted to their particular capabilities, and hence to be more similar to others, the mainstream.

The social model in disability studies (Thomas, 2004) points to the fact that disability is not only about the way society views disabled people and disability, but also about disabled people's own experience of life. The United Nations (UN) Convention on the Rights of Persons with Disabilities (CRPD) reflects the change from a former medical model to a social model in which disability is understood to result ‘from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others’ (Berghs et al 2016, p. 1). Lim and Nickpour (2015) have broadened the scope of Inclusive Design considerably by reviewing the psychosocial dimensions that could pertain to it. Still, these contributions also focus on the direct interaction between people and products, with the aim of mainstreaming the consideration of diverse motion, sensory and cognitive capabilities.

Similarly to the Microsoft Inclusive Design Toolkit mentioned earlier, Clarkson & Coleman (2015) define as relevant three dimensions of capability: motion, sensory and cognitive capability. Capabilities can be related within individual people, for example that a young person with limited eyesight may have very acute hearing to supplement a low level of visual information. The example shows that this person has also likely gained experiences throughout their life through which they have adapted to contextual experience. Living through such adaptations likely also triggers emotional experiences and reflections on one's position in life and on one's relationships with others. This can lead to greater insecurity as in the example of Goldtaler's research on women and computing (2014), but it can conceivably also lead to a more mature capability of self-inclusion, and strategies for it. The Inclusive Design field could learn from these.

An additional view of Inclusive Design is conceivable: that of supporting people in fulfilling needs, such as for social connection with others, aided by designs that facilitate this fulfilment in more ways

than connecting with a mainstream. From the perspective of Self Determination Theory (Ryan & Deci, 2000), people need relatedness, autonomy and competence. Such relatedness does not necessarily have to be to a mainstream. Besides wanting to be like everyone, people also seek out direct social connection with a diversity of those around them. How could this be addressed?

I contend that an additional layer of Inclusive Design could be that of a facilitator in which designs or interventions have an enabling role for a person to enhance their experience of life and their resilience in society, beyond physical adaptation. Such an approach could enable people with disabilities to position and assert themselves and their design needs better. That is why I propose an approach to Inclusive Design that is focused on the experience of situations and how to support a person's needs, rather than mainly on the development of products to compensate for specific disabilities. This may contribute particularly to users being designers or at least participating in the design process (Zhang and Dong, 2016), by supporting their own recognition of their unique experience rather than only the physical make-up of situations. Such an additional view is not proposed as an alternative to the current definition of Inclusive Design but could rather serve as an additional layer. The ambition to mainstream inclusive design remains an important social and economic societal ambition. To this literature I add a focus on the experience of those involved as elicited through combined embodiment and participatory design activities. An outlook is provided into how these insights can be made productive in the design process.

This paper presents two cases that were specifically selected to illustrate enablement in experience, facilitating self-inclusion rather than designing for the users' capabilities. I will show two cases, each with a different angle on experiential self-inclusion. Each sheds light on an example situation: one, where a change in the person is the key object of inclusive design. One, where a change in a person's product ecology is the key object of inclusive design, where someone is highly aware and critical of how an inclusive solution (a wheelchair) does not sufficiently support her in her entirety as a person. And as a second participant in that case, where a person lacks this awareness entirely yet is affected similarly.

2 Method

Both cases are based in design education activities and are constructive design research cases (Koskinen et al, 2011), linked through a programmatic interest in the topic of inclusivity in design for experience. This means, a thread of inquiry into this is continued throughout successive cases (Binder & Redström, 2006). The design cases rely on an approach emphasizing embodiment (Boess, Hummels & Saakes, 2007; van Dijk & Verhoeven, 2016). With this is meant, studying any issue not only intellectually with hermeneutic tools such as visualisations, but physically and contextually by actually experiencing the interactions at hand. A pioneer in inclusive design of this approach is Patricia Moore who built inclusive design consultancy on her own earlier experience (1985), putting deciders in the situations over which they had decision power. For example, asking executives to sit in wheelchairs and then waiting until they had to go to the toilet in one of their properties. Embodiment has also widely been adopted in human computer interaction design because of its dynamic and contextual nature, which resulted in a need to enact the contribution of digital artifacts in contexts of use (Boess et al., 2007).

3 Case 1: Self-inclusion: a tactile emotional approach

The first case is about designing for autistic children. The possibilities of touch encouraged us to explore and research the world and life of an autistic child in order to design something which persona Tommy will benefit from. We have described the development of Fuzzy Bird elsewhere (Boess et al., 2017). Here I present this case to show an example of designing to facilitate emotional self-inclusion.

3.1 Designing inclusion for autism

Van Rijn and Stappers (2008) sketched an evocative picture of how children on the autistic spectrum experience the world: it is a challenge for them to integrate many sensory impressions. In consequence, they frequently withdraw or get stressed in social interaction, which in turn impedes their social connections. An example is the integration of auditory impressions: children on the spectrum find it difficult, which easily leads to sensory overload. A frequently tested intervention is the use of headphones, which is why we created a persona who often wears headphones (Ikuta et al., 2016) (Figure 1). One in 70 to 100 children is diagnosed as being on the autism spectrum (www.autismspeaks.org/what-autism, www.autismeurope.org/about-autism).

We wanted our persona Tommy to be able to participate, to get included on a social level. What prevents Tommy from participating? In autism emotion leads to self-isolation, but it can be addressed in some high-functioning cases, and Tommy can be enabled to include himself better in social interactions. Rather than creating special environments or products for Tommy as a member of a specific group, people on the autism spectrum, our aim was to design something that will enable him to develop the skills to include himself in social connections. The barrier Tommy needs to overcome in this is his own anxiety and aversion to engage in social interaction. He needed to learn to dare to be more open in new and unexpected situations, so he can feel more socially included. Helping Tommy feel confident in this sense would be very beneficial for the development of his social skills and eventually help him to develop the skills to include himself in social connection.

3.2 Transitional objects for social self-inclusion

Van Rijn and Stappers (2008) describe elements to take into account when designing for autism: 1. give them a feeling of being in control 2. provide a structured situation, 3. let them create a structure themselves, 4. make use of their special interests 5. facilitate their excellent memory 6. reward them with sensory experiences 7. facilitate their eye for detail 8. let them use their whole body. However, little research is as yet available about the influences which physical objects can have on the social and emotional everyday life of autistic children. Literature does describe so called "transitional objects": objects that a child can uses to provide psychological comfort, especially in unusual or unique situations, and that can also represent relationships with others (Holmes, 2011), but this has not yet been applied in design.

We conceptualized a support as a soft, nonthreatening, inviting, and above all, passive object inviting touch while also exercising restraint (Boess et al., 2017). I briefly reiterate the interaction possibilities of the object here, as an illustration of a design for self-inclusion:

> *Fuzzy Bird is a fuzzy, cuddly, and soft baby bird. The instantiation was chosen for its huggable round shape with little definition and few but distinct movements (flapping little wings). The overall appearance and feel of Fuzzy Bird passively invite interaction, thereby exercising restraint and providing the reward of touch. An initially stressed child can squeeze and hug Fuzzy Bird ruggedly or even throw it about, absorbing initial anxiety or distress and involving the whole body. The simple responses gradually convey structure. Once calmer, or if the child is already calm, Fuzzy Bird offers three direct, predictable, and minimal responses, each discoverable by touch and depending on the first move from the child, thus facilitating a feeling of control. This enables the child to create structure of its own and discover the object's response without overload. These are Fuzzy Bird's responses: its wings sport colored patches, one green and one pink; on its belly, there is a yellow patch. A child can squeeze or hit the patches. If Fuzzy Bird's green or pink wing is squeezed, its head tilts to that side and a green or pink LED light up on the belly. The yellow patch on the belly also lights up on touch, and Fuzzy Bird shakes its head left and right gently (**Figure 1**). Fuzzy Bird responds to each action with only one direct, simple response, which in turn invites a direct, simple response from the child.*

Fuzzy Bird mirrors and takes on the child's actions, but no longer its distress, and invites mirroring in turn, with subtle guidance toward calm. (Boess et al, 2017).

Figure 1, top row: overview of Fuzzy Bird's interaction possibilities. Middle row: a child initially closed, interacting with Fuzzy Bird, then opening up to social interaction. The child's experience may become calm and structured enough to be able to cope without headphones more often. Bottom row: the Fuzzy Bird prototype.

This case only presents the finished outcome of the design process. The process was described earlier (Boess et al, 2017), and it is less interesting here because it followed a familiar user needs elicitation process alternating with design steps. The uniqueness of the case lies in what the design outcome demonstrates: that Inclusive Design could mean designing something that readies a person for social self-inclusion. The design does not appeal to a mainstream. Rather, the design provides a service that strengthens its user and increases that person's resilience and competence in the social interactions they will encounter.

4 Case 2: supporting people in developing directions for self-inclusion

This case, in contrast to Case 1, does not present a finished design object but rather the early steps towards a design concept and stakeholder action plan. With this case, we turn to the methods aspect of designing for emotional capability. The case took its starting point in Microsoft's Inclusive Design Toolkit (Microsoft, 2015) to compare different situations of disablement, and then explored new avenues by focusing on the experiential aspect of these situations. The MS toolkit recognises that disablement arises from mismatched human interactions in a context, rather than from personal health conditions. The toolkit distinguishes between enduring, temporary or situational disablement in specific situations and interactions (Figure 2). In order to make a comparison as advised in the toolkit, the designers collaborated with two participants.

Figure 2: continuum of situations of persona disablement (Microsoft, 2015)

The first participant was a wheelchair user, I will call her Iris, who challenged us to design something that would help her enter houses without bringing in dirt from the wheels. The problem she experienced was that if the weather was bad, she would always leave traces of dirt with her wheelchair in the entranceway of the house or building she visited. Her request was a functional one: design something practical to help me clean my wheelchair wheels when I enter someone's house. Because this project could only cover initial steps, this was transformed into: elicit the need in the context and for this stakeholder.

For comparison, the team recruited a second person I will call Marian. She is a young woman, an expert snowboarder, who had recently had a snowboarding accident and then an operation on her leg. Her disablement was temporary and she expected to return to full health, but at present she was unable to run or walk fast. Since wheels play no role here, she and the design team focused on the situation of an arriving train stopping far away down the platform and having to reach it on foot.

The design research team developed a tool to elicit each participant's experience of their situation. The tool focused on the character of all the actors in the situation (people and things), and on identifying the intent of each of these actors (Figure 3).

Figure 3: Examples of "character" cards and "intent" cards. The example character cards here describe a "bystander", "no one", and "a friend". The example "intent" cards describe "being friendly", "helping", and "wanting to get away". Twelve of each were presented in the session, with the option of adding more.

Additionally, the tool contained a 'playing board' on which the intentions of these characters could be noted, and then ideas noted during the enacting and reflecting phases on emotions in the situation and on desired future interactions.

Each of the participants, was invited to participate in one session of ca. 1.5 hours' duration. The sessions served to facilitate the participant in envisaging their present situation and its social interactions, and then to formulate a desirable future situation with new social interactions. The

purpose of this was that in a potential next step, the participant could collaborate with the designers in sketching design interventions that would support the desired new situation.

4.1 Session steps

Each session consisted of six steps. The design team prepared those steps in order to guide the participant through them. The first three steps related to their **current** situation. The participant was first asked to **immerse** in the current situation – the participant was asked to reflect on a current interaction of their choosing with things and people in the actual environment in which these interactions take place. This served to enable them to bring realism, social aspects and embodiment into the session. Step 1 was to **make** the current situation – when the participant arrived for the session, props and story tools were available so that the participant could re-create that real-life situation in the studio setting. The sequence of current interactions was noted on a large board evocative of a game board, to represent and analyse the sequence of the interaction. The next step was to **reflect** on the current situation – the participants were then given a set of cards to represent the character of those involved, as well as the intent of each of those involved. These three steps could be repeated and adapted flexibly. When a participant had reflected on the situation, they had the opportunity to **immerse** in it again, for example by enacting it to remember and discover new aspects, or to **make** new parts of it from memory. Once these situations had been enacted and the role of all actors in the situation analysed, the participant was invited to move towards creating a desirable **future** situation. This would start with the designers supporting a participant in **making** parts of a desirable situation by using props and re-arranging the actors and their characters and intentions. Then the participant could **immerse** in the situation by enacting it and experiencing its effects in an embodied way. This provided a basis for **reflection** on the situation and its effects for the participant. Again, these three steps could be repeated and adapted flexibly to discover new aspects or to change the situation in a way they pleased.

4.2 Results of the Case 2 sessions

Iris who is permanently in a wheelchair, it turned out, hated being helped. She had a great deal of pride in her full professional life and in her ability to live and drive herself around independently. She rejected any notion that social interaction could play any role in the solution space. However, when she was asked to also give the objects involved a character and an intention, valuable insights emerged.

The tools revealed that she viewed the interaction of entering her sister's house as one of *mutual* helping, characterised by love and the mutual will to offer a service. She had a ritual of collaborating with her sister in this activity: Iris would bring in a mat that she always keeps in the back of her car, her sister would roll out the mat for her, she would ride a pattern on it in her wheelchair, and the mat would then stay rolled up in her sister's hall during her visit. They were a team in carrying out this action. (Figure 4).

However, when it came to visiting others, Iris felt very differently: that she would rather not visit others than having to receive their help with this. The cards she chose to describe her feelings about the eventuality of this situation were 'victim' and 'egotist'. Such a situation would make her feel both that she would impose too much on others, and that she would feel and be seen as a victim. She commented that 'people think they have to think for someone in a wheelchair'. This was the reason she wanted a design that would put the activity of cleaning her wheels under and within her control. For the future situation, whatever she would then have would have these characteristics: facilitate optimal human respect from others, being able to always clean her wheels when desired, cleaning the wheels being a natural *part* of entering any building just as one would have with shoes, with the action being spontaneous, reassured, and based on free choice. The provision could appear strange when first introduced, but it should then be capable of becoming normal, just like cleaning shoes. The session did not become more specific than this, but these points illustrate well how requirements for inclusive design could be based on experiential insights. Given the delicate

experiential positioning of the design direction, Iris (or others with similar experience) would clearly need to stay involved in next design steps.

Figure 4: Iris' session cards. In her current situation with her sister, all were characterised as "problem solvers" and "bound by love". Their intentions were to "offer service" and to "help", in an emotional situation of self-respect and autonomy. By contrast, the situation in which Iris would visit strangers, would lead to her perceiving herself as a "victim" and an "egotist", which she precluded by saying "such a situation would never happen".

In the second session, Marian who had a temporary and invisible impairment with her knee, enacted the situation of an arriving train stopping far away down the platform and having to get to it. In this situation were also involved the train conductor and a fellow passenger. In the enactment of the present situation, Marian experienced herself as a 'no one' and a 'victim' (by selecting those cards). She experienced the conductor as a 'fool' and her fellow passengers as 'selfish people', and all others together as 'in a hurry'. Marian saw her own intent as 'being polite', but that of the others as 'wanting to leave'. Immersing by enacting this scenario revealed her experiences, which she described upon reflection as feeling ignored and feeling guilt about imposing on others. Continuing on to create and enact a desirable future situation, Marian characterised herself as 'innocent' - a similar wish to Iris' earlier wish for 'normality' – the train conductor as 'a good samaritan', and a fellow passenger as a 'hero'. In this situation, the conductor would immediately be aware of and understand Marian's inability to walk fast towards the train and urge other passengers to help Marian get to the train. The others' intentions would be to be 'responsive' and 'polite'. This session too ended at this stage, with experiential insights that could inform requirements. Here too, next steps should be undertaken with Marian's involvement.

The two participants' situations were both described here in order to highlight the differences in experience between someone who is an expert at their situation, having lived with a permanent disability for a long time, and someone for whom their temporary disability is unexpected and surprising. The differences found were: visible versus invisible disability, very experienced and goal-directed versus rather thrown by daily life interactions and as a consequence of these differences, rejecting versus hoping to get offered help. This highlighted how different the experiences between permanent and temporary disability can be. However, for both of them, design solutions might be preferable to the help of strangers. Although Marian was much more open towards it, she also felt guilt. The Microsoft Inclusive Design Toolkit notes that "We use a persona spectrum to understand related limitations across a spectrum of permanent, temporary, and situational disabilities. It is a quick tool to help foster empathy and to show how a solution scales to a broader audience." The cases presented here had different contexts and therefore no conclusions about scaling could be drawn, but they did show that both would benefit from design solutions. However, they also showed how different their starting points were, and that designs would have to take into account that someone might be disoriented and overwhelmed by a new situation and focused on their own predicament, whereas someone else might be very goal-directed, focused on practical solutions with low acceptance of human involvement, and already have considered the broader application of potential designs.

5 Discussion

The results section has presented two cases that elucidate the emotional aspect of dis- en enablement. The cases differ in that the first one focuses on emotions as a part of the disability itself, and presented a design to address them in order to promote self-inclusion. The second one focused on physical disabilities and the attendant emotional experiences and how they hold potential for design directions. I propose an approach within inclusive design that is focused on the experience of situations rather than mainly physical disability. In the first case, the physical aspect comes into the situation as a positive contribution. Facilitating hugging and predictability as a conduit towards learning social interaction skills, corresponds to Clarkson and Langdon's (2014) observation of how one capability can support another. The second case highlights the emotional aspects of a physical disablement, and particularly the differences and similarities arising from differences in level of experience with the disability. I add to the inclusive design literature a focus on the design potential arising from the emotional and broader psychosocial insights from combined embodiment and participatory design activities. Although one of the cases is presented through the example of a design outcome, this is not the key contribution of this paper. For example, in contrast, Heylighen & Bianchin (2013) argued that inclusive design and good design matched when all critics could agree on the quality of the outcome. Here, the outcome itself is not the focus but rather how the outcome (first case) and the method (second case) engage with a person's emotional self-inclusion and contextual emotions.

The findings in our Case 2 are closer to Desmet & Dijkhuis' (2003) analysis of children's needs for their wheelchair than to the inclusive design literature. Their research had found that feeling and looking independent was one of their most important concerns. The case of Iris showed a very similar result, though for someone who was a seasoned, independent professional. Because of the level of her experience, however, she was able to not only pinpoint this, but also provide ideas of how her situation should be generalised. In addition, our more general method (not specifically focused on wheelchair design as yet) delivered a number of possible points of entry, such as doorway design, accessory design or wheelchair design. The findings also echo those of Stenberg et al (2016) study into the user perspective of wheelchair users, who found that practical, personal and social dimensions were intertwined and significantly involved. Our findings provide a follow-up to those findings by providing various contextual entry points for design. I have shown how an embodied, contextual approach similar to that advocated by van Dijk & Verhoeven (2016), can achieve this.

An often-cited goal of inclusive design is to mainstream consideration of different ranges of capabilities and thus accessibility of products, aiming their arguments at companies and the potential to achieve market and brand advantage (Clarkson & Coleman, 2015, p. 2). Annemans et al (2014) provided a perspective aimed more at designers' sensibilities, advocating designing for a person rather than for a patient. Taking up Ostuzzi et al's (2017) finding that a ‘Design for the one’ can be generalised and applied on a broader scale, we can ask whether our approach, featured here, can do this as well. I suggest that Fuzzy Bird, designed with a focus on children diagnosed with autism, can be applied on a broader scale. Not only an autistic child like Tommy could benefit from a design promoting self-inclusion, but also a generally very shy child or a child who is nervous for his first day at school. My main specialism is not the theoretical field of emotional design but rather participatory and inclusive design. What this paper contributes to the field of inclusive design is the further exploration of the ‘emotional dimension’ within the inclusive design field just as it has begun to be explored in Langdon et al, 2014, by adding the emotional capability to the three capabilities relevant to inclusive design in the model by Clarkson & Coleman (2015). We have seen, for example, that Iris has compensated her physical disability with depth of emotional understanding of wheelchair use. What this means for the model has not yet been defined, but this design case suggests that further development of the model could broaden the field of inclusive design. It would be valuable to develop a more structured inclusion of the emotional domain in the inclusive design

field so that these fields can also be integrated for the mainstreaming efforts as sketched by Clarkson & Coleman (2015).

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Investigating Perceptions Related to Technology Acceptance & Stigma of Wearable Robotic Assistive Devices by Older Adults – Preliminary Findings

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Longevity, and good Quality of Life enhances a positive ageing experience by post-retirement adults. However, physical decline and limitations may affect independence and autonomy to conduct and engage in day to day tasks and social activities. Assistive robots can offer support to assist, and become embodied features that are accepted and worn by older adults. To date, research is limited and little is known about older adults' opinions of assistance by robots in personal and home life. There are a number of Technology Acceptance Models (TAMs) presenting quantitative based questionnaires that attempt to gauge acceptance and usefulness of robots by older adults. This paper presents preliminary findings from a qualitative study with older adults. The findings discussed are from an initial cohort of 8 older adult participants, which are part of a larger, ongoing study. The purpose of the study was to understand older adults' perceptions relating to technologies commonly used and future technologies and their acceptance and usefulness. The preliminary findings are based on a cross section of eight participants, and their perceptions. The findings of the full study will inform and assist the user centred design of a soft robotic exoskeleton.

older adults; assistive robots; stigma; qualitative research

1 Introduction

Baltes refers to lifespan development as an ongoing process of change, from conception to death (Baltes, 1987). It is widely viewed that within a user centred design research project, the user needs, must firstly be identified, and secondly be involved in the process of research and design (Dreyfuss, 2012ed., Papanek 1985; Fisk et al, 2004; Farage et al, 2012; Norman, 2002).

The global population of adults aged over 60 is expected to exceed 2 billion by 2050 (UN, 2015). This demographic in 2013 represented 11.7% of total global population. By 2050 it is predicted to be as high as 21%. This growth, combined with the continuing decline of fertility and birth rates indicates that there will be a greater number of older adults than children aged <15 (UN, 2013).

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Older adults are members of a disenfranchised group that collectively experience the 'digital divide' (Newell, 2011). The 'digital divide' refers to the pace of emerging technologies and the ability to use devices by groups such as older adults. It can impact on everyday task application experience, and challenge using technology such as ATM's, mobile phones and computers. Assistive technology should enhance quality of life and support the limitations experienced by the user. It should not be a source of frustration that invokes a reluctance to use a device. This implies the need to pursue and crossover the digital divide by understanding the challenges faced by older adults using technologies.

Graafmans et.al. (1996) calls for a 'lifespan approach' to design that features and emphasises an adaptability and flexibility that matches the needs of the user. They further discuss the influencing factors that can encourage or dissuade older adults from using technology devices. They express that more development is required to define people's acceptance and use of technology beyond their chronological age.

Technology, and its adoption or abandonment has had numerous models developed as a means to measure and identify the factors that optimise its acceptance [i.e. TAMs]. In more recent years such models have been adapted to include older adults, their home environments and social robots or technology devices (Heerink, 2010; Chen & Chan, 2014). These models typically compose of constructs with Likert scales that gauge the potential for acceptance. Generally, they are quantitative measures that do not always accommodate the expression or intimate thoughts of the older adult. TAMs are critiqued and discussed by many authors. Salovaara & Tamminen (2009) detail how TAMs have influenced design, attributing terms such as 'user acceptance' and 'diffusion' and 'adoption'. However, they also share concerns to TAMs as tools that can predict acceptance of technology by people, and discuss the flaws of measures that depend on user self-reporting, and short user exposure to the technology in question.

There is a need to consider alternative ways to understand and evaluate older adult user needs in relation to the acceptance of technology, specifically assistive robots (Shore. et. al. 2018). Consideration is required to the new emerging technology forms and the experiences and opinions of older adults, who are often quite engaged with ICT. Chen and Chan (2014) discuss a qualitative study they undertook that highlighted the positive attitudes older adults in Hong Kong appeared to have, in relation to everyday technology devices. However, other factors influenced more negative attitudes to acceptance and use, i.e. health risks, social problems, environmental and complexity of the technology. Qualitative studies regarding acceptance of wearable assistive robots by older adults is scarce. It was identified by literature review that there was a need to enquire and develop understanding, in relation to the perceptions older adults have to the presence and use of assistive robots.

Robots can be an effective intervention to support a person with mobility limitations. Assistive robots typically are grouped into three categories: manipulation, mobility or cognition (Van der Loos & Reinkensmeyer, 2008). The mobility group of assistive robots includes gait training robots and exoskeletons. ISO 13482 (2014) presents specific safety evaluation criteria for the design of personal care robots, based on three categories or robots: mobile servant robots, physical assistant robots and person carrier robots. Physical assistant robots, in ISO13482 are not defined as medical devices, but devices that can improve quality of life. Under ISO 13482 exoskeletons are classified as physical assistant robots.

Exoskeletons are used typically in rehabilitation, military and industry environments. When we consider the needs requirements of older adults with limited mobility, an exoskeleton could potentially offer enhanced abilities to engage in Activities of Daily Living (ADLs - Katz,1963). This in turn could maintain autonomy and independence as ageing progresses. However, there are relatively few studies that engage researcher with older adult participants in their home and day to day settings. Age UK (2009) found that the majority of studies involving technology and older adults, focussed on internet use and access. Other commentators suggest that, in addition to developing

robots that assist with current needs of a person, there is a need to focus on technologies that can prevent decline and maintain health (Robinson, et al. 2014).
The current authors embarked on a qualitative study involving twenty-four older adult participants in Ireland. The intention was to interact with older adults and understand their experiences of ageing and perceptions of wearable assistive robots. This paper discusses preliminary data based on analysis of eight participants.

2 Purpose of the study

The primary aim of this study was to increase understanding of day to day life and experience of adults aged over 60, and living independently in the community. Specifically, this enquiry would focus on use of technologies, activities such as dressing, and perceived barriers to adoption of technologies.

2.1 Design research and older adults

The design researcher looks beyond what people say, and captures also what people don't (or can't) do, and hearing what people don't say, (Brown, 2009). This focus and skill highlights the importance of quality, over quantity of information gathered during research. Design research can be the most thrilling ride when surprises and discovery happen. However, the designer's role as an impartial moderator (Demirbilek, 1999) also emphasises the responsibility a designer has to the participants involved in the study and their expressions and views.

The ageing global population are a cohort that will continue to grow over the coming years (UNFPA/HelpAge International, 2012). This highlights the need to consider this demographic as a group requiring design led enquiry and new product interventions that can enhance autonomy and independence. This ageing population may hold unprecedented concerns for the future. The European Commission have stated that in the future, young people (>14) and older adults (<65) may become "too heavy a burden on younger working age people (15-64) (EU, 2011)." Concerns are not just economic, and as a consequence of age, our bodies change and decline (Torge, J, 2014). As a result of longer lifespan and medical advances we are now living longer in our own homes, often with some form of functional limitation (Haak, et. al. 2007).

The requirement to involve older adults in the design process has been further discussed by numerous commentators (Fisk, et.al, 2004; Farage, et.al, 2012; Pirkl, 1994; Demirbilek, 1999; Newell, 2011) with Universal, Participatory and Co-design approaches recommended.

2.2 Technology

During literature review, numerous terms were offered when discussing 'new' technology for older adults, for example: assistive social agents, healthcare robots, personal care robots, domestic robots, assistive robots, socially assistive robots, robotic aids and assistive walking technology (Heerink, et.al. 2010; Broadbent, et. al; 2009; ISO, 2014; Smarr, et.al. 2013; Miller, 1998; Wu, et. al. 2014; Van der Loos, 2008; Feil-Seifer & Matarić, 2005 and Tapus et.al, 2007). Generally, the association with each of these authors was the need to understand, evaluate and gauge acceptance and use of these technologies.

With so many terms applying to fundamentally similar technologies, this presents a challenge to designing a study, and its language 'out in the field' to communicate with participants. Language, when used in participatory design research has been shown to optimise user engagement by the spoken behaviour of the design researcher (Luck, 2007).

The purpose of the overall study (n= 24 participants) was to learn from older adults, their perceptions to new technologies, and language, critical to their engagement when they shared stories or experiences. It was considered the familiar assistive devices such as wheelchairs, walking sticks, hearing aids would be helpful to building rapport and receiving commentary from the older adult participants. However, when robotic devices would be mentioned, the term robotic assistive

devices were used in the conversations with the participants. With consideration of exoskeletons and soft robotic trousers, the term 'assistive robots' appears to support the xosoft project outcome of a soft robotic exoskeleton. It correlates with Van der Loos (2008) who defines three areas of assistive robots, as manipulation, mobility and cognitive robots. Mobility assistive robots help a person move from place to place (Miller, 1998, Van der Loos, 2008).

3 Study approach

3.1 Methods

Creswell (2003) refers to the numerous methods that are available to researchers, namely quantitative, qualitative and mixed methods. This study will involve older adult participants and rely on their perceptions and experiences regarding wearable robotic assistive devices. For that reason, a qualitative study was undertaken with grounded theory and ethnographic strategies.

3.1.1 Grounded Theory

Grounded theory has evolved over the years. There are many commentators and authors of numerous articles and books defining grounded theory (Glaser & Strauss, 1967; Strauss & Corbin, 1994; Birks & Mills, 2015 ed; Charmaz, 2nd ed, 2014). For the purpose of this study a constructivist approach was undertaken. This approach would support the activity, where knowledge would be gained using methods such as coding, memo writing, and theoretical sampling. This in turn would be compared and contrasted to support the build of theory (2014, Charmaz).

3.1.2 3.1.2 Design ethnography

Ethnography is described as an "*integration of both first-hand empirical investigation and the theoretical and comparative interpretation of social organisation and culture*" (Atkinson & Hammersley, 2007). Ethnographic methods have been relied on as a design research tool. They are often recommended as a means to gather knowledge, and immerse researcher with participant in natural settings or environments, and needs to fit the requirements of the design challenge (Blomberg, 1993; Nesta, 2016; Salvador, et. al, 1999). Design ethnography affords the design researcher to understand what their participants do, how they think and what they say. It places the researcher in the context of the participants space or setting. To understand the lives and experiences of the participant, the researcher will enter the participants world with "*an open mind, not an empty head*" (Fetterman, 1998). Using ethnographic methods, the design researcher immerses themselves into the world of people, and discovers the participants desires and opinions of products, meanings and cultures. In addition, Salvador, et. al, note the value of other discipline influences such as anthropology, psychology and sociology (Salvador et. al. 1999).

For this study, the researcher spent time with the older adult participants in their homes. There were visits to social group sessions, and post stroke meetings in two counties. A qualitative approach of observation, audio and image capture, as well as semi-structured interviews were the main forms of knowledge capture during the five-month study period. In addition, opportunity presented to try or experience some products used daily by participants, as a means to deepen understanding e.g. a stair-lift (Figure 1). The audio files for each of the interviews were transcribed verbatim, noting observations of body language, participants tone or demeanour to different experiences or stories they shared.

Figure 1 Researcher experiencing a stair lift in participants home.

3.2 Participants

3.2.1 Recruitment strategy

Twenty-four participants were recruited for the overall study. Participants were sourced through community groups, where membership consists of older adults, e.g. Age Friendly Limerick and The Friendship Club. In addition, snowball sampling was used, where, word of mouth from one participant sharing with another, encouraged other older adults to participate. This afforded a good rapport and trust between researcher and participant. Visits to Post-stroke groups also supported participant recruitment. The full sample of participants varied in age from 60 to 87.

This paper will discuss preliminary findings from the sessions with eight of the participants. There is a gender balance mix of four male and four females, aged between 69 to 87. Four participants were married and four were widowed, and were living in rural and urban areas. Six of the homes they lived in were two-storey, with the remaining two homes classed as bungalows, or with no stairs. As required by ethics committee approval and research planning strategy, each participant was asked to complete the 'mini-cog' test (Borson, 2000). This was done prior to consent form being signed and agreed between researcher and participant.

3.2.2 Ethics

The study was approved by the Research Ethics Committee of the University of Limerick. The submission of the application included strategy and approach to observe, and spend time with older adult participants. It included the information and consent form templates that would be offered to participants to invite them to become involved. In addition, there was a consideration to the cognitive challenges that may present with ageing, and as a means to not unduly infringe or impose, a 'mini cog assessment' (Borson, 2000) was undertaken by each participant prior to consent form being signed. This is an evaluation tool to assess the participant's cognitive ability and their suitability to participate in the study. All participants passed the mini-cog test without stress or challenge. All participants were also advised (and, as stated on the information sheet) that at any time they could stop the session. In addition, image and audio capture was highlighted as tick boxes, that participants would acknowledge if they were happy for this or not, prior to signing the consent

form. Each participant was anonymised, with an agreement that should imagery capture revealing background or personal features, they would not be visible, and would be blurred.

It was explained to each participant how their involvement was of importance to the understanding and development of soft robotic lower limb assistive concept. For the participants, this was described as a soft robotic trousers. It was explained there would be a total of six questions, on various aspects of life and experiences around technology and day to day life. Six questions were developed as conversation guides to the sessions, these questions were developed to optimise the interactions between researcher and participant. The questions are listed and displayed on Table 1:

Table 1 Fieldwork questions:

Question number	
1.	What are your experiences using or helping someone to use assistive devices and/or technologies? –sub a) Glasses or hearing aids; b) Computers or smart phones; c) Rollator or wheelchairs.
2.	Describe any difficulties or barriers to using a technology device?
3.	If you are/were to experience reduced mobility, how does/would it affect your way of life?
4.	When I mention robotic assistive devices, describe what that means to you?
5.	What is your opinion of older adults being supported by robots to do tasks and activities?
6.	How do clothing and dressing options change as we age?

4 Results

4.1 Semi-structured interview sessions

Six semi-structured interview sessions – 'conversations' were arranged with the eight participants. Two of these were conjoint; involving, one married couple, and the second involving two friends. One of the single participant interviews involved the participants daughter entering the room at various times and offering commentary with regard to whatever topic being discussed during the conversation. Prior to the session, each participant read the information and consent form. In addition, they completed the mini-cog test and were offered opportunity to ask any questions before beginning to record the session.

To portray activity and commentary during the sessions, the conversations were broad, and facilitated the older adult participant, the freedom to discuss ageing experiences and technology in general; and on their terms. This approach supported a user-led empowerment and the opportunity as a researcher, to see the world through the participants experiences and stories.

4.2 Findings

The preliminary findings were coded using Nvivo software (QSR International). A total of 341 codes were generated from 3,098 referenced comments from the eight participant's interview transcripts using line by line coding and generating open code techniques on Nvivo. From the initial open codes (phase one) [341], eleven categories (phase two) emerged which are displayed on Figure 2:

Figure 2 Categories emerged from initial open codes.

The eleven categories displayed have a number of sub categories to each. Each one is displayed and defined in Table 2. The categories were generated from each code and based on the following criteria: a) volume or quantity of the recurring topics; b) quantity of comments to a particular code i.e. wheelchair use. A breakdown of codes to categories, with definitions are displayed in Table 2:

Table 2 Categories, definitions, sub categories.

Category	**Definition**	**Samples of codes generated from transcribed interviews**
Accessibility	How accessibility is experienced to a number of places or settings.	Home; Home adaptation; Bathroom; Stairs; Steps; Stoves & Fires; Kitchen; Doors; Entry & Exit points; Nursing home or life planning; Ramps; Packaging; Furniture; Lifts; Product adaptation; Public Buildings; Road surface; Footpaths; Assistance or grants.
Ageing	The experience of ageing.	Daily activities & tasks; Dressing; Toileting; Travel; Transport; Reminiscence; Career or profession; Retirement; Accidents; Acceptance of ageing; Personal tasks; Trust/trust people; life adaptation; less active
Assistive Robots	How these new technologies are perceived.	User expectation of assistive robots; Barriers to adoption of; Positive perceptions; worn or carried devices; personalised or tailored; unsure of what an assistive robot is; emotional or personal connection.
Death	The effect and thoughts about death, or passing by self and others.	Coping after death of a life partner; Death of others; Death of self.
Family	How we interact and engage with family life and relationships.	Familial stories; non-family stories; Children; infantilising parent; children assisting parent; inherited devices; being a couple; being a burden; family trust; connecting and communicating; older adult parent supporting adult children.
Health Conditions & Care	Experiences using healthcare services, and the assistive devices and health conditions discussed by the eight participants.	Healthcare; Service systems; stories & experiences; dissatisfaction; relationships with health professionals; Hearing aids; challenges with hearing aids; Glasses; challenges with glasses; Experiences using assistive devices; experiences helping someone use an assistive device; wheelchair use; crutches; mobility scooters; personal alarms; shared stories; Health conditions – *Arthritis, Bladder, Blood pressure, Alzheimers, cancer, colostomy, diabetes, sleep apnoea, stroke, varicose veins,*

		vision, hearing, DVT, Diabetes, Heart, leg, feet, spine, overweight, skin, pain, sleep, memory, medication, *IBS.*
Hobbies & Interests	The social hobbies and interests that affect our daily experiences.	Holidays; Walking; Volunteering; Television, Reading; Dancing; Day trips; Tea & Coffee; Clubs & Groups; Cooking & Baking; Music; Being kept busy; Gardening; Keeping pets, Games.
Dependence & Independence	As we age and remain independent or begin to experience times when we can be dependent.	Quality of life; Fear; Anxiety; Loneliness; Being alone; Assistance; Not wanting to be a bother; appreciate help; embarrassment; self-critical; Empowerment; Limitations to independence; Accomplishments. Shopping; Assisted shopping; Costs & expense; Service providers; Bills & Utilities; Online shopping.
Physical Decline Awareness	How self-aware we are to the change that ageing may introduce to our lives.	Resilience; user adaptation with assistive devices; Mobility; Problems with mobility; Task planning because of reduced mobility.
Stigma	Times when experiences can be uncomfortable.	Perceived social barriers; Technology; Stories and experiences shared.
Technology & Devices	The numerous devices we interact with daily, and the technologies that support them.	Technology acceptance; Everyday Devices – Telephones, Mobile phones, computers, iPads, tablets; Internet; Usability & Function, Anxiety, Confidence, Technology Trust, Robot Trust; Social Influence.

The categories were then compared further with existing codes and refined to four distinct Themes (phase three), expressed by the data presented. The four themes namely are: Ageing, Health Conditions & Care; Technology & Devices; Quality of life. This process is visualised on Figure 3.

Figure 3 Four themes emerged from data.

As a means to display further the manual construct and endorsement of connections to each category and themes, from the codes, this work was mapped, and is displayed in digitally generated images, (Figures: 4, 5, 6, 7).

Figure 4 'Quality of Life' theme mapped connections from codes to categories, digital generated version.

Figure 5 'Ageing' theme mapped connections from codes to categories, digital generated version

Figure 6 'Health Conditions and Care' theme, mapped connections from codes to categories, digital generated version.

Figure 7 'Technology & Devices' theme, mapped connections from codes to categories, digital generated version.

Figures 8 and 9 detail the development graphically from **codes** (phase one) to **categories** (phase two) to **themes** (phase three). Starting from the outer circle the initial codes generated from transcribed interviews. The middle circle shows how the categories emerge, before finally the inner circle shows the themes. There are a series of one large and six smaller charts, the first showing the overall group and each of the six referring to each of the interview sessions (two were performed with 2 couples together).

Figure 8 Graphical display of theme development from the overall group of eight participants, generated on Nvivo. Note how the outer circle (phase one) converges into phase two categories, and evolves finally, to the inner circle of themes.

Figure 9 Graphical display of theme development from each of the interview sessions, generated on Nvivo.

4.3 Session snapshots

As a means to share insight and the rich data expressed during the conversations, this section highlights and shares snapshots of responses by the participants (M= male; F= female).

Q1: What are your experiences using or helping someone to use assistive devices and/or technologies? –

Participant Eight (M) – "*He said [Consultant] I was severe sleep apnoea, and the next night was, now, we have to put you on machines and test, to see what strength you require, to tailor it [sleep apnoea machine], for my needs so, I rented it for the first year or two, then I thought, I'm renting this, and the man who supplies it – I asked - and what if I was to buy this? Well he said, I can sell you that machine, look it will do you for another two years, so half the price."*

Participant Three (F) – *"Oh, I have, they're left everywhere!"* [speaking of the numerous walking sticks in different areas of participants home].

Q1 a) Glasses or hearing aids;

Participant Four (F) – *"She [participants sister] takes it out [the hearing aid, when the participant phones her sister] she takes it out! And it's her family have told me what she's doing, but she won't admit it to me."*

Participant Seven (M) – *"I can hear the person beside me alright, if the person …people; if it's a babble of conversation and everyone's talking together, then I'm lost [problems trying to hear layers of conversation with hearing aids]."*

Q1 b) Computers or smart phones;

Participant Five (F) – *No, it's always on ringtone [mobile phone]. It fits in my pocket, it goes everywhere with me."*

Participant Six (M) – *"Another thing about the phone is, you have a line, that you, for medical reasons [or devices like personal alarms]no, but you can actually um, use, um, use other older aids if you like through the landline."*

Participant Two (M) – *"I have a smart phone, it's a hand me down from XXXX [daughter]."*

Q1 c) Rollator or wheelchairs.

Participant Eight (M) – *"I didn't realise how much you needed to know, how to balance a wheelchair, how to get it up and down."*

Participant Four (F) – *"I'll give you an example [helping someone in a wheelchair] about one particular man; he needed it [wheelchair] so badly, um, he got it, we were at a seaside resort and he got into the wheelchair and as he went down, closer to the house normally he would spend his holidays in. It was a B&B, he got out and he said, I don't want her [the landlady of B&B to see me [in a wheelchair] she mightn't take me."*

Q2: Describe any difficulties or barriers to using a technology device?

Participant Eight (M) – *"Doing things that involve money or cash, that mightn't be right, you hear so many things going wrong with that technology, you know what I mean? People scammed or doing this, you know what I mean? I'd be nervous in that sense to go that far, I should maybe, I should push myself more, not to bothering my kids, but they make it so easy for me."*

Participant Five (F) – *"I wouldn't be able to…" [fingers, isn't it Mum –participants daughter]* - participant has difficulty using key pads or any device that requires input with fingers.

Participant Three (F) – *"I don't understand them, and I have no use in … you know?"*

Participant Seven (M) – *"If it operates on a battery it has to be regularly charged."*

Participant Two (M) – *"I suppose the, um, the eh, things are too small. [mobile phone screens] The fingers are too big. The numbers there you know? yeah and you know like, now they're big enough [directed to iPad screen] but if you're writing something, it's [the text] very small."*

Q3: If you are/were to experience reduced mobility, how does/would it affect your way of life?

Participant Eight (M) - *"well there's only … I'd say you'd be trying to hide it more than anything, if you could, maybe that's not the right word 'hide' but sure look, pretend you're not as bad as you are. I wouldn't like to be a burden on my family."*

Participant Five (F) – *"It makes me feel bad that I can't do a lot of things for myself, you know, right now."*

Participant Four (F) – *"Well, I was to learn that very recently, I had, I pulled tendons and ligaments in my foot and eh, for me, it meant I couldn't leave the house without help. I live in the country [rural area] there is no public transport. I would be completely and utterly isolated."*

Q4: When I mention robotic assistive devices, describe what that means to you?

Participant Three (F) – *"It doesn't mean anything. I haven't seen them, I can't ever say I've seen them."*

Participant Seven (M) – *"I feel, well no, I think it's more than that, I think there's, eh, a personal relationship with these robots, unless; when they begin to break down, it's like a serious illness, you know; you almost know you need a new one. It's when your car gives you trouble, you need a new car, you have an attachment to the old car, but, at the same time, it's not as reliable, and you need something reliable."*

Participant Six (M) – *"Take the comparison like, what we were talking about earlier on; you needed to go to the toilet, or whatever it was. I don't think you would have any embarrassment about asking a machine to do it for you [assisting toileting]."*

Q5: What is your opinion of older adults being supported by robots to do tasks and activities?

Participant Eight (M) – *"Yes, to my family, I'd say, I'm with my… my friend [assistive robot] is with me today and they'd [family] say, oh you will be alright today, as I say, my friend is with me today, So, I'd accept it like, and the family would, yea, yea, 'Joe' [assistive robot] is with me, and we'd call him like…"*

Participant Three (F) – *"Sure it would get me to do more. I wouldn't be sitting down in the chair half the day sleeping, I'd love to be able to get around again. I'll never see 16 [again] anyhow."*

Participant Six (M) – *"let the person have that option, let that be one of their options [personalising or customising the robot] if they can take it from a photograph, whatever, and make him look like [for example] my husband, he's now doing things that he never did in his life when he was alive, so, you know, you know; yeah, mental, and physical, to their physical, emotional…"*

Q6: How do clothing and dressing options change as we age?

Participant Eight (M) – *"But, I mean if I don't, if I was I need something [shopping] I need milk or I think I need butter… If I have to buy another shopping bag, it'll kill me, so I got into the habit, I stick one [shopping bag] in the back pocket [of trousers]."*

Participant Five (F) – *"I know, yeah, going to the loo, trying to [remove tights] everything hurts [participant has arthritis in her hands]"*

Participant Four (F) – *"Well, things, you are trying to conceal, the bulges I suppose because they are there, and but eh, in addition to that you know, you don't have the curves that you had before so therefore you kind of tend to wear things that maybe are 'boxy' on you or maybe a little bulgy in the wrong places."*

Participant Six (M) – *"But, I think, colours express your mood as well. I think more so, again, with ladies, going… but you know, if you see someone in black all of the time, you can bet your bottom dollar that person's very down."*

The snapshots are brief insights to the descriptive answers by the participants, to initial six questions. Each session lasted between 40 mins and 1.5hours.

This study reveals many expressions and perceptions the older adult participants shared in relation to technology and its acceptance or abandonment. The participants expressed at times a sense of stigma, self; or observed, and likewise a dependence at times on others to support technology use and acceptance.

The participants expressed commentary on various technology devices and service systems. In relation to robotic assistive devices, there was a range of opinion, from not knowing or showing interest in the potential of robot assistance, to visualising an emotional connection and personalisation of them e.g. giving the robot a name. In relation to stigma, it appears that there is an attempt by some people to cover up or disguise a condition (e.g. poor hearing). However, becoming a burden is a worry and cause of anxiety among some of the participants. At times, some of the participants referred to older adults in a way that deflected from their ageing (e.g referring to 'granny shoes' they wouldn't wear; other older adult friends of a similar age, that needed their help). Personal appearance was perceived and expressed as a determinant sometimes of someone's mood (e.g. the colours they wore) and a conscious effort to feel comfortable.

5 Discussion

The preliminary findings presented in this paper offer insights to the rich content by contextual enquiry, that can be undertaken with a relatively small group of participants. It offers expression of an intimate nature at times. This requires the build of trust and rapport between researcher and participant. The stories and share are a valuable commodity to draw on throughout the process of design. They are to be valued and captured with both respect and concern that the participant is heard, and their experiences voiced, with relevance to product or service system development. Participants can identify challenge or problems of use and experience with products or service systems. Designers' define and develop solutions that attempt to address the participants expressed problems. In addition, design research adds rigour by observing the unspoken, creatively logging and delivering insight that informs products and service system development that can enhance quality of life.

This study asked the older adult participants, what their perceptions were to newer technologies, by mentioning and discussing robots and exoskeletons. This introduction at times was challenging to visualise, and also insightful, with topics such as personalisation, colour, function and user-expectation being discussed. Existing TAMs that are designed to gauge acceptance and use of robots or technology devices by older adults afford some enquiry to constructs such as adaptability and trust, however the nature of a wearable exoskeleton (e.g. xosoft) may become, in effect an item of clothing with various features that require understanding and use potential & optimisation. Examples of some of the questions raised by the participants in this study:

- How to put it on and take it off?
- Would it be noisy?
- How fast would it go?
- What would it cost?
- How would it operate (e.g. battery) – does it need to be charged? And remembered to?
- Wearability – People wearing the same item and other people noticing or knowing, it's the 'same trousers'
- Aesthetics – what it would look like, and look like when wearing?
- Human Factors concerns – e.g. Diabetes, arthritic hands/joints etc.
- Collision detection/falls would it know or protect you?

To date there does not appear to be a TAM or tool that can effectively capture exoskeleton or robotic assistive device acceptance and use, studies such as the one discussed in this paper, could provide the basis for such a tool.

5.1 Research limitations

This paper discusses preliminary findings from a cross section of eight participants involved in a larger study that involved twenty-four older adult participants. Due to the rigour of the process and time constraints, a cross section of the study was analysed to highlight the insights and experiences shared during the interview sessions. In addition, it can be a caution to interview two people together in a conjoint interview setting. There is a risk that one participant may feel less inclined to openly be expressive and commit commentary to the session. However, it can also be an empowering and rich experience where stories can have heightened perspectives shared and discussed collectively.

It was acknowledged that despite the older adult participants being independent, and living in their own homes in the community, that in some instances, 'gatekeepers', i.e. family members may be aware of the research and visits to homes of participants. It was envisaged that should this present as a problem, that there would be an openness and an effort to build trust between the gatekeeper and researcher. During the study, an episode was encountered where the daughter of one of the participants spoke on the phone to enquire more about what would happen during the session. The participant in question lived with her daughter, and family. It was important that everyone was comfortable in this scenario, and the researcher successfully overcame this challenge by building rapport with the daughter and inviting the daughter to feel free to sit in on the session if participant was happy with this. The session was conducted comfortably for all.

6 Conclusions

This study was an endeavour that facilitated freefall contextual enquiry by the researcher with older adult participants. The accommodation and openness shared by the participants revealed intimate share of the world through their eyes. In addition, opportunity presented to see and engage with devices typically associated with ageing, and support by assistive devices, i.e. walking sticks, stair lifts and sleep apnoea mask. These devices have become part of day to day life for some of the participants. Insights such as, the participant with sleep apnoea having to ensure the device is packed as part of holiday luggage to ensure a pleasant and healthy holiday.

The methods presented here display rigour and application of work collected and gathered out in the field and driven by real commentary and perceptions by the older adult participants. Older adults have a tacit understanding, and experience of life that is new – ageing happens only once - we are alive until we die. The older adult participants discussed, what can be conceived as 'sensitive' topics such as death, the loss of a partner, the feelings of being a burden. Tasks such as dressing or needing assistance were on occasion empowering but also acknowledged as an aspect of physical decline awareness. The recollection of one participant (aged 81) arriving to an interview carrying a 'dashcam' that they would fit themselves, highlights the embrace of technology, yet conversely another participant preferring the assistance of family, to new technology or technology tasks (i.e. updates on computers, shopping online). This diversity of technology adoption by the older adult participants endorses this study and the potential for support tools development that assist understanding to technology acceptance.

It is clear from the experiences shared by the older adult participants that there are many pleasures, and causes of frustration, or anxiety to the use and acceptance of technology as we age. Likewise, the presence and potential of robots and robotic assistive devices is an area yet to present measurement or acuity by older adults. As an emerging technology, there is a need to enquire and express further the needs requirements of the ageing population and the acceptance and use of these devices in day to day activities and tasks.

The findings of this study require further analysis and build to incorporate the findings of the remaining 16 participants insights. When this work is completed, it will be compared and contrasted separately and collectively to understand and define a hypothesis that directs the build potential of a Technology Acceptance Model that is not currently available, namely an evaluation tool to gauge technology acceptance by older adults to assistive robots, and specifically exoskeletons.

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A Study of Roles and Collaboration in the Development of Assistive Devices for People with Disabilities by Clinical Experts and Design Experts

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This study is part of a research program promoting the expertise of professional manpower in the Korean assistive device industry. Based on interviews with clinical and design experts, the authors discuss the advantages and difficulties of this collaboration, and suggest ways in which it might be improved. They discuss the roles of clinical and design experts, and consider the product components involved in the development of assistive devices. The roles of clinical experts and design experts have common elements in that both groups take a human-centered approach to product development. Design and clinical experts should collaborate further in the development of assistive devices, and this should lead to the shortening of product development time and to user needs being better met in new products. Research exploring guidelines for collaboration is needed in order to solve problems and difficulties arising from the convergence of these two areas of expertise.

roles of specialists; collaboration; assistive devices; human-centered design

1 Introduction

1.1 Background and Purpose

Assistive devices and technologies are those whose primary purpose is to maintain or improve an individual's functioning and independence, to facilitate participation, or to enhance overall well-being. Examples of assistive devices and technologies include wheelchairs, prostheses, hearing aids, visual aids, and specialized computer software or hardware that increase mobility, hearing, vision, or communication capacities (WHO, 2017).

According to a survey of the assistive device industry in Korea (Kweon & Park, 2012), 64% of companies active in that industry are private enterprises rather than corporations, and more than 40% have capital of less than US$ 44,610. Although almost 60% of the respondents indicated that they were investing in research and development, the scale of their efforts and the methods they

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employed were variable. They reported difficulties in creating the systems necessary to manufacture assistive device, procuring operating funds, financing technology development, securing a place in the domestic market, and exploring overseas markets. Apparently as a result, the Korean assistive device industry is quite small and lacks the required infrastructure and manpower. In general, further research into product development work using limited numbers of people is necessary; there is also a specific shortage of research on the needs of assistive device makers and on how they might assemble a workforce with the necessary expertise.

Choi et al. (2006) note that companies involved in assistive device production often have little awareness of the existence of AT (Assistive Technology) experts. As a result, it is difficult for AT companies to deploy research and development in order to develop the domestic market or to build a strong global position. A pool of trained professional AT manpower will not emerge if jobs are not available. A multidisciplinary approach involving occupational therapists, physiotherapists, audiologists, and other rehabilitation experts is necessary to understand the levels, types, and functional characteristics of disabilities and to meet the needs of people with these disabilities.

In this study, the authors regard clinical and design experts as fundamental to assistive device development. Both groups have roles to play in product development, in bridging the gap between humans and technologies. However, there are differences in the background knowledge and approaches of these two expert groups—that is, clinicians and design experts—and, consequently, there will be differences in their roles.

The authors of the present study first discuss why collaboration between clinical and design experts is necessary, and identify ways to facilitate this collaboration. Second, they examine the commonalities in, and the differences between, the roles of these two expert groups. Third, they analyze the product components that both groups employ in the development of assistive devices. Through this approach, the authors intend to promote collaboration and increase the efficiency of research and development relating to assistive devices.

1.2 Method and Scope

This study uses the analysis of expert interviews as a qualitative research tool. Research of this kind reconstructs social situations or processes in order to build knowledge in a sociological way. Interviews provide researchers with specific knowledge from participants in the specific situations and processes under examination. In this research, interviews were semi-standardized; although the interviewer's role was structured by a pre-determined questionnaire, each interviewee was free to answer questions in his or her own way (Gläser and Laudel, 2009).

Six experts were interviewed using the four question types proposed by Krueger and Casey (2009): opening questions, introductory questions, key questions, and ending question. Key questions related to the interviewees' careers and roles in assistive device development, their expertise in assistive device development, their perceptions of the advantages and disadvantages of collaboration, the product components they considered most important, and the HAAT model of assistive technology production. To facilitate analysis, all interviews were recorded, with the consent of those involved. Two authors worked on each interview, to agree and analyze its content. The transcribed contents were categorized according to themes observed among the words, contexts, emotional expressions, and actual experiences reported. Based on the results that emerged, the authors debated: the necessity, merits and difficulties of collaboration; how to improve collaboration; a definition of the roles of clinical and design experts in the development of assistive devices; and the product components that each expert considered crucial to the development of assistive devices.

Three clinical experts and three design experts were selected. Each had more than five years' experience in collaborating with experts from other fields in assistive device development. Clinical specialists were limited to occupational therapists who developed assistive devices and services. Assistive technology is one of the powerful frames of reference available to occupational therapists

(Jang, 2005),so occupational therapists are typically more associated with assistive technology than other clinical specialists. Interviewees are described in Table 1.

Table 1 Information on Subjects.

Division	C1	C2	C3
Highest degree and major	Ph.D. in Occupational Therapy	Master's in Ergonomics Therapy	Ph.D. in Health Science
Field experience	5 years	8 years	5 years
Details of assistive device development project undertaken collaboratively	Eye movement tracking mouse: a free development and dissemination project for ALS patients	Car seat development project for children with disabilities	Development of low-level exercise equipment for stroke patients
Division	**D1**	**D2**	**D3**
Highest degree and major	Ph.D. in Design	Ph.D. in Design (to be completed)	Ph.D. in Design
Field experience	More than 10 years	6 years	11 years
Details of assistive device development project undertaken collaboratively	Universal design guide for the elderly	Walking assistance robot designed for the elderly	Walking rehabilitation equipment for stroke patients

The research structure of this study is shown in Figure 1.

Figure 1 Research Structure.

2 Theoretical Background

2.1 Clinical Experts

2.1.1 Occupational Therapy and Occupational Therapists

The purpose of occupational therapy is to allow people with disabilities to live with the best possible function in relation to the physical, social and cultural aspects of life. Medical science provides the

theoretical background for occupational therapy. For this reason, the occupational therapist must understand, from a medical point of view, theories of disease, injury and functional limitation resulting from a disability. He or she provides therapy to reduce the limitations on daily living caused by these limitations. The role of an occupational therapist, therefore, is to analyze the activities of the subject, to evaluate their function, to train the subject in an environment where ability is maximized, and to select technologies appropriate to the subject's function (Pedretti & Early, 2001).

2.1.2 Theoretical Perspective of Occupational Therapists

Figure 2 The relationship between user functioning and AT usability. source: Arthanat et al., 2017

Functional limitations due to illness cause restrictions on participation in economic activities, education, play and daily living. Of the various intervention methods available, the application of assistive devices is seen as the best approach to overcoming functional limitations. Thus, when assessing the usability of an assistive device, the occupational therapist assesses the quantitative and qualitative recovery of function, as shown in Figure 2, to determine usability.

2.2 Development of Assistive Devices

2.2.1 Assistive Devices and Usability

The rehabilitation paradigm for people with disabilities is shifting from a treatment-oriented approach towards strategies that combine rehabilitation therapy and technology. From a series of attempts to overcome the limitations of rehabilitation, the use of technology has emerged as playing an important role in improving the accessibility and convenience of the daily and social lives of people with disabilities (Lee et al., 2012)

In one survey (Jung et al., 2009), 43% of respondents who had bought an assistive device themselves said that they did not use it because it was inconvenient. Respondents also said that the devices 'do not help me with what I need' (14.3%) and 'are ill-suited to my needs, preferences, and lifestyle' (14.3%). In essence, a major factor in the non-use of assistive technology devices is lack of usability. When the respondents were asked about the main reason for choosing their assistive devices, 38.8% answered 'efficacy,' 26.5% 'comfortable use,' and 8.3% 'safety.' The results of this study, therefore, suggest that the usability of an assistive device is also an important determinant of purchase decisions.

Unlike other consumer products, an assistive device is used by someone with a disability who has physical and functional discomfort. In addition, an assistive device differs in that it replaces or supplements the physical functions of the user. In contrast with medical devices, it is necessary to consider the complex context of the daily activities with which the user is in need of assistance. Therefore, assistive devices—a daily necessity for people with disabilities—need to be studied in terms of usability, considering the user, the context, and the environment (Kim, Chae & Kweon, 2017).

2.2.2 The Status of the Korean Assistive Device Industry and Supply

In many respects, the Korean assistive device industry is limited by its small size. Its import-oriented distribution structure has prevented the industry from becoming self-sufficient and competitive (Kweon & Park, 2012). The total government budget for the support of assistive device research and development, for the five years from 2011 to 2015, was about US$ 7.4m. A study of the government's support and activation plan for assistive devices for people with disabilities in Korea points out the lack of support for commercialization, which it links to the problem of inadequate support for national research and development. While important fundamental technologies exist, they are not yet being properly developed. Attempts at commercialization, therefore, have proved problematic (Korea Disabled People's Development Institute, 2016), resulting in dependence on imports rather than on domestic devices. Korean research and development needs to result in commercially available products.

In Korea, people with disabilities purchasing assistive devices benefit from financial support from the government as follows: 90% of the purchase price—which is capped—is offered by the government, with the remaining 10% of the expense borne by the user. For example, the maximum amount the government offers towards powered wheelchairs is US$ 1,900. If the actual purchase price of the product is US$ 18,500, only 90% of the US$ 1,900 maximum is provided through government support. In reality, therefore, financial support is very small, owing to the difference between the real cost of an assistive device and the government's upper limit. In addition, the list of assistive devices for which financial support is available is very limited, leaving many important products that have to be purchased at the personal cost of the person with a disability. This limited support for the purchase of assistive devices has caused the burden on people with disabilities to increase, in part because the government's policy has not kept up with market changes or changes in individual needs (National Health Insurance Service, 2016).

3 The Necessity and Benefits of Improving Collaboration

In the interviews, both clinical and design experts said cooperation between their two disciplines is necessary in the development of assistive devices. Both groups focused on applying the characteristics of people with disabilities to a product, and concentrating on the factors that enable people with disabilities to make good use of their products. However, since each expert offered a somewhat different point of view, it appears necessary for cooperation to begin in the early stages of development. The clinical experts considered the functional aspects of a given product mainly in relation to the characteristics of its users, while the design experts primarily considered the product's usability aspects. Table 2 shows the responses to the question about the need for collaborative work.

Table 2 The need for collaborative work.

Division	C1	C2	C3
Clinical expert answers	[It is] needed. Clinical experts have a lot of knowledge about rehabilitation and disability. However, commercializing technologies through product development is the strength of design experts. Each expert's perspective is different. From the beginning of the development process, the participation of the two experts seems to offer the prospect of greater efficiency.	I think it is necessary. The results of collaboration should enable a technology to be applied more effectively to the human user. Therefore, I think that clinical and design experts need to complement each other in order to develop human-centered products.	It is absolutely necessary. The roles of clinical and design experts are different: the clinical expert provides user information; the design expert visualizes actual ideas.
Division	**D1**	**D2**	**D3**
Design expert answers	I think it is necessary. Design experts are well aware of the technologies involved in a product, but they need a clinical expert to better understand the user.	[It] goes without saying. Clinical experts are very helpful in field work because they are familiar with the details of the story and of the situation.	[It's] needed. Designers can't make medical devices using a generic product development process. The experience of clinical experts who are familiar with the characteristics of people with a disability is very important to understanding their needs.

Questions and answers concerning the benefits of collaboration are shown in Table 3.

Table 3 The benefits of collaboration.

Division	Interview questions	C1	C2	C3
Clinical Experts	What do you see as the benefits of design expert participation in the development of assistive devices?	Discovering new perspectives and learning how to approach the process. Clinical experts are not focused on development (they focus on treatment, improvement, and maintaining function). I was able to see the process from the designer's point of view, which was more focused on product development.	Considering sales in assistive device development process. Commercialization is easier with the participation of design experts (and it results in time reduction). Users' aesthetic needs as well as their functional needs are met.	Visualization of the product in its realizable form is possible. The implementation of feedback is faster, and the progress of the work, therefore, is easier.
	How did collaboration with design experts help you improve your skills when developing assistive devices?	As our understanding of design terminology increased, communication with designers became clearer than before.	I was able to learn about important development factors (e.g., intuitive usability) from studies in product development.	I acquired design knowledge, and learned the language used by design experts relevant to each situation. Having experienced this different perspective,

				coordinating differing opinions became smoother.
Division	**Interview questions**	**D1**	**D2**	**D3**
Design Experts	What do you see as the benefits of clinical expert participation in the development of assistive devices?	They raise important issues related to users. They provide useful guidance for product development by offering helpful explanations of certain problems. During our collaboration, I gained information and knowledge about the context in which I was working.	On-site communication, such as interviews, makes for a tighter connection with the product users.	It is like creating a shell with no function, when only designers are involved.
	How did collaboration with clinical experts help you improve your skills when developing assistive devices?	[I] learned a lot from the presentation of research undertaken with users.	It is very helpful in this field. I learned how to use literacy data in practice, and how to explore it in order to gain deeper insight into the task.	Understanding the characteristics of the patients, and drawing up details of their short-term requirements.

The difficulties encountered in collaboration, and the areas that need to be improved or corrected in the course of collaboration, are shown in Table 4.

Table 4 Difficulties and necessary improvements in collaboration.

Division	**Interview questions**	**C1**	**C2**	**C3**
Clinical experts	What difficulties have you encountered when involving design experts in the development of assistive devices?	As the number of participants in the development process increases, the time and cost involved also increase. There is also the burden of maintaining control, communication, and collaboration among so many stakeholders.	It is time-consuming to add a design stage in the product development process, and communication is not always smooth.	Confusion about differences in terminology can arise, sometimes resulting in unintended consequences.
	How can the interactions among groups of experts be improved or modified to facilitate better collaboration?	We need to respect each other's expertise. Understanding each other's scholarship is important. Clarity of responsibilities is also required of each expert.	Increasing opportunities for collaboration will enable better communication among experts.	There is a possibility of friction emerging among experts of different disciplines.
Division	**Interview questions**	**D1**	**D2**	**D3**
Design experts	What difficulties have you	Basically, the understanding of	The terms that were used by design experts	In the prototype phase of working, the clinical

	encountered when involving clinical experts in the development of assistive devices?	design and decision making is different at the development stage. Conflicts can arise when colleagues persist in emphasizing their own understandings.	were not always accessible to clinical experts.	expert receives a lot of feedback. This increases the intensity of the workload.
	How can the interactions between groups of experts be improved or modified to facilitate better collaboration?	We need an open attitude in order to communicate well. Also, from the start, stakeholders should be involved in the process, so that their willingness to participate is maintained.	It is necessary to meet from the beginning. If I had a basic manual showing when to meet and talk, it would make things easier.	We need some collaborative guidelines so that we can apply everyone's ideas objectively and move in the right direction.

A common opinion was that a key advantage of collaboration was a shorter development time, but that confusion around terminology was a clear disadvantage. Clinical experts said that development time was shorter because the process of visualization of ideas became smoother; the design experts perceived that a better understanding of the user's needs similarly allowed a shorter timescale.

Although both clinical and design experts say that collaboration is necessary, it is rare that experts actually collaborate on assistive device development projects. In addition, even when both clinical and design experts are involved, there are few cases where they collaborate from the very first stage of development. The Korea Disabled People's Development Institute notes that the assistive device industry depends on imports and that the research and development of products are insufficiently commercialized in Korea. Domestic design and clinical experts should collaborate in the development of assistive devices, which should lead to a shortening of product development time and users' needs being met more accurately in new products. This will increase the merchantability of new products and promote the commercialization of research and development output. It is necessary, therefore, to explore how cooperation between these two expert groups can be encouraged. Based on an understanding of the roles of the two expert groups defined in this research, moreover, it is necessary to study the manpower requirements of the processes in assistive device development projects. There can be a lack of understanding and respect for the expertise brought by counterparts from another discipline, and communication difficulties arising from differences in language use can also arise. In order to improve collaboration, it is necessary for those involved to learn more about the process of collaboration. In particular, it is necessary to clarify the perspectives and roles provided by each discipline, to improve communication by learning about relevant terminology, and to facilitate the interaction of experts in the development process. Together, this suggests the need for guidelines on collaboration itself.

4 The Role of Clinical and Design Experts

Table 5 lists questions and answers regarding the role of clinical and design experts, as seen by the clinical experts.

Table 5 Expert roles as seen by clinical specialists.

No.	Interview questions	C1	C2	C3
1	What do you think is the role of clinical experts in the development of assistive devices?	Building a foundation for development based on theoretical and practical knowledge of, and experience with, the user.	Predicting problems with the assistive device based on knowledge of disabilities. Applying newly developed assistive devices to people with disabilities, and training them as users.	1. Determining the object, purpose and appropriate function of an assistive device. 2. Judging whether it is appropriate after development.
2	What do you think is the role of design experts in the development of assistive devices?	Drawing out areas that could be missed during development, such as specifying and segmenting particular needs, and typifying product composition.	Aesthetics and functionality of products.	The role comprises visualization, specification, and making tangible the clinical experts' summaries.
3	Do you think that experts from both areas have a common role?	Analyzing, observing and evaluating users (people with disabilities).	A human-centered approach to product development as a basic first step.	Involvement in the development itself provides a common role.
4	What do you think is the positive impact of your involvement in your assistive device development project?	Providing knowledge and know-how about the actual lives of people with disabilities.	Obtaining and providing data based on an understanding of the subject (people with disabilities, and the elderly). Highlighting improvement points in relation to actual subjects. Delivering information in terms easily understood by other experts.	In working with the assistive device, I can find practical problems and help solve them. Also, I am able to judge the results of any alternative solution devised.

The common role of clinical and design experts in the development of assistive devices is to analyze and evaluate users, to think about ways in which devices are used, and to fill in the gaps between humans and machines. The role of the clinical experts in the development of assistive devices was identified as defining the objects, objectives and appropriate functions of the assistive devices, based on an understanding of the disability. In addition, clinicians are able to judge whether an assistive device is suitable and to predict problems. The role of design experts in the development of assistive devices was identified as the segmentation of ideas, realization of actual products, visualization, and determination of technological possibilities. It is also evident that the role of design experts was to commercialize ideas and to deal with technical aspects of the new products.

The 'evaluation' provided by a clinical expert is an evaluation of the functional status of the user (a person with a disability) and of whether the user's function is recovered when the product is deployed. This term is used differently when a design expert 'evaluates' the usability of the product.

Table 6 shows questions and answers regarding the roles of clinical and design experts as seen by the design experts.

Table 6 Expert roles as seen by design experts.

No.	Interview Questions	D1	D2	D3
1	What do you think is the role of clinical experts in the development of assistive devices?	It depends on when they are brought into the development process. Their participation helps to understand the user.	Providing information about the characteristics of the subject (elderly persons) and their usage status. Determining whether the result is usable.	It is important for clinical research to maintain consistency so that it can proceed according to a clear protocol. Consistent clinical studies help in identifying problems.
2	What do you think is the role of design experts in the development of assistive devices?	Providing solutions to issues and moving projects towards their resolution.	Consideration of usability. Detailed knowledge of product materials and of design elements.	They deal with design, interview analysis, clinical research, usability evaluations, testing and compliance with FDA requirements. They catch problems in products that appear during clinical studies.
3	Do you think that experts from both areas have a common role?	End-users are important to both groups, but I think that roles and positions of each group will be different in each development process.	An approach which emphasizes the user's point of view.	The identification of problems and implementation of improvements through clinical research. Solving problems so that devices can provide optimal functionality in the field. (Clinical experts have responsibility for the functional part; design experts, for the usability part.)
4	What do you think is the positive impact of your involvement in your assistive device development project?	When I was conducting a field survey, I actually looked through the situation analysis to see what was inconvenient and what the problems were.	Basically, improving the design of the external part: usability, aesthetic aspects, etc.	End products that are developed to match as closely as possible the original purpose. Increased marketability with clear results. Products that fully reflect usability, accessibility, worries about maintenance, and worries about stakeholders. Products that are attractive for export.

The design experts agreed that understanding the user was a common role of the two expert groups, and that a common starting point was to think from the user's point of view. In addition, they said that both groups should use clinical studies to elucidate problems and improvement points so that problems could be solved in ways that allowed equipment to perform optimally. The role of clinical experts was seen as providing users information and resolving issues. The role of design experts was said to be enhancing the completeness of products, by considering product-user interactions and by upgrading products as a whole.

Table 7 summarizes the roles of clinical and design experts resulting from the interviews.

Table 7 The roles of clinical and design experts.

Division	Clinical experts	Design experts
Common roles in the development process	Human-centered approach to product development	
Differences in background knowledge	Theoretical knowledge and experience of functional limitations of disabilities	Understanding product components, visualization technology
Differences of perspective on humans	Focus on people and activities (↓); a vertical understanding based on anatomy	Focus not only on people but on things and environments (↔); a horizontal understanding of interaction
Differences of perspective on usability	Consider the purpose, function, and safety of the product. Help user restore limited functionality by using the product	Consider physical, aesthetic, and contextual usability, and factors such as product, usage environment, and stakeholders
Role in early stages of development	Identifying the characteristics of the user to be reflected in the product	Precisely defining user needs and converting needs into solutions
Role in later stages of development	Judging suitability and forecasting problems when using assistive device with people with disabilities	Consideration of details related to use, visualization, and tangible benefits

A clear difference in perspective emerges in Table 7: clinical experts look first at 'the disabilities of the person' while design experts look at 'how a user will interact with a device.' In addition, differences in defining 'usability' emerge: clinical experts consider an assistive device as 'a tool to replace or complement a physical function' of a person with a disability, while design experts regard the assistive device as 'a product for daily living' used by a person with a disability. In Table 9, the authors of this study show how these viewpoints change when considered in light of the HAAT model of the roles of the two expert groups.

Figure 3 shows the differences in the viewpoints and roles of clinical and design experts in relation to assistive device development, summarizing the results presented above. Clinical experts think from person to product and from product to person; design experts think about the interaction of people with products. Clinical experts use an understanding of the functional characteristics of the user to generate product ideas and to evaluate the product in the field; design experts work to enhance the completeness of the product based on the interactions between the product and the user.

Figure 3 Differences in viewpoints and roles of development process.

5 Considerations in Assistive Device Research and Development

5.1 Product Components

The authors asked each expert to list product components in order of the priority. The answers are shown in Table 8, below. The product components are aesthetics, motivation, function, ergonomics, mechanism, structure, production, economics, and presentation (Archer, 1965).

Table 8 Product components.

Order of priority	C1	C2	C3	D1	D2	D3
1	Function	Economics	Ergonomics	Motivation	Ergonomics	Ergonomics
2	Economics	Function	Function	Function	Function	Mechanism
3	Ergonomics	Ergonomics	Mechanism	Ergonomics/ Structure	Aesthetics	Function
4	Mechanism	Motivation	Aesthetics	Aesthetics	Presentation	Aesthetics
5	Presentation	Structure	Motivation	Production		Economics
6		Production		Economics		Production
7		Presentation		Mechanism		
8		Aesthetics		Presentation		
9		Mechanism				

All six experts gave higher priority to function and ergonomics, with two clinical experts more likely to consider economics in addition to these first two components. Functional and ergonomic factors are clearly important because of the characteristics of the users (people with disabilities) and of the context of use (as the products are intended to enhance the users' functional capabilities and convenience in the context of daily living activities). In addition, the reason that clinical and design experts shared this common emphasis on function and ergonomics was not only because they understood the characteristics of the users and of the context of use, but also because they have a shared aim to reflect research undertaken with users of the product.

Economics was selected as a high priority factor by two clinical experts. According to a survey on people with disabilities in Korea (Korea Institute for Health and Social Affairs, 2014), the salaries and levels of economic activity of people with disabilities living in Korea are less than 70% of those earned by people without disabilities. In addition, the domestic assistive device service law provides different services according to a person's level of disability. For these reasons, the majority of Koreans with disabilities face considerable financial hurdles when purchasing assistive devices. From the viewpoint of the clinical specialist using assistive devices in the field, therefore, economic factors that determine price are very important.

5.2 Details of the HAAT model

The HAAT model employs four elements to consider assistive technology: Human, Activity, Assistive Technology, and Environment and Context; the first three elements must be integrated (see Figure 4, taken from Cook & Polar, 2014).

Figure 4 The HAAT model. source: Cook & Polar, 2014

The HAAT model deals specifically with the AT field, but many similar models exist in the field of design (e.g., AEIOU: activity, environment, interaction, object, user). Looking at how the two expert groups handle the four elements of the HAAT model, therefore, we can see similarities and differences in their perspectives. In this study, each expert was asked to explain in his or her own words which subcritical items of the HAAT model he or she considered important in the development of assistive devices (Table 9).

Table 9 Component Details in the HAAT model.

No.	Component	Clinical experts	Design experts
1	Human	Physical characteristics: diagnosis (degree of damage), musculoskeletal structure and function level. Psychological characteristics: emotional state. Cognitive characteristics.	Physical characteristics: level of function, range of motion, human scale. Psychological characteristics: taste, aesthetic. Cognitive characteristics: cultural differences.
2	Activity	Activities of daily living, learning, work, leisure. Activities needed for independent living .	Behavior, posture requirements, life pattern. Activities needed for independent living.
3	Assistive Technology	How well it can be applied to a user, whether it is a technology that invites rejection or is a feasible technology. Safety, effectiveness, efficiency, satisfaction.	Requirements of technology according to life pattern (e.g., battery charging time). Accessibility, usability. The obtrusiveness of the technology.
4	Environment and Context	Considering where to use assistive devices (home, school, work, social/leisure activities, transportation), price (economy).	Considering where to use assistive devices, inside/outside, whether used alone or with multiple people, time (day/night).

The details of the HAAT model described by clinical experts are focused on product function, and based on disability and independent daily living activities. Design experts focused on users, on overall elements, and on how the context in which the products are used affects the product interface.

In relation to the human factors of the HAAT model, the clinical experts considered the diagnosis, the musculoskeletal structure, and the functional level to be among the most important physical characteristics. The design experts considered range of motion and human scale as the physical characteristics they considered most important. In relation to the activity element, the clinical experts referred to the activity type, while the design experts chose behavior, attitudes, and patterns and types of activities. In relation to assistive technology, the clinical experts cited acceptance or rejection of the technology when applied in the field, and also highlighted safety and

usability. Design experts chose technological requirements and usability in relation to life patterns. These differences suggest that clinical experts consider direct responses (psychological/physical) when using technology with humans, while design professionals see the congruence of context and technology. Here again, clinical experts stressed price in environment and context.

6 Conclusions

It is evident, as a result of the one-on-one interviews, that the roles of clinical and design experts have common elements, in that each group takes a human-centered approach to product development. This is especially clear when compared with, for example, the role of an engineer. An engineer focuses on the operation of a product, whereas clinical and design experts focus on its use. However, there are differences in the 'user-centered' approaches employed by the two groups. There are differences in background knowledge, differences in attitudes toward users, and differences in perceptions of the usability of assistive devices; thus differences in roles occur between the early and the later stages of device development (see Tables 7, 9; Figure 3). This study does not provide role comparisons for all stakeholders in the development of assistive devices, so further research is certainly required.

The implications of this study are as follows. There are few, if any, qualitative studies on collaboration between clinicians and designers of assistive devices; the present authors address this lack of qualitative analysis using a methodology that employed one-on-one interviews. Second, assistive technology is a field in which new technologies and equipment necessary for people with disabilities are developed; this study confirms the necessity of multidisciplinary research and development for assistive devices. Third, the authors have identified differences of view and role that should be addressed in collaborative research by expert groups in different fields. Fourth, collaborative research between design and occupation experts is an exemplary research model for the kinds of intervention research that should be done before an assistive device is turned over to the person with a disability. Intervention research tests consumer responses to existing commercialized technology, finds problems that occur as the technology is used, and revises and re-develops the technology.

This is an initial study of roles and collaboration in the development of assistive devices by clinical and design experts, and further systematic study of these groups is required. As noted, research that includes other experts (especially engineers) is also necessary in order to understand the multidisciplinary context more completely. Third, the authors have recognized and defined various differences in the viewpoints and roles of the two expert groups. Based on these findings, research on collaboration models and guidelines should follow. In particular, guidelines for collaboration are urgently required in order to solve problems and difficulties that emerge when expert groups converge. Fourth, there is a need for further research into the ways in which research on this kind of convergence can be disseminated in the field of assistive device production.

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Designing Play Equipment for Children with Cerebral Palsy: the context and design guidelines

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This paper presents an investigation into designing play equipment for encouraging peer-to-peer social interactions of children with cerebral palsy as a part of developing their social competence. The focus is on developing a new model of, and guidelines for designing play equipment for engaging children in peer interactions during play sessions. Research projects on the development of children with cerebral palsy have to date mainly concentrated on physical and cognitive areas or on social development through special educational programmes and training. This paper, in contrast, investigates developing social competence through empowering children to participate in open-ended peer play through a new model of play equipment.

child-centred design; peer social competence; cerebral palsy; play equipment

1 Introduction

Despite the modern achievements of medicine, the birth of a child may entail unforeseen consequences connected with numerous disorders. Infantile cerebral palsy is one of them. The issue of early intervention, development and sustentation of health conditions for these children requires a comprehensive and complex approach. According to the statistics of the National Health Service (NHS 2016), it is estimated that 1 in 400 people in the UK is affected by cerebral palsy. Approximately 1800 children are diagnosed with cerebral palsy every year. There are an estimated 30000 children with cerebral palsy in the UK (NHS 2016).

The most direct definition of cerebral palsy is that it is one of the most common forms of physical disability amongst young children (Parkes et al, 2001). Rozsahegyi (2014, p.47-53) examines a range of definitions of cerebral palsy and observes that the available explanations are often medical in nature. As a result, support for these children is often medical in nature and focuses on problems of motor coordination, balance and mobility, gross and fine movement (Cogher et al. 1992; Farrell 2008; Hinchcliffe 2007), while the picture of how cerebral palsy affects the child's development is much broader.

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In Vygotsky' socio-cultural view, cerebral palsy is seen as a developmental disorder with two kinds of implications: primary – the neurological, biological impairment, secondary – the social and cognitive implications which hinders the child to participate in everyday activities. The importance of the Vygotskian view is that the secondary implications make the child 'disabled'. He stresses the importance of social interactions and states that socialisation plays a significant role in children's development. Palmonari & Doise (1984) also draw attention to the importance of social interaction in development. They argue that social interaction and collaboration are critical components of development. In spite of this recognition of the importance of social interactions, it is still insufficiently studied.

As a group, children with cerebral palsy perform less well socially than do peers with typical development (McConnell and Odom 1999, pp.67-74). According to Guralnick et al. (1996, pp.359-377), children with cerebral palsy, when compared to typically developing children of similar ages, interact with peers less often and are less well accepted. Children who do not have a basic level of social competence by the age of six may have difficulties with relationships when they will be adults (Blandon et al. 2010; Ladd 2000; Parker & Asher 1987). The fundamental outcomes that need to be achieved for many disabled children and young people according to Department of Education (DfE, 2014) are communication. From the above, the idea of addressing social competence for these children was derived, as this is an important prerequisite for their holistic development.

The primary context for the development of social competence is play interaction with peers (Goldstein 2012, pp.5-8; Whitebread 2012, pp.5-6). During play, children are able to test out social roles and learn acceptable social rules. They are encouraged to share, take turns, cooperate, consider others' perspectives, and acquire self-control (Bracken, 2000; Gagnon & Nagle, 2004). The opportunity to play and explore provides children with the ability to learn about likeness and differences, acceptance and understanding, and socialization in a way that cannot be taught through any other means.

All children learn through play, but play does not come naturally to all children. Sometimes the right tool can spark enough interest to start something new. The term for tools used in children's play is play equipment. As part of the physical environment, it has the ability to contribute or retard developmental process. Designing play equipment that are appropriate for children with cerebral palsy can be challenging. This project is primarily focused on clarifying the issues that must be taken into consideration when designing play equipment for developing social competence of children. Play equipment in this study is regarded not only as a part of physical environment or tool for children to play with. Here play equipment is treated as a tool for engaging children into child – object – child interactions.

Encouraging social competence development of children with cerebral palsy is a challenging aim and addresses deep issues about the nature of social interactions and social skills. Studying play equipment as mediators in this domain adds an additional level of complexity. However, when approaching this challenge from the bottom up, taking it step by step, this project will provide evidence as to the possible role of play equipment in development of the social competence of children with cerebral palsy, and can contribute into understanding how can one approaches to create play equipment for children with cerebral palsy, by providing design guidelines for such equipment.

This paper outlines the context and the key concepts for designing play equipment for early years children with cerebral palsy that encourage them to engage in open-ended play with other children and foster their social development. To understand the peculiarities of children and to define criteria and requirements for designing such play equipment, the discussion begins with the conception of cerebral palsy and an outline of the current status of medical and social views on cerebral palsy. This is followed by the discussion of the importance of the development of social competencies. Based on this, the concept of play, and play equipment as a means to play are presented. The contextual

review finishes by outlining the theoretical concept and design criteria for creating a new model of play equipment.

2 Medical and social views on cerebral palsy

As a basis for the discussion, it is necessary to consider what cerebral palsy is since cerebral palsy has been conceptualised and defined in a number of ways.

The medical perspective of cerebral palsy focuses on problems of motor coordination, balance and mobility, gross and fine movement, combined with cognitive and perceptual difficulties (Cogher et al. 1992; Fox 2003; Farrell 2008; Hinchcliffe 2007). Such a view advocates professional physio-therapeutic means of rehabilitation and development to compensate the impact of cerebral palsy (Rozsahegyi 2014, p.7-53), which is easiest to observe and measure in all patients. But even if the motor abilities of the patient increase, the psychological distress and social engagement may not necessarily decrease (Parkes 2008, pp.405-413; Landsman 2006, pp.2670-2680; Landsman 2005, pp.121-139).

While physio-therapeutic support of children remains dominant in the United Kingdom, Rozsahegyi (2014, p.21) has argued that such an approach encourages only the child's passive participation and emphasizes the dysfunction, rather than its abilities. Hári and Ákos (1988), Hári (1997, pp.17-33) and Sutton (2010, pp.xi-xiii), for instance, stress the significance of the emotional, social and cognitive difficulties which the child faces as the result of physical disability and ways how these difficulties may be overcome. Vygotsky (1978, p.79-91), Kozulin (1990, p.254), and Meadows (1993, pp.104-126) believe that the development of the child arises from his/her attempts to deal with everyday problems and from interactions with the child's environment.

According to Vygotsky (1929, vol.2) children with disabilities are not limited by defects or less developed in comparison to their peers without disability, but they develop differently. The personality of a child with disability is something special and not the sum of any 'defects' or 'limitations'. Moreover, any defect creates incentives for compensation (Stern 1923, p.145 cited in Vygotsky 1929, vol.2). This does not only mean physical compensation, but also psychological. The positive difference of disabled children is created not because of lack of certain functions that a child with typical development has, but because this lack triggers a unique personal reaction to the disability and a unique compensatory mechanism.

According to Vygotsky (1978, p.57) 'every function in the child's development appears twice: first on the social level and later on the individual level; first, between people and then inside the child'. For example, initially a child's gestures can be just motions without particular meaning. However, when people respond or react to the gestures, they become meaningful. Then, after a child comprehends, they can be used for social communication. A number of skills which can be developed with social guidelines and collaboration are often wider than skills which can be developed alone (Fani and Ghaemi 2011, p.1550). The social environment influences the developmental uniqueness (Scherbina 1916, p.10 cited in Vygotsky 1929, vol.2; Burklen 1924 cited in Vygotsky 1929, vol.2). Compensatory processes are also socially determined and are directed on overcoming difficulties caused by the defect and not directly on overcoming the defect which is often impossible. Rogoff (1990, pp.171-188; 1998, p.686), based on the work of Vygotsky, emphasised the social nature of children's development. Further evidence that supports the idea that it is important for children with disabilities to be integrated in society and not to be treated differently and to be isolated can be found in a number of personal stories and experiences from people with cerebral palsy provided by the "My Child" informational website (2016).

These stories indicate that social aspects in the development of disabled children play a vital role, but are still addressed insufficiently. Despite a diversity of views and definitions, the effects of cerebral palsy are clearly visible in children's lives, shaping their experiences and participation in

social life (Rozsahegyi 2014, p.52). In the following, this paper therefore discusses the social development of children in more detail.

3 Social competence for children with cerebral palsy

"Social competence refers to a child's ability to get along with and relate to others" (AEDC 2011, p.2). Being socially competent involves many elements, including the ability to regulate emotions, developing knowledge and experience of social interactions and understanding social situations and customs (Katz & McClellan, 1997). For young children, social skills include learning to be a friend, to negotiate personal needs and deal with difficulties, to be assertive without being aggressive and to relate effectively with adults and peers (Linke, 2011).

Social competence is interrelated with other aspects of development and should be seen as being important in young children's development as physical, emotional and cognitive development. (Blandon et al. 2010). The holistic approach understands children's development to consist of these inter-dependent dimensions. Children's holistic learning and development 'involves all areas of development and embraces a view of the whole child developing in the context of family, home and community' (NCCA 2007, p.12). Based on the above, the progress in one area affects progress in others and if one area of the development is strengthened we can anticipate development in other areas. The possible difference between development of children with cerebral palsy and children with typical development can be represented as follows (figure 1):

Figure 1 The possible difference between development of the child with cerebral palsy and the child with typical development

During the early years, social competence involves the ability to separate from parents and engage with peers in shared play activities (2017, informational website "Children's health"). Social competence includes 'knowing what is expected for social interactions, such as making eye contact, taking turns, listening to others, not being aggressive; "reading" other people's facial expressions and gestures; recognizing emotions in others and oneself; and being able to communicate effectively with others, including family members, peers, and adults' (2016, informational website "Happy Tots").

As early years children are just learning to coordinate their social behaviour, their interactions are often short and marked by frequent quarrel, and friendships are less stable than at later developmental stages. During the early years, children are primarily focused on group acceptance and having companions with whom they can play (AEDC 2011, p.2). Thereby, the development of

social relationships with peers is one of a major achievement of the early years for children (Guralnick 2001, pp.3-35) and is the focus of this research.

Disabled children have broadly the same aspirations in social acceptance as non-disabled children and the outcomes they would like to achieve are therefore similar. However, for many disabled children and young people, there are fundamental outcomes that need to be achieved as a foundation for others, including and especially, communication. For some children with cerebral palsy acquiring the skills and knowledge necessary for interacting positively and successfully with peers is a challenge (Odom 2005, p.2). Disabled children tend to be less accepted by peers, may interact awkwardly and inappropriately in social situations and sometimes are socially incompetent. Disabled children may have difficulties in forming and maintaining relationships because the impairments caused by their disability limit or restrict them from participating in everyday activities with their peers (Odom 2005, p.2).

Some children with disabilities have difficulty in picking up social cues that allow them to cooperate with others (e.g. following the rules of a game, taking turns). This potentially can lead to poor social skills in communication with peers and later with schoolmates, while social interactions with peers are one of the key areas of social development. Significant determining factors of interpersonal communication are in the child's physical environment (Strain et al. 1986, p.29). The combination of these sorts of factors can lead children with a disability to be at risk of developing mental health difficulties, such as low self-esteem, and mental health disorders, such as depression. Many children thus would benefit from help with bridging their differences and finding ways to learn from and enjoy the company of others.

4 Play as a tool for social competence development

For young children, a primary component of social competence is establishing effective interactions with peers during play (Mathieson & Banerjee 2010, pp.9-20; Craig-Unkefer & Kaiser 2002, p.3; Zigler & Bishop-Josef 2004, pp. 1- 13). Children, who are able to initiate play, enter ongoing play groups, appropriately respond to peers initiations, and resolve conflicts with peers will be socially competent in other aspects of peer relations (Howes & Matheson 1992, pp.961–974).

Play is the primary context in which children build their emergent social communicative skills, as well as establish social competence (Mathieson & Banerjee, 2010). Using social communication in play allows the child to satisfy their needs and desires, control the behaviour of others, participate in a social exchange, express opinions or feelings, engage in fantasy, obtain information, and provide information to others (Athanasiou, 2007; Craig-Unkefer & Kaiser 2002; Zigler& Bishop-Josef, 2004). Social play involves a high level of reciprocity and cooperation to work well and children learn about turn-taking, sharing, allowing others to go first, controlling emotions and putting the continuity of the play before their own immediate needs and wishes (Kay 2007, p.10). All of these social communicative behaviours coalesce to form the child's capacity for social competence.

Play is considered to be so important for children's development, that it is a universal right for all children under article 31 of the United Nations Convention on the Rights of the Child (2013, p.3). Whilst playing, children can experience, respond and adapt to a wide variety of social situations (Gleave and Cole-Hamilton 2012, pp.10-13). According to Ellis (1973), play fosters the behavioural variability of the child. Conventionally and currently, leaders in theories of early childhood education see play as fostering well-being, creative thinking skills, cognitive and social skills (Piaget 1962; Frost & Sunderlin 1985).

To sum up, interactions with peers during play are the main component of the social competence of early years children, and include a number of social skills. The main of these skills were defined and are presented in figure 2.

Figure 2 Social skills for early years children

Although most theories of play, such as the Psychoanalytic theories of Freud and Ericson, Cognitive theories of Vygotsky, Sutton-Smith, Bryner, etc. (Mellou 1994, pp.91-100) assume that play is imperative to children's development and learning, there is widespread debate regarding the magnitude of the benefits, and when these benefits occur during development. Despite considerations of the magnitude and occurrence of benefits of play, it is assumed generally to have advantages and provide areas for children's social growth. Through play between and among children, they learn how to get along with one another, to be helpful and share, to understand the consequences of their own behaviour, etc. (Pellegrini 2000, pp.360-366). Quality play builds confidence and reinforces a child's desire to explore and learn. Therefore, without knowing, during play, children participate fully in their own social development (Isenberg & Jalongo 2006, pp.53-55).

5 Peculiarities of play for children with cerebral palsy

The play of children with disabilities often differs from that of their non-disabled peers. Play repertoires can be more limited, and play may occur less frequently in children with developmental disabilities (Li 1981, pp.121-126). Children with physical disabilities may find it hard to participate in games that other children play. Jennings et al. (1985, pp.162-169) presents characteristics of play of children with physical disabilities as more solitary, with a limited availability of materials.

Some children may find it difficult to approach their peers to engage in social activities. Not all children have the opportunity to meet and play with other children on a regular basis in nurseries and play groups. Specific aspects of play may be related to the type and severity of the disability (Kaplan-Sanoff et al. 1988, pp.137-161). Children with disabilities may experience physical, cognitive, emotional, or social difficulties or a combination of these. They may need more support with accessing the physical environment, to engage with toys and objects, encouragement to initiate and sustain interactions. For example, they may lack appropriate physical surroundings to play in and lack suitable playmates. These elements may conspire to foster an impression that children with disabilities experience basic play deficits. In fact, this impression may be completely false since the observed play differences could be environmental in origin (Hughes 2010, p.209), as children's development is directly linked to their ability to interact with their physical environment.

Children develop an understanding of themselves through their interactions with events and materials outside themselves. Beckung and Hagberg (2002) have investigated activity limitations and participation restrictions with gross and fine motor functions under the mobility, education and social relationship in children with cerebral palsy. They indicated that the effect of a child's

impairment or activity limitation on participation might vary depending on environmental factors (Beckung and Hagberg 2002, pp.309-316). Environmental factors are defined as “the physical, social and attitudinal environment in which people live and conduct their lives” (WHO 2007, p.16). While the disability is present, environments have the ability to contribute or retard developmental process. The environment should offer children opportunities to actively explore surroundings, make decisions and follow through with their ideas, engage in different types of play, increase control over their bodies (Hohmann and Weikart, 1995). Objects for play and access to peers, for example, are essential components of major life situations of early years children.

6 Play equipment as a mean for engagement into play

The objects used in children’s play are no less important than the game itself. Children have their own particular relationship with objects. Objects provide a means by which children can represent or express their feelings, concerns, or preoccupying interests. For children an unfamiliar object tends to set up a chain of exploration, familiarization, and eventual understanding, and often repeated sequence that will eventually lead to more mature conceptions of the properties (shape, texture, size) of the physical world (Garvey 1977, p.41). Objects represent a mediating element between a child and his/her world. They also may help children to explore what they can do and what are their limitations, thus contribute to develop self-image.

There is an enormous range of play equipment that a disabled child may require and use. It can be toys, heuristic baskets, activity boards, play sets, multisensory rooms, etc. (internet stores eSpecial Needs, Fat Brain Toys, Toys ’R’ Us). For a child with cerebral palsy, toys can cater to specific areas of development or preference and can serve as a therapy aid (Hoffman et. al 2014).

However, finding play equipment that is appropriate for a child with cerebral palsy can be challenging. Bandri (2016) defines two ways in which toys can be chosen for disabled children. Firstly, the toys have to be such that they are geared to suit the abilities that the child currently has, or, secondly, they are such that they will move the child towards developing the abilities that he/she is working towards. Shusterman (2011) says that the key criteria for selecting toys should be ease of manipulation, minimal frustration, and something that attracts the child’s attention. Children with more complex needs may experience difficulties with producing the same range of motion, muscle coordination, and dexterity that playing with play equipment designed for children with typical development may require. Consequently, children who do not have the physical or cognitive proficiency to play with the equipment provided may become bored or uninterested because of the lack of success. So what might seem like a 'normal', 'simple enough' for children without developmental difficulties, might pose obstacles for a child with cerebral palsy.

Nielsen (1992) with the 'Little Room' for children with visual and complex needs and Goldschmied and Jackson (1994) with the treasure baskets agree that it is important to give opportunities to explore space and objects without interference. The 'Little Room', as well as some other surroundings for children with complex needs is arranged in a way that the child can learn cause and effect. A certain movement leads to a certain tactile or auditory experience, e.g. handling a certain object can lead to production of different sound (Nielsen 1992). According to Gascoyne (2012, p.13), an inclusive way of encouraging play and development is sensory-rich play equipment. Early years children learn best and retain the most information when they engage their senses (Arnheim 1974 and Piaget & Inhelder 2000).

Toys can be classified in different manners in dependence of the purpose of the classification. The diagram below (figure 3) presents examples that are currently available for children with cerebral palsy. They were contingently divided into groups which aid to development of particular areas. For each group from a range of equipment were taken the most representative. In the context of this study we are more interested in toys from the group “Social development”, which will be discussed in more details later.

It is important to notice that the same piece of play equipment often can be used for children with typical development as well as for children with cerebral palsy and based on investigation of the today's market there are no clear borders between them. Often, the only difference is the age range and level of physical and cognitive development to use certain equipment.

Figure 3 Examples of toys that are currently available for children with cerebral palsy

Let us consider three examples of existent equipment which perform social function and are intended for use by two or more individuals simultaneously.

One of the examples for promoting social communication of children is a Seesaw (figure 4), that was designed for children with cerebral palsy and supposed joint use for two children.

Figure 4 Seesaw for children with cerebral palsy. source: http://www.coroflot.com/kerenrelin/design-for-children (with a permission to use)

The positive side is that this Seesaw supposes cooperation and making eye contact with the other child –two of the skills of the repertoire of social competence. It has assisting facilities designed

especially for children with cerebral palsy. However, there are also weaknesses, such as lack of attractiveness for a child, and the inability to use it without the help of an adult.

Another example is the Gobug interactive toy (Katz and Rim 2011) (figure 5). It helps facilitate a comprehensive social learning experience, not just for children but individuals of all ages. Two – three children can play with this toy simultaneously together. Every user takes ownership of a single controller. While each user points out his/her remote in a particular direction, the Gobug moves around in the combined direction of active controllers. The more these controllers are in synchrony, the faster the Gobug moves in the same guided direction. Gobug will activate only when 2 or more controllers are in-hand. It helps users work together on verbal, physical and non-verbal communicative levels. However, Gobug was designed for school age children with autism spectrum disorder, and does not take into account physical needs and peculiarities of children with cerebral palsy.

Figure 5 Gobug interactive toy. source: http://www.core77.com/posts/19262/autism-connects-gobug-interactive-toy-19262 (with a permission to use)

An example of a play tool that supposes sharing and develops certain social skills is an Art installation - Montreal's "Musical Swings". The idea of the swings is that swinging sets off musical notes, and together forms a melody (figure 6). So, the aim is cooperation and obtaining a common result – a melody. This installation, however, does not require a joint use and can be utilized independently. It is designed not for early years children with cerebral palsy, as they may need more support with accessing these swings.

Figure 6 Montreal "Musical Swings". source: https://www.mtl.org/en/what-to-do/festivals-and-events/21-balancoires-montreal (with a permission to use)

There are very limited options in the market when it comes to toys specifically designed for children with cerebral palsy. The majority of the available examples have not been designed with considering the challenges of such children but are rather intended for any child. Available toys/toy sets take into account mainly physical abilities of children, but when designing for these children their social needs also should be a concern for toy designers, beside their abilities (Hassenzahl et al. 2012, p.5).

From the discussion above, some criteria of child friendly design which play equipment for children with cerebral palsy should have can be defined, such as: appropriateness for developmental level, focusing on strengths to minimize possible frustration, visual attractiveness, intuitiveness and positive feedback to carry rewards to children, sensory, and ergonomic to correspond to the child's anthropometry (figure 7).

Figure 7 Criteria of play equipment for children with cerebral palsy

7 Theoretical concept of play equipment for social competence development

Play equipment in this study is treated as a tool for engaging children in social peer interactions by means of an object. When designing play equipment for social development, it is practically impossible to create a form, appearance, etc. that directly relates to functions of social development. But if we consider design as an interface for meaning-making, the designer's task shifts to constructing semiotic content that can trigger cognitive and emotional processes of children for the intended perception of the play equipment that can engage and thus develop specific social skills (figure 2).

Figure 8 Interactions within a system 'child – object – child'

In the context of this research this means encouraging aspiration to interact with the designed objects and building social interactions through interacting with these objects (figure 8). The triangular model of relationship between person-object-person was discussed by Niedderer (2007, p.6). Such a design model links cognitive and emotional processes of communication with the designed object. Play equipment should enable and guide children in creating understanding and following behaviours that triggered by contact with the designed objects.

Children connect certain meanings with certain carefully chosen material objects in response to the immediate focus of their interest. This supports the concept that reality depends not only on the intentions, which are embedded in the design, but the interpretation of children who experience designed object. Moreover, the existing rules that govern play, but which are not inherent in the object, may influence the perception of the object. Perception is usually situated within various contexts of social processes and social relations where meaning is represented (Halliday 2005, pp.59-82). Representations are context-bound. This may suggest the necessity of understanding the context in which children interact with design objects and its influence on their meaning-making. Also the ways of meaning-making determine specific social situations and social relations where this meaning is presented.

Play equipment in this study is regarded as a part of the physical and social environment or as a tool for two or more children to play with. This project looks on play equipment not only as triggers of emotions and certain responses on them from children but focuses on encouraging social interactions between children mediated by those objects. The concept of objects around which social networks are form was put forward by Engeström (2005). He developed the theory of 'object-centred sociality'. It describes the phenomenon whereby shared objects are the means by which people connect to each other to form social relationships and networks. According to this concept, links are created not just between people, but between people and objects, or around objects. Social objects in this case can be a central points of interpersonal interaction. Play equipment should trigger interactions between children not only around itself but by means of itself.

8 Design guidelines

To design for children play equipment that encourages their social development, design criteria should be developed. Based on the analysis of related literature and existing examples of design objects, it is possibly to identify characteristics which play equipment should have in the context of social development.

Design criteria represented in the form of the scheme (figure 9) and have two levels. The first one is indicators from the design position, and the second one - indicators of purpose.

The levels are interrelated and implementation of criteria from the second level depends on the realisation of the first level's criteria. At the top of the scheme is play equipment which should have a child-friendly design to be engaging – the first level of criteria. Child-friendly design means that equipment should be intuitive, sensory, visually attractive, developmentally appropriate, with positive feedback, focused on strengths, ergonomic, and safe. Through child-friendly design, play equipment can empower children to participate in open-ended group play, during which children are led by the equipment to practice social skills and to foster self-confidence. Social competence involves a range of skills and refers to the smooth sequential use of these skills in an effort to establish an ongoing social interaction. Social skills are a collection of isolated and discrete learned behaviours gender (Brownell 1990, p.840). The main social skills that early years children should develop competence in include: sharing, cooperation, taking turns, helping, initiating interactions, making contact with other children. These social skills, together with self-confidence, are criteria of the second level.

Figure 9 Design guidelines

Let us consider child-friendly design criteria in more details:

Play equipment should be intuitive. The concept of intuitive use of objects was studied by Blackler et al. (2007, pp.4-24). She formulated a definition: "Intuitive use of products involves utilising knowledge gained through other experience(s). Therefore, products that people use intuitively are those with features they have encountered before. Intuitive interaction is fast and generally non-conscious, so people may be unable to explain how they made decisions during intuitive interaction". Intuitive use will allow children to play with the equipment maximally independently with minimal help and guidelines from adults. Intuitiveness is especially significant while designing products for children with disabilities as it may allow them to feel more confident and convenient, allow accept the product and minimize rejection. The whole products and its individual parts should communicate and transfer a message, so that children as users know how the product should be utilized. In this case children can focus on what they want to do instead of how, with minimal help from adults.

Play equipment should be sensory. Children learn best and retain the most information when they engage their senses. Sensory element criterion shows if the play object has characteristics that appeal to any of the five senses (sight, touch, hearing, smell and taste) or give some sensory response in case of cause and effect toys. Sensory-rich play is an inclusive way of encouraging learning and development, with the hands-on approach appealing to children with different thinking and learning styles (Gascoyne 2012, p.13). For children with special needs, the detail of colour, texture, smell and lighting can have a much greater impact, depending on their disability. These things can be a source of discomfort and pleasure, as well as information, entertainment, education and reward (Bishop 2012). These characteristics are considered on the basis of lights, sounds, texture, smell, and taste. Visual characteristics and children's reactions to them were studied by Savva (2003, pp.300-313) and Savva & Trimis (2009, pp.527-539). Object perception through the

touch was discussed by Klatzky & Lederman (2003). Bensafi et al. (2002), and Herz & Engen (1996, pp.300-313) studied physiological effect of the smell.

Play equipment should be visually attractive. Visual perception is dominant among all the human perceptual activities because it supplies first-hand sensory experience (Myers 1989). Play equipment with attractive visual image is more engaging. It can also contribute in keeping children's attention for longer.

Play equipment should be developmentally appropriate. Play equipment intended for younger than the target group children can be boring and uninterested, while equipment for older children can be too complicated. This may lead to inability to play with the play equipment provided and to loss of interest. Moreover, further it may lead to passivity in playing in general. This criterion is hard in implementation because of developmental difference of children even in one age group. The way to overcome this is designing open-ended equipment without stress on functional fixedness and taking into account physical, cognitive, emotional and social peculiarities of children.

Play equipment should have positive feedback to motivate children to continue current task, reach new results and try new activities. It can stimulate and prolong play, and raise self-confidence.

Play equipment should be focused on strengths rather than weaknesses. It is one of the main criteria in order to shift the perception of disability as a limitation to a more positive way. Children see and percept outer world in their own way and adapt to it depending on their abilities. It is necessary to find specific approaches and put the right priorities which correspond to children's needs and wishes.

Play equipment should be ergonomic and correspond to child's anthropometry (Goloborodko 2012, pp.21-25, 58-73). Anthropometric data helps to evaluate the fit between children, play equipment and physical environment. An understanding of this fit is critical to ensure that children can use play equipment intended for them. It protects them from harm by ensuring that hazards are properly guarded or placed out of reach.

Play equipment should be safe for reducing the potential for injuries. A list of essential safety requirements are set out in the Toys (Safety) Regulations 2011.

9 Conclusion

This paper has outlined the context and the key concepts regarding the development of social competencies of children with cerebral palsy through play and engagement in play through play equipment. To understand the peculiarities of the children and to define criteria and requirements for designing play equipment, the discussion began with the conception of cerebral palsy and an outline of the current status of medical and social views on cerebral palsy. This was followed by the discussion of the importance of the development of social competencies. Based on this, the paper discussed play and play equipment as tools for gaining necessary social skills. The contextual review defined the theoretical concepts and outlined the design criteria for creating a new model of play equipment.

Future research will develop a number of design ideas through ideation and brainstorming based on these criteria. Design guidelines and design ideas from this stage will be used for further refinement and development after collecting data from observations of children and interviews with their parents. One design idea will be chosen for implementation and intervention. Data gathered in observations before and after the design intervention will be compared in order to determine any changes in children's social interactions.

The paper highlight the difficulties of peer-to-peer interactions experienced by children with cerebral palsy and underline peculiarities of their playing with play equipment provided. The research will contribute new understandings of design for open-ended group play and will provide a set of design guidelines for this specialist play equipment. This new design model is intended to

empower and lead children through the process of obtaining and practising peer social skills to be socially competent. It is also aimed at changing social perceptions of cerebral palsy and shifting the accent from limitation to potential and benefit of the children with cerebral palsy.

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Section 17.

Sustainable Design

Editorial: Sustainable Design

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This year we have a spread of papers that address everything from products to architecture to fashion. However, there are a number of themes that run throughout all of these. Firstly, the need to move towards a circular economy within all these disciplines comes through as a strong driver of research topics and the strategies selected to explore them. This seems to go hand in hand with a greater emphasis on systems design, be it a focus on product service systems, or a less tangible nod towards systems thinking through the introduction of repair (Lefebrve) and Use2Use strategies (Selvefors) Secondly most of these papers focus specifically on the user, and the need to fully understand them, and their potential to contribute towards sustainable approaches.

Firstly, Bosserez *et al* discuss taking a user-centred approach for resource efficient buildings which considers dynamic residents and varying conditions through the seasons. They propose taking a user centred approach to reducing the energy demand of buildings in order to afford resource savings during renovation. They use student projects as case studies to analyse different scenarios and conclude that efficient occupant behaviour and contribute to the energy efficiency of a building. Next Petrulaityte *et al* present an exploration of Distributed Manufacture and the role it may have in improving the implementation of product service systems. Their work has resulted in the development of a PSS +DM design tool that has the potential to support PSS solutions development process. Then Bakirhoglu *et al* introduce their first internship programme at the University of Limerick. The internship aims to build capabilities for Circular Design and highlights the potential for these through real-life innovation challenges. We then take a short dip into fashion, where Raebild and Bang discuss furthering sustainable strategies for seasonal fashion collections. Our last two papers bring the focus back to the user, and the goal of moving to circular product design. Lefebvre's research supports a circular economy through an investigation of user driven repair of consumer products. She takes a user-focussed approach to the subject area to highlight factors that hinder or support repair propensity in users. Finally, Selvefors *et al* argue the need for a re-framing of circularity from a user's perspective, considering different consumptions models that may be available to them. They propose tighter 'Use2Use' loops and highlight preconditions that enable these consumption models to occur.

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Shifting Towards a User-Centred Approach for Resource-Efficient Building: lessons from an educational study

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When implementing energy-efficient housing concepts in practice, designers often apply an object-centred design approach that generates a static built environment, causing higher material consumption, building costs and actual energy demands when the building is in use. To provide an alternative solution for current energy-efficient renovation concepts, previous research suggests a user-centred approach which considers dynamic residents and varying conditions throughout the seasons. The approach aims to promote more efficient occupant behaviour to decrease the actual energy demand by enabling a dynamic way of living throughout the seasons. The research hypothesis is that decreasing the actual energy demand of the resident by means of a user-centred design approach can limit the need for additional quantities of materials and renovation costs (resource-efficiency). In this context, the shift from an object-centred approach for energy-efficiency to a user-centred approach for resource-efficiency is tested by means of an educational study within the design studio 'Zero Pentathlon: sustainable housing renovation' at Hasselt University, Belgium. The paper presents a critical reflection on the students' analyses of dynamic residents, the resulting dynamic design concepts, and the effect of the user-centred approach on the energy-efficiency of the building. The paper finds that the resulting designs which best enable a dynamic way of living throughout the seasons come from students who analysed the dynamic properties of residents more in-depth. These designs promote efficient occupant behaviour and show potential to contribute to the energy-efficiency of the building. However, it is also concluded that it was challenging for all students to create a synergy and incorporate both the analysis of residents *and* analysis of the built environment within a resource-efficient building design. The findings will serve as input for future research to further develop an alternative user-centred design methodology for resource-efficient building.

energy efficiency; educational study; user-centred design approach; resource-efficient renovations

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1 Introduction

1.1 From an object-centred to a user-centred design approach in resource-efficient renovations

Due to environmental, economic and social developments, the traditional detached single-family dwelling, a common housing model in Flanders, is under pressure (Bervoets & Heynen, 2013; Gerards, De Ridder, & De Bleeckere, 2015; van de Weijer, 2014). With a larger average living space than other housing models (e.g. terraced houses), these dwellings bring forth a high *total* environmental impact (energy and material consumption) and have higher renovation costs (ADS, 2014; Verbeeck & Ceulemans, 2015). Furthermore, 40% of these large, detached single-family dwellings are underused due to demographic trends such as decreasing household sizes (Bervoets, 2014; van de Weijer, 2014). This can result in inefficient heating and occupation of a large building volume and leads to large actual energy demands. The Flemish Housing Policy is currently aiming at more affordable, quality and sustainable housing, with a strong focus on energy efficiency (Vlaamse Overheid, 2015). This resulted in the implementation of energy-efficient housing concepts (e.g. passive housing and low-energy housing) which generate new challenges such as higher material consumption and renovation costs (Audenaert, De Cleyn, & Vankerckhove, 2007; Hollberg & Ruth, 2016).

The currently imposed energy-efficiency measures focus mostly on optimization of the building skin by applying large quantities of additional materials and active systems which is referred to as an object-centred approach for energy-efficient building (Author, 2017). Furthermore, other parameters that influence the energy demand, such as outdoor climate and residents, are often seen as static in this object-centred approach (Author, 2017). Moreover, the lack of user interaction that results from this approach can induce inefficient user practices which can lead to an increase in actual energy demand (Gram-Hanssen, 2013). So, while the current and commonly used object-centred approach focuses on providing an energy-efficient supply, based on (Bierwirth & Thomas, 2015; Cauberg, 2016; Rovers, 2015; Thomas & Brischke, 2015) we suggest to promote more sufficient energy demand by considering dynamic residents.

Based on a literature study (Bosserez, Verbeeck, & Herssens, 2017), this paper proposes a shift from the object-centred to user-centred approach for energy-efficient building by suggesting the application of an alternative design methodology which analyses not only objects but also users and considers their needs to allow for more energy-efficient user interaction with the built environment. This user-centred approach proposes to consider the residents as dynamic and takes their behaviour into account in the buildings' design by enabling a dynamic way of living throughout the seasons. From the literature study, three design criteria are derived which aim for: 1) varying indoor climatic conditions for efficient heating of spaces; 2) an adapted space plan for diversified occupation of spaces throughout the seasons; and 3) support of the resident for more environmental experience and user satisfaction. The research hypothesis is that the user-centred approach can decrease the actual energy demand and lead to an energy-efficient design which limits the need for large amounts of additional materials when optimizing the building skin. This alternative user-centred approach is tested within an architectural design studio, Zero Pentathlon, to explore what information is generated from analysis of dynamic residents and how this is considered within a design for energy-efficiency.

1.2 The design studio Zero Pentathlon

For several years, the design studio of Zero Pentathlon has addressed current environmental challenges such as climate change and depletion of natural resources by investigating sustainable residential renovations. First year master students of Architecture, organized in 7 groups of 5 students, are assigned to renovate an existing dwelling into a zero-energy building with a minimal impact on water and material use. During the design studio students are guided by means of tutoring sessions, lectures and workshops on related topics. The assignment's requirement is

twofold: a logical constructive *and* architectural dynamic design for resource-efficient renovation. By applying a user-centred approach, students are required to come to a synergy of two approaches where the built environment as well as the dynamic resident and varying seasons are taken into account (Figure 1). The architectural dynamic design concept should contribute to the decrease of the actual energy demand in such a way that the need for large amounts of additional materials and active systems is limited within the constructive design.

Figure 1 Shifting from an object- to a user-centred approach within the design studio Zero Pentathlon

The constructive design aims for decreasing the *total* environmental impact. Students need to analyse an existing, large, underused, detached, single-family dwelling in the region of Flanders by means of calculations of material, energy and water consumption and in-depth description of the buildings' construction. Then, students are encouraged to develop a constructive building design by implementing the PENTA-strategy to reach optimal sustainability. The strategy is based on the TRIAS-strategies (energetica, materia, aquatica) and is supplemented by an "from passive to active" approach where physical-spatial measures are integrated with constructive-technical measures.

The architectural dynamic design focuses on decreasing the actual energy demand by enabling a dynamic way of living throughout the seasons which promotes efficient heating and occupation of spaces. The students are provided with a design methodology which is divided in two main phases: analysis and design. They are required to analyse the dynamic aspects of the seasonal living pattern of current residents as follows: (1) Collection of data on occupant behaviour by means of semi-structured interviews (pre-scripted by instructors); (2) Visualization of the collected data by means of a mapping-method (selected by students); (3) Interpretation of the collected data and description of the seasonal living pattern; (4) Establishing case-specific design requirements which respond to dynamic residents to implement in design phase. Based on the results of the analysis of the existing situation, students are requested to create an innovative renovation concept which allows for a more dynamic and efficient use of the large, underused, living environment throughout the seasons based on three user-centred design criteria mentioned above (Bosserez et al., 2017). The resulting energy-efficient design concept and dynamic spatial use of the renovated living environment needed to be presented through visualizations. In addition, a description of the applied design strategies and measures which link the dynamic design concept to energy-efficiency is requested.

The design studio provides an observational setting when shifting from an object- to a user-centred approach for resource-efficiency. The paper aims to elicit information on barriers and needed improvements for future research and further development of the alternative design methodology which enables a dynamic way of living throughout the seasons. Therefore, the paper presents an analysis of the students' design process (from context analysis to concept design) and the resulting design concepts of Zero Pentathlon. It critically reflects on the analysis of the existing residents' seasonal living pattern, how dynamic properties of residents are considered within in the design and how that affects the energy-efficiency of the building.

2 Method

The results of the design studio are analysed by means of students' final reports, observations during the tutoring sessions and posters of the final jury. The criteria presented in Table 1 are based on the design assignment and used to critically reflect on the design process and resulting designs of students.

Table 1. Criteria used for critical reflection on the design process and resulting architectural design concepts of students within the design studio Zero Pentathlon

Analysis of the dynamic resident	**Results from analysis**
Collection of data: transcriptions and summaries of interviews	• The presented properties of dynamic residents • The representation of the dynamic aspects • Description of comfort needs and spatial preferences of residents
Visualization of data: maps on occupant behaviour	
Interpretation of data: analysis of seasonal living pattern	• The properties which define the seasonal living pattern according to the students • The influence of the seasonal living pattern on the actual energy demand according to the students
Design for enabling a dynamic way of living throughout the seasons	
Implementation of information from analysis within design	• Application of insights from analysis of residents within the design
Design concept response to dynamic residents	• Concept for responding to dynamic residents throughout the seasons
Contribution to energy-efficiency of the resulting concepts and applied principles	• Potential impact of the resulting concepts and applied principles on the actual energy demand of residents
Integration of dynamic design concept into a holistic sustainable renovation	• Integration of the dynamic and the constructive designs within the entire design project

3 Results and discussion

3.1 Collection of data

The students' transcriptions of the interviews entail information on the profile of the residents, the occupation and heating of spaces and the residents' comfort needs. The analysis of the transcription shows that all residents were retired couples or individuals, with children who had left the house many years earlier. Daily activities and hobbies include cooking, reading and watching TV and occur mostly in the common living areas (e.g. kitchen and living room).

All residents experience their living environment as too large as the dwelling contains several vacant and underused rooms. The latter are often second living rooms or former bedrooms of their children which currently have a flexible function as they can be used as storage room, guest bedroom or for family gatherings when needed. However, in general the indoor living environment is considered static and non-adaptable because of the small, enclosed rooms and the solid walls which do not

allow expansion and reduction of spaces when needed (e.g. family gatherings). According to the residents missing functions include a glass-enclosed veranda or winter garden with optimal thermal comfort, and a convenient office and hobby space. Furthermore, in one third of the cases the residents only want to use the ground floor to increase functional comfort in view of ageing, thus leaving nearly half of the living area unoccupied.

Besides functional comfort, thermal comfort levels are not perceived as ideal throughout the year. In most cases, the living room and veranda are experienced too hot in summer and too cold in winter, also bedrooms are often experienced too cold. Responses to such discomfort often include closing doors, opening windows and turning on stoves. In one household, residents switch from the bedroom on the north to one in the south in winter for improvement of thermal comfort. In addition to thermal and functional comfort, residents often refer to the connection with the outside and the need for plenty of daylight. Consequently, all residents migrate from the living room in winter to the garden or veranda in summer.

When the living room is too cold in winter, most residents have additional local heating (e.g. wood stove) for more heat and cosiness. In summer, when the veranda is too hot, no active cooling is applied, instead residents put down blinds and close windows and doors to block the sun. In general, the thermostat is not adjusted and residents keep a constant indoor climate throughout the year, except for additional heating (e.g. stoves) in winter.

The transcriptions contain information on occupant behaviour (heating and occupation), personal comfort needs and spatial preferences. In addition, dynamic elements are found such as diversified occupation and varying heating of spaces in summer and winter. However, most students' final reports are limited to *only* transcriptions of the interviews. In addition, some groups added very short descriptive summaries or general conclusions. During this first step within the design process, students were not reflecting on the influence of occupant behaviour on the energy demand. However, when collecting data on the building itself for the constructive design, students already reflected on the environmental impact of the obtained data.

3.2 Visualization of data

All students visualized the obtained data by means of drawings or sketches of the floorplans. Most data are visualized by marking/highlighting different spaces on the floorplan. The type of data which are mapped include: circulation routes, favourite spots of residents, spaces with adequate comfort, occupation rate, and heating of rooms. Data on heating, occupation and thermal comfort of spaces are mapped most often and different ranges and units for mapping these properties were used (Figure 2). These included highlighting the often, rarely, or non-occupied spaces and heated and non-heated spaces. During the tutoring sessions, students reflected on the latter to gain more insights on relationship between the spatial use and the heating of the existing living environment. However, half of the students' reports lacked the proper legends and additional information on which properties were mapped and why they are relevant (e.g. residents' favourite spots and circulation routes). Overall, it appeared challenging for students to properly map the gained information of the living pattern and interpret the maps in view of energy-efficiency. This can be explained by the general lack of knowledge of students on the influence of occupant behaviour on the actual energy demand.

Figure 2 Mapping of occupation rate and heating of spaces (occupant behaviour) by Azdud Soukaina, Boes Ellen, Bernaerts Jonas, Schuermans Naömi and Smets Ella

To present the dynamic elements of residents' living pattern, students developed multiple floorplans on one property of the living pattern (e.g. occupation of rooms), by making distinctions between winter and summer, day and night and weekdays and weekend. However, during the tutoring sessions within the design studio, the students' scope of analysis was too wide to select relevant data for which they struggled to represent or visualize all the dynamics within residents' living pattern. Therefore, seasonal time boundaries remain important to avoid that all dynamics are visualized separately (e.g. day/night maps *and* summer/winter maps), and instead are viewed throughout the seasons (e.g. differences between days or nights in summer and days or nights in winter).

There was a distinction between groups of students in the use of the mapping method. Two student groups used the mapping method to only process data by means of visualization. These two groups are referred to as cluster A in the rest of the paper. The five other student groups also used the maps for analysing the seasonal living pattern of residents. These five groups are referred to as cluster B. Cluster A developed rather static or a limited amount of maps and relied more directly on the knowledge gained from the interviews to further analyse the residents. The more nuanced and dynamic maps belonged to the latter, cluster B. Some of the students from cluster B visualized the information gathered on the built environment such as location and amount of heating systems,

load-bearing structures and ventilation which affected the analysis of seasonal living pattern. The latter is further discussed in the following section.

3.3 Interpretation of data

Students in cluster B analysed the seasonal living pattern based on interpretations of the conducted interviews *and* the resulting maps. The properties which mostly defined the derived seasonal living pattern are occupation and heating of rooms. The analyses of cluster A on ***occupation of rooms*** are limited to descriptions of which rooms are (not) underused. The analyses of cluster B are more nuanced as they also described how often rooms are used and when. The occupation rate of rooms is occasionally explained by the thermal comfort of residents (e.g. the living rooms is not used as it is too cold). In addition, when the duration of occupation is mentioned, it is always linked to the residents' activities in the room (e.g. the office is only shortly used when reading e-mails and the living rooms is used for a longer time when watching TV). The analysis of ***heating of rooms*** is linked to the functions of rooms (e.g. circulation spaces are not heated). Furthermore, occupation of rooms is also linked to the heating of rooms (e.g. the bathroom is only heated when occupied). In addition, some students of cluster B analysed the organization of heated and non-heated rooms (e.g. the often heated rooms are not grouped together). The latter is a direct interpretation of the mapped floorplans. Besides the description of occupation and heating of rooms, half of the students of cluster B reflected on the influence on the energy-efficiency of residents' living pattern (e.g. the heated rooms are not zoned together which causes unnecessary heat losses to less occupied and non-heated rooms).

Students from cluster A directly rely on the interpretation of the interviews' transcription for the analysis of the seasonal living pattern while students from cluster B also interpreted the maps as part of the analysis. The latter have a more nuanced analysis as they correlated the heating, occupation and thermal comfort of spaces. Two of those five groups also mapped properties of the built environment (e.g. amount, type and location of heating systems) and described which heating systems are in use, when they are used, and how that room is occupied. Furthermore, within students' reports of cluster B, preliminary ideas and strategies to increase energy-efficiency are mentioned (e.g. often heated rooms can be zoned together to avoid extensive heat losses). Other students from cluster A and B did not yet link the analysis to energy-efficiency but rather implemented strategies to improve the functional comfort of residents (e.g. sound-proofing the walls to block noise from the living room to the kitchen or move bathroom downstairs as a response to immobile resident). Students from cluster A who did not include a critical reflection on the analysed seasonal living pattern, lacked relevant insights on the influence of the occupant behaviour on space- and energy-efficiency. These students struggled with mapping and correctly interpreting these maps to derive the residents' seasonal living pattern. Although the descriptions on the seasonal living pattern of cluster A are limited, from the resulting transcriptions and maps, dynamics of the occupant behaviour are effectively detectable, but the students were not able to do so. Cluster A, which based the analysis on the interpretation of interviews *and* maps gained more insights on the seasonal living pattern and the dynamics of occupant behaviour. As several studies (Gram-Hanssen, 2010; van Dronkelaar, Dowson, Spataru, & Mumovic, 2016) on occupant behaviour indicate, there are properties such as heating and occupation of rooms which influence the actual energy demand of the building. The following section will discuss further whether mapping and analysing the dynamic way of living throughout the seasons of existing residents can improve the dynamic design and its impact on energy-efficiency.

3.4 Synthesis of analysis

After the analysis of the seasonal living pattern, four student groups (all from cluster B) evaluated if the current built environment responds to the dynamic elements of residents living. Cluster A who did not interpret maps or reflect on the seasonal living pattern, did not manage to set up explicit design requirements.

The main conclusions students derived from the analysis of residents is that the living environment is too large, therefore not adapted, *and* it consists of small and static rooms. As a response, several students from cluster B derived flexible walls and adaptability of the spatial plan as design requirements. These design requirements all relate to adapting the structure, spatial plan and heating systems of specific spaces within the living environment. From the analysis of the building for the constructive part of the design studio, students from cluster A and B conclude that the existing situation leads to high heat losses. The most common responses are wrapping up the entire building volume by adding insulation, applying solar panels and implementation of mechanical ventilation. This and several other derived design requirements relate to the building skin and systems.

Figure 3 Overview of the relation to the built environment of design requirements from cluster A and cluster B after the analysis phase

It can be concluded that cluster B, students who analysed the dynamic properties of residents more in-depth, are not only considering the building skin and systems but also the structure and spatial plan when transitioning to the design phase (Figure 3). Furthermore, cluster B's results in this stage of the design process show more potential on enabling a dynamic way of living throughout the seasons rather than developing a constant, static and controlled living environment as seen in object-centred approaches. However, whether the analysis of residents effectively leads to dynamic design concepts *and* contributes to the buildings' energy-efficiency is further explored in the following sections on the resulting designs.

3.5 Dynamic design concept: responding to dynamic residents and varying seasons

In general, two main architectural design concepts resulted from the design studio: multi-unit dwelling and the greenhouse dwelling. Five of seven student groups (cluster A and B) responded to the underused living space by dividing the building in two living units, one unit for the existing residents and one mostly for starting families. The multi-unit designs have flexible rooms such as

additional living space, work spaces or ateliers which can be used by both residential units when needed. The remaining students (cluster B) implemented greenhouse structures within their design. One student cluster from cluster B even combined the multi-unit concept with a greenhouse which serves as a buffer between protected and non-protected volumes (Figure 5). The other students (cluster B) applied the greenhouse concept as an extension of the living area where it serves as a seasonally adaptable space.

Both concepts respond differently to the residents' living pattern for which two interpretations of the residents' *dynamism* arise. Within the multi-unit concept, the dynamism of residents' occupation is viewed on the long term. When the household size changes (e.g. empty nest), the dwelling is adapted by dividing it into several living-units (e.g. Figure 4). In addition, the flexible rooms respond to a short term dynamism within the household size, for instance, when occasionally a larger living room is required for family gatherings, a playroom for grandchildren or for meetings.

Figure 4 Multi-unit dwelling designed by Dupont Yves, Janssen Sascha, Paolini Laura, Peulen Sandrine, Verheyen Femke

Within the greenhouse concept, the design responds to seasonal dynamics (e.g. Figure 5). Most students' analysis of the seasonal living pattern shows that in winter the living room is used as the main living area while in summer, residents migrate to the terrace, garden or the glass-enclosed veranda to be more connected to the outside. The latter is preferred by residents as the main living area, but in other seasons, it is too cold. Therefore, students (cluster B) suggest the greenhouse to serve as the main living area throughout the seasons and increase the connection with outside. The greenhouse differs from the traditional glass-enclosed veranda as it serves as an adequate living space. The greenhouse is incorporated within the building skin and spatial plan, it is part of the protected volume and constructed with insulating glass. In addition, it enhances the connection between indoor and outdoor living environment and visual comfort.

Figure 5 Greenhouse dwelling designed by Azdud Soukaina, Boes Ellen, Bernaerts Jonas, Schuermans Naömi and Smets Ella

3.6 The link between the dynamic design concept and energy-efficiency

Besides increasing space-efficiency, the multi-unit concept increases energy-efficiency by dividing the living area and total energy demand among more residents. However, by minimizing the living area per resident, the multi-unit designs also limit the dynamic way of living throughout the seasons. So, although the multi-unit concept resolved the underuse of the living area, it created an obstacle for students from cluster A to enable a dynamic way of living throughout the seasons. Due to limited living space per resident, students designed rooms to become more static and created a constant, isolated indoor climate which is not in dialogue with the seasons. In general, multi-unit may contribute to lowering the environmental impact of dwellings, but it is intrinsically focused on improving social sustainability (Gerards, 2016; van de Weijer, 2014), whereas enabling a dynamic way of living throughout the seasons aims at reducing the actual energy demand by heating and occupying spaces more efficiently. Nevertheless, both are responding to dynamic residents which can provide confusion when applying a user-centred design approach.

The greenhouse is intended by students from cluster B as a climatic buffer between outdoors and indoors (Figure 6) or protected and non-protected building volumes. The greenhouse intercepts thermal differences in order to provide optimal indoor climatic. It considers the dynamic occupation of rooms throughout the seasons and simultaneously lowers the need for active cooling or additional heating of rooms. The latter is achieved by transporting the stored heat during intermediate seasons to the colder rooms of the indoor living environment (Figure 6). Despite the fact that the greenhouse can become too cold during winters because it is heated only by solar gain and not actively, it can be occupied during all other seasons and it improves the experience of the living environment by increasing the connection to the outside.

Figure 6 Greenhouse dwelling designed by Akkermans Floris, Bosmans Brecht, Mathoul Niels, Van Cauwenberge Eline, Vannes Michael

Besides the previous strategies that the students presented as their main design concepts, smaller interventions are found within the resulting designs. Firstly, the occupation rate of spaces and the heating of rooms are combined in order to group these rooms together into zones and provide a more compact heated volume. In addition, day and night functions and cold and warm areas are grouped together to prevent heat loss and provide optimal heating distribution. These principles are also known as *thermal zoning* within climate-responsive building and are shown to contribute to the energy-efficiency of buildings (DeKay & Brown, 2014). Secondly, *flexible rooms*, that can be enlarged or reduced, are designed to provide appropriate and more efficient acclimatization of rooms when occupation rates change. The effectiveness of this intervention depends on the occupant behaviour. For instance, if residents do not shrink the room when the number of occupants is low, unnecessary heat losses can occur to the underused parts of the room. Thirdly, a more innovative intervention was applied where heating systems were linked to the duration and frequency of occupation to provide more *dynamic heating*. For instance, in rooms which are constantly occupied and need higher temperatures in winter, floor heating was applied. Whereas in rooms which are only shortly or irregularly occupied, infra-red panels, which can heat up and cool down faster, are applied.

3.7 Implementation of the analysis of seasonal living pattern in the design

Cluster A produced two multi-unit designs. One of the designs also included flexible rooms which aim for acclimatization adjusted to the occupation rate of the room. The other design in cluster A did not further apply measures which promote dynamic and efficient use of spaces. Cluster A's reports contain insufficient analysis of the existing residents. Their resulting dynamic designs seem to have a limited impact on the energy-efficiency of the building.

Cluster B submitted five designs of which two are greenhouse concepts that respond to the seasonal living pattern of residents. Both these designs apply the principle of thermal zoning which can

decrease the energy demand. Two other designs are based on the multi-unit concept which responds less to the dynamic way of living throughout the seasons. However, the principle of thermal zoning was also applied within these two designs to improve efficient heating and occupation of the indoor living environment. The fifth design is a combination of the multi-unit and the greenhouse concept. As an additional intervention, this design proposes dynamic heating by means of infra-red panels as a response to the varied occupation of spaces by the residents.

The analysis on consideration of dynamic residents within an energy-efficient design shows that cluster B, which are students who conducted a more in-depth analysis of the existing residents, developed designs which fitted the aim of enabling a dynamic way of living throughout the seasons the most. These are also the designs that have the most potential to decrease the actual energy demand of the building. It appears that the visualization of the data by means of mapping improves the analysis of the seasonal living pattern. The designs of cluster A, which are characterized by a more limited analysis of the residents, are responding less to the dynamic properties of residents which can influence the energy demand (e.g. heating and occupation of spaces). However, within the collected data of these students, several dynamics within the living pattern of residents are detected. From observations during tutoring sessions it is noticed that cluster A spent less time on the analysis of residents (user-centred) and kept a strong focus on the analysis of the building (object-centred). This approach created an obstacle for the cluster A students to design an energy-efficient living and built environment which responds to dynamic residents and varying seasons.

Exploring the application of analysis on dynamic residents within the design showed that cluster A, which lacked in-depth analysis of residents by means of the provided methodology did not create designs which respond to dynamic residents and their seasonal living pattern to decrease energy demand. Cluster B, which did carry out an in-depth analysis of dynamic resident behaviour had designs which enabled a dynamic way of living throughout the seasons and showed potential to increase energy-efficiency.

3.8 Object-centred versus user-centred approach

This paper reflects on the integration of the dynamic design and the constructive design within the entire design studio of Zero Pentathlon. Besides the architectural design concepts also constructive designs by all students are developed to increase energy-efficiency by applying measures such as insulated exterior walls, mechanical ventilation systems, heat pumps and solar panels and solar boilers. In addition, an increase in material-efficiency was created by reusing materials (e.g. bricks which were removed to apply insulation were used again as finishing for exterior walls) and used sustainable materials when additional materials were needed. During the tutoring sessions it is noted that the constructive and dynamic part of the design studio are designed separately rather than in synergy. However, the initial goal of the alternative user-centred approach was to shift away from an object-centred approach and limit the need for large quantities of additional materials by promoting more efficient occupant behaviour and decreasing the actual energy demand. It appeared highly challenging for all students to create a synergy where the dynamic design and constructive design complement each other.

Due to a small number of participants (35 students), the results (7 designs) of the educational study are limited. In addition, the design studio is organized in a Flemish context which can contain different design approaches in terms of functionality and for energy-efficient housing compared to an international context. Nevertheless, the study introduces a method for analysing residents when developing an energy-efficient building. Furthermore, illustrative design examples are presented on the integration of building, resident and climate within sustainable building. The study provides relevant insights on obstacles for designers when shifting from an object- to a user-centred design approach.

4 Conclusions

This paper explored the implementation of a user-centred approach for resource-efficient renovation within an architectural design studio for first year Master students. The alternative approach aims to counteract the challenges currently occurring within an object-centred approach for energy-efficient building. The user-centred approach aims at responding to dynamic residents and varying seasons to induce user interaction and thus promote space- and energy-efficiency. First, students needed to analyse the seasonal living pattern of existing residents by means of interviews and mapping of the occupant behaviour in winter and summer. Secondly, the students had to integrate the analysis of dynamic residents within a resource-efficient design. In Table 2, the main results from the analysis- and design-phase of the different student groups are presented. A distinction is made between cluster A, and cluster B which conducted a more in-depth analysis of the existing residents.

Table 2 Overview of results from analysis and design phase divided in two groups

	Cluster A (2 student groups)	**Cluster B (5 student groups)**
Analysis	Information on comfort, occupation and heating of spaces	
	Development of static and limited amount of maps	Nuanced and dynamic maps + some students mapped properties of the building (e.g. heating systems, structures, ventilation)
	Use of mapping method for processing and visualization of information on living pattern	Use of mapping method for processing, visualization *and* analysis of seasonal living pattern
	Focus on analysis of built environment, design requirements on building skin and systems	Both analysis of residents and building, design requirements on skin, space plan and structure + introducing flexibility and adaptability
Design	All multi-unit concepts	Mix of multi-unit and greenhouse concept
	One group included an additional measure to respond to dynamic residents (flexible room)	All groups applied measures which respond to dynamic residents (dynamic heating, flexible room or thermal zoning)

It is further concluded that the analysis of the seasonal living pattern of dynamic residents is an important aspect to gain insights on the influence of the occupant behaviour on the energy demand. Overall, it was challenging for students to visualize relevant information on residents' living pattern and correctly interpret the resulting maps in view of energy-efficiency. However, it is clear that the transition from analysis to design is a crucial part within the aim for resource-efficiency by means of a user-centred approach. In general, the analysis of dynamic properties of residents and implementation of these findings in the design phase appears difficult for students. The ability to relate user practices to energy efficiency created a barrier for many students. From this point in the design process, many students shifted from a user-centred to an object-centred approach on energy-efficient building. Moreover, the paper concludes that it is challenging for all groups of students (A and B) to create a synergy between the dynamic design and constructive design as both designs are mostly developed separately.

Further research on how to consider the influence in design of the heating and occupation of rooms on the actual energy demand is necessary. The study suggests that the development of a modified analysis tool, to interpret interviews and maps, can guide designers when applying a user-centred approach for resource-efficient building. Future research will be conducted on the underlying design methodology of the user-centred approach which enables a dynamic way of living throughout the seasons.

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A Design Tool to Apply Distributed Manufacturing Principles to Sustainable Product-Service System Development

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The Product-Service System (PSS) concept is considered a promising type of business models that has the potential to couple social, economic and environmental sustainability. However, there are a number of organisational, cultural and regulatory barriers that hinder a wide PSS implementation. The research hypothesis of this paper is that Distributed Manufacturing (DM), described as a network of localised and customer-oriented production units, can be applied to PSS to address some of the previously mentioned barriers. In order to understand to what extent DM can improve PSS implementation, existing PSS barriers were gathered and coupled with collected potential DM opportunities. Most promising pairings were described in a set of near-future scenarios which were later integrated into the first version of the PSS+DM design tool. The first testing of the tool was carried out with 45 design students and initial findings suggest that, with further improvements, the PSS+DM design tool has the potential to support PSS solutions development process.

sustainable product-service system; distributed manufacturing; future scenarios; design tool

1 Introduction

A Product-Service System (PSS) can be defined as an integrated offering of products and services which represent the shift from selling a physical product to providing a system that aims to fulfil a specific customer demand (UNEP, 2002; Baines et al., 2007). An appropriately designed PSS has the potential to provide companies with competitive advantage, and at the same time improve production processes and consumption patterns towards environmental sustainability (Cooper & Evans, 2000; Mont, 2002a). PSS business implementation extends PSS provider's responsibility of the product in all life cycle stages, encouraging reduction of material usage and energy consumption, development of more durable and easy to maintain product components as well as collection of the product at its end-of-life, remanufacturing or recycling (Tukker & Tischner, 2006; Beuren et al.,

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2013). However, PSS implementation requires companies to adopt different ways of managing business processes compared to traditional business models, as a result, creating a number of obstacles for companies to overcome (Besch, 2005). Sustainable PSS business models can be complex to implement because of a number of implementation barriers, related to organisational resistance to change, lack of customer acceptance and lack of appropriate regulations (Ceschin, 2013; 2014; Vezzoli et al., 2015). This paper investigates Distributed Manufacturing (DM) and to what extent this production model can tackle existing PSS implementation barriers. DM can be defined as a network of small scale production units equipped with advanced manufacturing technologies, which facilitate localised and individualised production (Petrulaityte et al., 2017). From this definition three main DM features can be highlighted: *application of physical and digital technologies*, *localisation of manufacturing units* and *customer-orientation*. Application of physical and digital technologies refers to the use of manufacturing hardware, such as Additive Manufacturing or Computer Numerical Control machinery, and data capturing and transferring equipment, such as Information-Communication Technologies (ICT) or sensors (Srai et al., 2015; Rauch et al., 2015). Localisation of manufacturing units describes close proximity between manufacturing facilities and customers or manufacturing resources (Pearson et al., 2013; Matt et al., 2015). Customer-orientation refers to personalisation of products and services according to customer needs (Moreno & Charnley, 2016; Rauch et al., 2015). These features bring certain advantages that can potentially improve PSS development, to name a few: better design, production and maintenance of products, personalised services and closer PSS provider-customer relationship (Matt et al., 2014; Srai et al., 2015; Rauch et al., 2016; Petrulaityte et al., 2017). Trough improving PSS business model implementation, DM has the potential to improve sustainable development: to reduce transportation and, at the same time, CO_2 emission; to minimise number of produced goods through personalised and bespoke production, at the same time reducing material usage and waste production; to contribute to social sustainability through employing local communities and sourcing local materials (Ford & Despeisse, 2016; Rauch et al., 2015).

A few scholars have proposed initial attempts to apply DM principles to PSS development (Suominen et al., 2009; Arup, 2015; Despeisse & Ford, 2015; Ford et al., 2015; Moreno & Charnley, 2016; Ford & Despeisse, 2016). However, these attempts are still very fragmented. The literature where DM application to PSS is mentioned focuses on a small number of DM features, mainly describing the potential of customisation and product life extension. All sources being initially dedicated for DM topic do not focus on the issue from the PSS perspective and miss a clear identification of existing PSS implementation obstacles. Authors agree that a systematic in-depth analysis of DM application for improved sustainable PSS development is missing (Ford et al., 2015). In addition, there is a need to translate this knowledge into practically applicable guidelines for PSS designers. This research, framed in a three-year project *LeNSin* funded by the European Union Erasmus+ programme, aims to fill this knowledge gap by answering the following research questions:

1) How the features of DM can help to address implementation barriers of PSS?

2) How to support a practical application of DM for improved PSS development?

This paper is structured in eight sections. Section 2 presents the methodological framework applied in this research. Section 3 provides an overview of the problem and the list of PSS implementation barriers. Section 4 introduces the potential of prospective DM opportunities. Section 5 details how DM opportunities can address some PSS barriers, and presents the development of PSS+DM near-future scenarios. Section 6 focuses on the integration of the scenarios into the PSS+DM design tool. Section 7 describes the first practical application of the tool and lastly, Section 8 concludes by providing recommendations for future research.

2 Methodological framework

The aim of this article is to identify the potential of DM to address PSS implementation barriers, and to translate these insights into a PSS+DM design tool, to support design practitioners and PSS

companies. The methodological framework of Design Research Methodology (DRM) (Blessing & Chakrabarti, 2009) has been chosen to outline the research activities. The DRM provides a plan of action in order to support the development of theoretical knowledge and its practical application. This approach is particularly essential for this research since it frames the development of the design tool and supports the iterative process of testing and revising. Each research stage, with corresponding sections, research activities and outcomes, is presented in Figure 1.

Figure 1 Research activities according to Design Research Methodology

Analysing the problem: identifying existing PSS implementation barriers. The development of the first version of the PSS+DM design tool required a collection and an in-depth analysis of existing PSS implementation barriers on the one hand, and the identification of current and future potential DM opportunities and challenges (with a 10-year timeframe). The comprehensive literature review was carried out to collect this data. It has been identified, that the literature is a sufficient source of information for the collection of existing PSS implementation barriers. However, the literature on DM is still fragmented, regarding benefits and challenges related to DM model, with a limited overview of the future vision.

Identifying the potential: collecting prospective DM opportunities. In order to collect most up-to-date knowledge and contributions regarding DM, semi-structured expert interviews and a research workshop were conducted. Ten participants with expertise ranging from Additive Manufacturing to open-source fabrication and personal production in makerspaces, were interviewed for an average of one hour each. Interviewees were asked to answer five prearranged questions related to DM benefits, challenges, future trends and existing case studies. Additional questions were provided depending on participant expertise and focused on sustainability of DM, the role of manufacturing technology and DM model suitability for different contexts. The research workshop activities included presentations of DM feasibility studies followed by group discussions about DM definition, drivers, benefits and future vision. The workshop invited 28 academics involved in six DM research projects: 1] 3D printing-enabled DM; 2] Big Data for DM; 3] The role of makerspaces; 4] Sustainable local food, energy and water; 5] DM for resilient, sustainable city; and 6] DM in healthcare. Descriptive Study I research activities helped to validate literature review findings and, most importantly, identify DM near future trends for the next 10 years. More detailed results have been published in Petrulaityte et al. (2017).

Finding the synthesis and making it practical: developing PSS+DM design tool. Initial research proved, that there are yet no existing solid examples of DM applied to PSS development. For this

reason, future scenario technique was chosen to illustrate the potential. Data gathered during the first two research stages was used to generate a set of PSS+DM near-future scenarios. Firstly, the initial literature review on scenario development was carried out in order to explore scenario planning methods and analyse elements used in existing scenario examples. Secondly, a theory building approach (Meredith, 1993) was applied in the development of PSS+DM near future scenarios. The aim of this approach is to explore the relationship between PSS and DM and develop new insights by matching all existing PSS implementation barriers with DM opportunities and challenges in all possible combinations. In other words, each identified PSS barrier was systematically coupled with each individual DM opportunity to understand if the latter could tackle the former. The most promising and feasible pairings were described in short scenarios illustrating promising DM features and their application to address specific PSS implementation barriers. Later, all of the created scenarios were revised, illustrated and presented on 35 near future Scenario Cards. Finally, the Cards were categorised and mapped in the Innovation Diagram, compiling the first version of the PSS+DM design tool.

Testing the first application: identifying recommendations for further improvements. The first practical application of the tool was carried out during a 10-day Pilot Course on PSS and Distributed Economies organised by the European project *LeNSin* and implemented in Tsinghua University in Beijing (China). The Course comprised three days of theoretical lectures explaining concepts of PSS and Distributed Economies, one-day field trip, five days of design exercise and the final day committed for exhibition and presentations. The course was attended by 45 undergraduate and postgraduate students from various design-related backgrounds: product design, architecture, design management and PSS design. One day of the Pilot Course was appointed for the testing of the PSS+DM design tool. Ethics of the study has been approved by the Research Ethics Committee of Brunel University London and consent forms have been signed by all participants. Students, working in 10 groups, were given a task to use the tool to incorporate DM principles into their initial PSS solutions. Students spent the first half of the workshop reading and analysing Scenario Cards and, after a break, they started generating ideas onto Innovation Diagrams. Before starting the 10-day Pilot Course, the majority of the students did not have knowledge about PSS business models and Distributed Manufacturing. The tool testing workshop intended to bring mutual benefits: 1] to help the researcher to collect valuable data; 2] to provide students with knowledge about sustainable PSS design and DM features. Five data collection methods were applied: 1] verbal feedbacks from workshop participants; 2] questionnaires evaluating usability and effectiveness of the design tool; 3] analysis of initial ideas generated by the students; 4] analysis of ideas selected to be incorporated into final PSS solutions; and 5] researchers' observations. Insights gathered from the testing were collected, summarised and applied to identify improvements needed for an updated version of the design tool.

3 Analysing the problem: existing PSS implementation barriers

A literature review method was carried out to collect existing barriers which prevent companies from successful PSS implementation. Scopus was used to locate 62 sources containing keywords *Product-Service Systems, Product-Service Mix, Servitisation, Performance Economy* and *Barrier, Limitation, Obstacle*. All of the papers were analysed in chronological sequence in order to collect a broad range of barriers, discard the ones which are obsolete and select those barriers which are still relevant for the present time. Both B2B and B2C barriers were taken into consideration. In total, 41 barriers were found in at least two sources. All PSS implementation barriers collected for this research were grouped according to three categories: 1] PSS barriers for companies; 2] PSS barriers for customers and 3] Context-related PSS barriers. PSS barriers for companies are linked to organisational mind-set, lack of knowledge and know-how of product and service development, financial resources, internal organisational procedures, partnership with stakeholders, relationship with customers and their behavior. Barriers for customers are related to PSS acceptance and include customer mind-set and cultural status, lack of knowledge about PSS offerings, relationship with PSS

providers, financial concerns as well as convenience using products and accessing services. Context-related barriers of PSS are related to financial constraints and other regulations. Table 4, provided in the appendix of this paper, lists all the barriers collected to be addressed in the next steps of this research.

4 Identifying the potential: prospective DM opportunities

Prospective DM opportunities, presented in this section, are combined of DM benefits and future trends for up to 10 years' time. These were collected during the literature review, semi-structured expert interviews and the research workshop. Each DM opportunity was accompanied by a number of challenges, which were collected along with DM benefits and future trends. DM challenges hinder successful DM implementation and must be taken into account when exploring potential DM applications. DM opportunities and challenges were divided according to three categories: 1] opportunities, related to application of physical and digital technologies; 2] opportunities brought by localisation of manufacturing units and 3] opportunities, linked to customer-oriented production. Application of physical and digital technologies present the potential of using Additive Manufacturing, real-time monitoring as well as data and information sharing. Localisation of manufacturing units provides opportunities of reduced transportation and flexible, resilient and rapid manufacturing close to end customer. Customer-oriented production presents the potential of customer involvement in design and manufacturing processes and various levels of customisation of products and services. Table 5, placed in the appendix of this paper, presents all the DM opportunities and corresponding challenges collected in this research.

5 Finding the synthesis: coupling of PSS barriers with DM opportunities

This section presents the process of how the initial set of the PSS+DM near future scenarios was built. In order to systematically arrange the collected data (PSS implementation barriers and DM opportunities) into possible future events, cognitive mapping method, identified from the literature review, was applied (Goodier & Soetanto, 2013). According to this method, opportunities, trends, challenges and other collected data has to be mapped in an empty space between present issues and desirable futures. In the case of this research, PSS implementation barriers were identified as undesirable situation that needs to be addressed. A desirable future was related to better PSS implementation from company's point of view and customer acceptance. Collected DM opportunities were named as a link between present issues and ideal futures. In total, 41 PSS implementation barriers were coupled with 48 DM opportunities and 28 DM challenges in all available combinations to explore ways to achieve desirable futures (Figure 2). Most promising and feasible pairings were described in short near future scenarios, with multiple scenarios addressing individual barriers. As a result, 35 scenarios illustrating up to ten years future of DM-enabled PSS development were built. Figure 3 represents examples of different PSS barriers addressed by DM opportunities and challenges and summarised into five near-future scenarios. A complete list of the titles of all PSS+DM scenarios are provided in Figure 4.

Figure 2 Schematic illustration of PSS+DM scenario building applying cognitive mapping method

PSS barrier	DM opportunities	DM challenges	PSS + DM near future scenario
13. Companies resist to collaborate with other companies because of concerns linked to sharing confidential information about internal procedures.	1. Facilitated collaboration between geographically dispersed stakeholders supported by Information-Communication Technologies.	Challenges related to information exchange, communication and control between different production sites.	**Additive Manufacturing enables geographically dispersed production without sharing digital files** Technologies will allow digital file and data transfer around the world in order to produce products in local factories. Same digital standards and machinery will provide an ability to control manufacturing equipment from distance. Production files will be able to be sent directly to 3D printers in geographically dispersed factories. **Challenges** However, communication and information issues can occur and it can be challenging for companies to manage complex manufacturing tasks.
	3. Remote control of manufacturing equipment.	Managers receive greater responsibilities and difficulties caused by complex manufacturing tasks.	
17. Companies find it challenging to define customers' purchase and service acceptance behaviour and develop PSS for a specific local context and culture	34. Resilience to changes in demand caused by moving from centralised production of single product to small-scale production of multi- products.	Reduced efficiency of manufacturing processes compared to centralised mass production facilities.	**Personalised parts upgrade products of PSS offerings** DM will enable PSS providers to upgrade shared products with personalised parts created for specific customers. Customers will be able to access digital libraries of PSS providers and choose from available designs in order to make shared products more attractive. Personalised objects will be produced in a manufacturing facility located at the close proximity to customers. **Challenges** However, efficiency of small-scale manufacturing in local factory may be reduced compared to centralised mass production facilities. Moreover, customers must be willing to pay a higher price for personalised products. There is also a risk to increase the environmental impact of manufacturing with more and more people having access to production files and facilities.
	39. Ability of customers to use digital design tools and send a production request to local manufacturing facility.	A risk to move from consumption of products to consumption of production.	
	46. Mass customisation and cost-effective bespoke production.	Higher cost of personalised /bespoke products and services compared to traditionally mass manufactured equivalent.	
29. Customers lack information about life cycle costs of owned products versus products involved in PSS solutions.	6. Improved product monitoring through the application of sensor technology.	Challenges related to fitting new technologies into existing companies' production lines.	**Sensors help to compare traditional offerings with PSS** PSS providers will supply sensors for customers who are not yet sure whether they should choose PSS offerings instead of traditionally owned products. Sensors will be applied to customers' products to show energy consumption and life cycle costs. Data collected from sensors will be sent to PSS providers in order to offer best suitable PSS solution as a replacement of owned products. **Challenges** However, companies can face challenges related to fitting sensor technologies into existing companies' processes, including high initial investment, maintenance and upgrade. Moreover, it can be challenging to encourage customers to adopt monitoring technology.
		Security issues related to companies' and customers' data.	

Figure 3 PSS+DM near future scenario examples

1. Personalised PSS offerings bring higher profit for PSS companies
2. The PSS database contains PSS designs made by customers
3. Open-source digital libraries of PSS designs can be accessed and modified by customers
4. Independent makerspaces enable collaboration between PSS providers and customers
5. Makerspaces owned by PSS providers invite customers to create PSS offerings
6. Personalised PSS offerings available on high street
7. Entirely bespoke products available for customers
8. Sensors help to compare traditional offerings with PSS
9. Personalised parts upgrade products involved in PSS offerings
10. Additive Manufacturing enables production of lightweight products
11. Communities provide PSS for local people
12. Becoming a partner of a bigger PSS provider facilitates business implementation
13. Localised manufacturing reduces supply chain
14. Additive Manufacturing reduces resource consumption
15. Outsourced manufacturing enables on-demand local production
16. Additive Manufacturing enables geographically dispersed production without digital file share
17. Additive Manufacturing enables remanufacturing of simplified product components
18. Independent makerspaces enable PSS providers to support PSS offerings
19. Licensed makerspaces possess digital production files shared by PSS providers
20. Personalised product parts ordered by customers improve hygiene of shared products
21. Home-manufactured personalised product parts improve the hygiene of shared products
22. Customers run manufacturing, PSS providers carry out service provision
23. Standardised replaceable product parts improve hygiene of shared products
24. Sensors improve development of future products
25. Independent makerspaces invite customers to share and gain knowledge
26. Product maintenance is carried out by customers in independent makerspaces
27. Product maintenance is carried out by customers at home
28. Localised manufacturing simplifies distribution
29. Information about PSS offerings available in local factories
30. Sensors provide information about product use to PSS providers and customers
31. Sensors provide information about product condition only to customers
32. Sensors indicate the level of hygiene of leased products
33. Sensors indicate product end-of-life
34. Obsolete products are turned into personalised offerings
35. Localised recycling facilities simplify product collection and recycling

Figure 4 Titles of 35 PSS+DM near future scenarios

The next section describes the integration of the near future scenarios into practically applicable PSS+DM design tool.

6 Making it practical: development of PSS+DM design tool

PSS+DM design tool aims to support idea generation processes for PSS development through the use of near future scenarios. Each of 35 scenarios was described on a double-sided card, consisting the

following elements: a title and a short description, an illustration, a summary of challenges and potential benefits and a question supporting idea generation (Figure 5).

Figure 5 PSS+DM near future Scenario Card example

In order to make scenarios work as an idea generation tool, categorisation was crucial. For this reason, all 35 Scenario Cards were mapped on an Innovation Diagram to help users to identify areas which scenarios intend to address. The Diagram comprises two polarities: one addressing PSS and one focusing on the DM feature. According to Lelah et al. (2014), attention to PSS life-cycle phases is essential for the development of sustainable PSS. For this reason, Scenario Cards were classified according to six identified PSS life cycle stages: *Design*, *Business Implementation, Material production and Manufacturing, Distribution, Use* and *End-of-life*. Concerning the focus on DM, the level of customer involvement was chosen as a second polarity. Matt et al. (2015) describe DM as *democratisation of design* and emphasise customer involvement in product development and manufacturing processes. Customer involvement for Scenario Card categorisation is described in five levels: *Customer only uses PSS offerings, Customer chooses from PSS offerings, Customer monitors PSS offerings, Customer designs PSS offerings* and *Customer manufactures products/components for PSS offerings*. For customer involvement to be possible, manufacturing companies have to be willing to cooperate and enable customers to operate blueprints and manufacturing facilities. For this reason, the level of company's openness was also taken into account when categorising Scenario Cards. This describes with whom company shares open production files of products or product components and instructions on how these products or their components must be produced. Four levels of openness were identified: *Company does not share data, Company shares data with other manufacturing facilities, Company shares data with customers,* and *Company shares data open-source*. To summarise, the Innovation Diagram consists of two polarities, a complete list of scenarios and numbers, icons and colour coding representing the position of each scenario (Figure 6).

Figure 6 PSS+DM Innovation Diagram

The tool can be approached in two different ways depending on user experience and intentions. Users without initial PSS solutions should start from reading and analysing contents of all Scenario Cards from each life cycle stage starting from left to right, taking the level of customer involvement into account. Users with initial PSS solutions or previous PSS development experience can start using the tool from reading Scenario Cards from a specific life cycle stage they wish to address or the level of customer involvement. In any case, ideas triggered by Scenario Cards must be written down on post-it notes and placed on an empty Innovation Diagram.

The next section provides an overview and the findings of the first empirical testing of this initial version of the PSS+DM design tool.

7 Testing the first application: workshop with design students

The first version of the PSS+DM design tool, including Scenario Cards and Innovation Diagram, has been tested in order to evaluate its usability and effectiveness as an idea generation tool. The summary of findings and recommendations for un updated version of the tool are presented in the following paragraphs.

7.1 Findings

Effectiveness and usability of the first version of the PSS+DM design tool were evaluated using the insights from verbal feedbacks, questionnaires, initial and final ideas provided by workshop participants and researchers' observations.

Figure 7 Students analyse all PSS+DM Scenario Cards and, later, place generated ideas on the Innovation Diagram

7.1.1 Effectiveness

Tool's effectiveness aimed at demonstrating how well the tool can: 1] support idea generation and integration into final PSS concept; and 2] help the users to understand potential benefits of DM application.

Generating ideas and integrating them into final PSS concept. The design challenge, introduced to workshop participants, invited them to create PSS lighting solutions for Chinese context. Students generated initial ideas and, later, chose the most promising ones to be integrated into their final PSS solutions. In total, 190 ideas were generated by students working in ten groups and 86 ideas were incorporated into their final PSS proposals. Initial ideas, triggered by Scenario Cards, were recorded on post-it notes and placed on the Innovation Diagram. Figure 8 illustrates DM ideas developed for PSS lighting equipment for pest control and shows that initial ideas cover a complete PSS lifecycle, as well as various levels of customer involvement. After developing a number of initial ideas, students were free to choose their own way of incorporating most promising ideas into final PSS solutions. In Figure 9, the concept of supporting field workers using drones, provides an example of how DM features were summarised for the final presentation. Here students indicated ideas for each PSS life cycle stage, clearly identifying levels of customer involvement and company's openness. Furthermore, students provided a map illustrating distribution of central facility, local entrepreneurs and resources. Highlights of DM benefits for their specific PSS business model are also summarised.

Figure 8 Example of initial ideas generated for each PSS life cycle stage

Figure 9 Example of a final presentation showing DM features integrated into final PSS concept

Understanding benefits of DM. Analysis of initial and final ideas showed that the tool helped workshop participants to grasp potential benefits of DM model. Firstly, the Innovation Diagram supported students in considering democratisation of manufacturing by choosing different levels of customer involvement (Figure 8). Secondly, icons representing levels of company's openness were included in the majority of the final presentations (Figure 9). Finally, developed ideas reflected all

three key DM features: application of physical and digital technologies (*"Sensors show efficiency and end-of-life of water filters and solar panels and indicate leaks in pipes."*), localisation (*"Farmers make products in makerspaces from materials provided by local recycling station."*) and customer-orientation *("Our business model includes different levels of satisfaction which create a long-term relationship with a client"*). Table 1 summarises feedback from the evaluation questionnaires collected to evaluate tool's effectiveness.

Table 1 Feedback collected to evaluate effectiveness of the Scenario Cards and the Innovation Diagram.

Scenario Cards						
Question	Evaluation / Answer					
	1 Very poor	2 Poor	3 Sufficient	4 Good	5 Excellent	Average
1. To what extent the Scenario Cards helped you to understand the potential benefits of DM applied to PSS?	0	0	3 (7%)	23 (53.5%)	17 (39.5%)	**4.3**
2. To what extent are the Scenario Cards useful to generate ideas?	0	1 (2.4%)	6 (14.6%)	17 (41.5%)	17 (41.5%)	**4.2**
3. To what extent the Scenario Cards helped you to stimulate the discussion in your group?	0	1 (2.4%)	5 (12.2%)	25 (61%)	10 (24.4%)	**4**
Innovation Diagram						
Question	Evaluation / Answer					
	1 Very poor	2 Poor	3 Sufficient	4 Good	5 Excellent	Average
1. To what extent is the DM + PSS Innovation Diagram useful to generate ideas?	0	0	5 (12%)	21 (50%)	16 (38.1%)	**4.3**
2. To what extent has the Innovation Diagram helped you to take into account a complete life cycle of your concept?	0	1 (2.4%)	7 (16.7%)	17 (40.5%)	17 (40.5%)	**4.2**
3. To what extent the Innovation Diagram helped you to stimulate the discussion in your group?	0	2 (4.9%)	6 (41.6%)	16 (39%)	17 (41.5%)	**4.2**

7.1.2 Usability

Tool's usability aimed at assessing visual and textual communication elements of Scenario Cards, the layout of the Innovation Diagram and overall ease of use of the tool. Since the students already had initial PSS concepts before starting using the Scenario Cards and Innovation Diagram, they were able to choose their own way to approach the tool. Verbal feedback from workshop participants and researchers' observations showed that the majority of ten groups firstly analysed all of the Scenario Cards, and later started generating ideas for each life cycle stage, starting from the first one - Design (Figure 7). One group started their idea generation process from analysing the Innovation Diagram (*"We jumped from one stage to another, one stage triggered ideas for another stage."*). Questionnaires completed by each participant provided a more detailed feedback, summarised in Table 2.

Table 2 Feedback collected to evaluate usability of the Scenario Cards and the Innovation Diagram.

Scenario Cards						
Question	Evaluation / Answer					
	1 Very poor	2 Poor	3 Sufficient	4 Good	5 Excellent	Average
1. To what extent are the illustrations on the Scenario Cards easy to understand?	0	0	5 (11.4%)	24 (54.5%)	15 (34.1%)	**4.2**
2. To what extent are the descriptions of the scenarios easy to understand (including Limitations and Challenges)?	0	2 (4.7%)	13 (30.2%)	23 (53.5%)	5 (11.6%)	**3.7**
3. To what extent are the colour coding and the icons easy to understand?	0	0	8 (18.6%)	15 (34.9%)	20 (46.5%)	**4.3**
4. To what extent, in general, is the layout of the Scenario Cards relevant to its contents?	0	0	6 (14.3%)	22 (52.4%)	14 (33.3%)	**4.2**
5. To what extent are the Scenario Cards easy to use?	0	0	8 (19%)	25 (59.5%)	9 (21.4%)	**4**
Innovation Diagram						
Question	Evaluation / Answer					
	1 Very poor	2 Poor	3 Sufficient	4 Good	5 Excellent	Average
1. To what extent is the Innovation Diagram easy to understand?	0	0	7 (16.7%)	30 (71.4%)	5 (11.9%)	**4**
2. To what extent is the Innovation Diagram easy to use?	0	0	1 (2.3%)	26 (60.5%)	16 (37.2%)	**4.3**

7.2 Discussion

The initial testing proved that the PSS+DM design tool helped students to understand potential opportunities of DM and generate a variety of ideas, describing how their initial PSS concepts can be enriched through the application of DM features. Feedback from workshop participants, analysis of PSS+DM ideas and researchers' observations helped to identify successful tool features and aspects which need improvements.

The majority of students identified scenario illustrations as inspiring and narratives of each scenario easy to understand. However, participants shared that icons, representing customer involvement and company's openness, in some cases restricted idea generation process. The study also showed, that the tool is missing more detailed presentation of DM features, including DM case studies and focus on technological aspects. It is also required to simplify textual information and support each scenario with more questions. The majority of the students agreed that the Innovation Diagram encouraged them to consider each life cycle stage of their PSS concepts and supported group discussion. However, categorisation of Scenario Cards according to two different DM features created confusion and, in some cases, restricted idea generation process. There was also lack of guidelines provided on where to start and finish, as well as how to integrate initial ideas into final PSS solutions. Some PSS life cycle stages were identified as not being well supported with an efficient number of Scenario Cards. Drawing conclusions from the first testing, recommendations for new features to be integrated in the updated version of the PSS+DM design tool are summarised in Table 3.

Table 3 Recommendations for new features for the updated version of the PSS+DM design tool.

Scenario Cards	Worked	Did not work	Suggestions from participants	Recommendations for new features
Effectiveness	1. Illustrations were engaging and easy to understand. 2. Overall DM concept and the way it was presented aroused students' interest.	1. Descriptions in English were difficult to understand for Chinese students. 2. DM categorisation (customer involvement and company's openness) was too specific and restricted idea generation process.	*"A good case study as an example could help us to better understand DM concept"* *"More in-depth information about the technologies."*	1. Include case studies to better illustrate DM potential. 2. Provide descriptions of advanced technological features.
Usability			*"Reduce the amount of text, add bullets and highlight key points."* *"Give more questions to inspire us."*	1. Highlight key message each scenario delivers, including clear identification of environments and stakeholders. 2. Provide more questions in each Scenario Card to trigger idea generation.
Innovation Diagram	Worked	Did not work	Suggestions from participants	Recommendations for new features
Effectiveness	1. Focus on a complete PSS life cycle. 2. Lively group discussion.	1. Lack of guidelines where to start and where to finish idea generation process. 2. Confusion linked to two different DM categorisation: customer involvement and company's openness. 3. Insufficient number of scenarios in some PSS life cycle stages (e.g. Distribution).	*"It is not easy to map on the diagram. [Customer involvement icons] need to be simplified or re-categorized and help user to understand the contents easier."* *"There could be some PSS+DM innovation examples provided."*	1. Simplify the Diagram, keeping PSS Life Cycle Stages and removing Customer Involvement and Company's Openness, potentially replacing them by different axis. 2. Support the Diagram with DM/PSS case studies.
Usability			*"If the diagram could have more rules and activities it will be better."* *"Beginning at random stages of life cycle – starting at end of life might change the final design – order can matter."*	1. Provide more specific step-by-step guidelines of the tool application process, particularly emphasizing where to start and where to finish. 2. Customise guidelines for different potential tool user groups (design practitioners, PSS companies, students).

8 Conclusions and further research

Product-Service System is considered a promising type of business models to improve production and consumption towards social, economic and environmental sustainability. Nevertheless, the implementation and acceptance of PSS business models are still limited by a number of organisational, cultural and regulatory barriers. The research hypothesis of this paper is that Distributed Manufacturing, described as a network of localised and customer-oriented production units, can be applied to PSSs to address some of its implementation barriers. Existing attempts to combine PSS and DM can be found in the literature, however, a systematic analysis of how PSS

barriers can be addressed by DM is still missing. An ongoing research, presented in this paper aims at filling this knowledge gap as well as providing PSS companies and design practitioners with practically applicable PSS+DM idea generation tool. This article has described the research process which was carried out to develop the first version on the design tool, created to support PSS solutions development through the application of Distributed Manufacturing features.

The initial version of the PSS+DM design tool contains 35 near future Scenario Cards which illustrate DM opportunities and their application to PSS development. All the Scenario Cards are classified and mapped on the dual-axis Innovation Diagram, facilitating idea generation process by encouraging tool users to consider a complete PSS lifecycle. Since the scenarios for the integration into the design tool were developed by coupling existing PSS implementation barriers with near future opportunities of DM, they intend to address real world obstacles for PSS integration and acceptance. The first testing of the design tool carried out with 45 undergraduate and postgraduate design students demonstrated that, with further improvements, the Scenario Cards and the Innovation Diagram has the potential to support PSS solutions development processes.

Future research will focus on the iterative process of the development of improved versions of the PSS+DM design tool and empirical tool testing with various user groups. The next testing of the updated version of the tool will be carried out with experts from PSS-and DM-related fields. Later, PSS industry professionals will be invited to apply the tool in their business processes. Upcoming testings will aim at evaluating effectiveness, usability as well as completeness of the tool's contents. The aim of empirical applications of the PSS+DM design tool is to create a versatile tool which can support design practitioners, PSS companies and students in PSS development processes.

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Appendix

Table 4 PSS implementation barriers.

No	Subcategory	PSS implementation barrier	Literature source
PSS barriers for companies:			
1	Organisational mind-set	Companies might find it challenging to adopt mutual PSS-oriented mind-set and embed PSS culture across the organisation.	UNEP, 2002; Martinez et al., 2010
2		Companies might resist to change and adapt new ways to manage business processes within organisations.	Besch, 2005; Martinez et al., 2010
3		Companies might resist to make long-term decisions needed for PSS implementation.	Bartolomeo et al., 2003; Kuo et al., 2010
4	Lack of know-how	Companies might lack of know-how, knowledge and expertise in methods and tools needed to develop, evaluate and deliver a competent PSS.	UNEP, 2002; Bartolomeo et al., 2003; Baines et al., 2007
5		Companies might lack of know-how of designing and developing a product for PSS offerings.	Mont, 2002b; UNEP, 2002
6	Finance-related challenges	SMEs might lack of financial resources to implement and run PSS type business models.	Besch, 2005; Vezzoli et al., 2015
7		Companies might find it challenging to cover the initial investment required for PSS offerings.	Mont, 2002a; Barquet et al., 2013
8		Employees might lack of knowledge and practice in pricing PSS offerings and taking into account costs related to the use stage of products.	Barquet et al., 2013; Mont, 2002b
9		Companies might find it challenging to estimate cash flows and financial savings in completely new system of gaining profits.	Mont, 2002b; Bartolomeo et al., 2003
10		Companies might find it difficult to quantify environmental saving of PSS acceptance.	UNEP, 2002; Ceschin, 2012
11	Internal organisational issues	Organisational bodies within companies might face disagreements caused by the lack of communication.	Martinez et al., 2010; Vezzoli et al., 2015
12		Service providers, the intermediaries and other bodies might lack of organisational commitment.	Bartolomeo et al., 2003; Mont, 2004a
13	Collaboration with stakeholders	Companies might resist to collaborate with other companies because of concerns linked to sharing knowledge, expertise and confidential information about internal procedures.	Cooper & Evans, 2000; Mont, 2004
14		Companies might face organisational fragmentation, caused by multiplicity of actors in service chains, none of whom may have an overview of the entire chain and/or the ability to influence other actors.	UNEP, 2002; Bartolomeo et al., 2003
15		Companies might be concerned of weakened administration of core competencies caused by co-dependence of partners.	Mont, 2000; UNEP, 2002
16		Companies might be concerned of conflict of economic interest caused by different partners.	Cooper & Evans, 2000; Vezzoli et al., 2015
17	Relationship with customers	Companies might find it challenging to define customers' purchase and service acceptance behaviour and develop PSS for a specific local context and culture.	Mont, 2002b; Catulli, 2012
18		Companies might be concerned of the requirement for PSS provider to access customers' personal data or even enter into their property.	Källrot, 2001; Mont, 2001
19		Possible mismatch between the characteristics of contracts being offered by PSS companies and the needs or desires of their potential customers.	Catulli, 2012; Hannon et al., 2015
20		Companies might find it difficult to provide PSS offerings with higher or equal level of performance than traditional solutions.	Mont, 2002b; Martinez et al., 2010

21	Customer behaviour	Ownerless consumption might lead to careless behaviour.	Mont, 2002b; Barquet et al., 2013
22		Companies might face challenges of customers not being willing to return the product at the end of contract.	Mont, 2002; Catulli, 2012
PSS barriers for customers:			
23	Mind-set and cultural status	Customers might lack of PSS-oriented mind-set needed for cultural shift to accept some of PSS solutions and believe that product ownership is related to social status and measure of achievement in life.	Manzini et al. 2010; Catulli, 2012
24		Individualisation trend: customers might believe that quantity and quality of accumulated goods is perceived as a measure of success in life.	Mont, 2004a; Besch, 2005
25	Lack of knowledge about PSS	Customers might lack of understanding and knowledge about the overall PSS concept and believes that PSS solutions are less comfortable.	Ottosson, 2000; Mont 2002b; Catulli, 2012
26		Customers might believe that high initial investment when purchasing a product guarantees better reliability and overall level of satisfaction.	Mont, 2004a; Besch, 2005
27	Relationship with PSS provider	Customers might resist to accept long-term relationship with PSS provider.	Bartolomeo et al., 2003; Hannon et al., 2015
28		Possible mismatch between the characteristics of contracts being offered by PSS companies and the needs or desires of their potential customers.	Catulli, 2012; Hannon et al., 2015
29	Financial concerns	Customers might lack information about life cycle costs of owned products versus products involved in PSS solutions.	White et al., 1999; Cooper & Evans, 2000
30		Customers might believe that owning a service "package" is more expensive than owning a product.	Rexfelt et al., 2009; Catulli et al., 2012
31	Use of product or access to services	Customers might have concerns of independence and convenience related to the access of shared products.	Cooper & Evans, 2000; Mont, 2004b
32		Customers might have concerns related to hygiene of used or shared products.	Mont, 2004b; Catulli, 2012
33		Customers might have concerns related to ruining or damaging shared products.	Rexfelt et al., 2009; Catulli, 2012
34		Customers might be concerned of the requirement for PSS provider to access customers' personal data or even enter into their property.	Källrot, 2001; Mont, 2002b
Context-related PSS barriers:			
35	Finance-related challenges	Externalities (environmental impacts) might not be included in the market price.	UNEP, 2002; Mont & Lindhqvist 2003
36		Financial institutions might lack of knowledge about PSS concept.	Mont & Lindhqvist 2003; Barquet et al., 2013
37		Financial institutions might not be willing to support PSS development.	Mont, 2004; Barquet et al., 2013
38		Low cost of resources might encourage manufacturing of products using raw materials instead of recycling.	Mont, 2002b; Enckell & Isgran, 2017
39		High labour prices might prevent customers from choosing labour-intensive PSS offerings, which can be more expensive than purchasing a product.	Mont, 2002b; Ceschin, 2012
40	Regulatory barriers	There might be a lack of external infrastructure for product end-of-life stage including collection, recycling and remanufacturing.	UNEP, 2002; Kuo et al., 2010
41		PSS time-to-market can be prolonged compared to traditional product-based offerings.	Mont, 2002a; Kuo et al., 2010

Table 5 Prospective DM opportunities and corresponding challenges.

No	DM opportunities	Source	DM challenges	Source
Application of physical and digital technologies:				
1	Facilitated collaboration between geographically dispersed stakeholders supported by Information-Communication Technologies.	Basmer et al., 2015	Challenges related to information exchange, communication and control between different production sites. Managers receive greater responsibilities and difficulties caused by complex manufacturing tasks.	Durão et al., 2017 Durão et al., 2017
2	Spread of workloads across a number of manufacturing units sharing same digital standards.	Srai et al., 2015		
3	Remote control of manufacturing equipment.	Basmer et al., 2015		
4	Opportunity for companies to start selling technological knowledge instead of providing physical manufacturing service.	DS1	Lack of official data-sharing agreements between digitally connected supply chain actors.	Srai et al., 2015
5	Improved monitoring, control and optimisation of stock and material flows.	Srai et al., 2015	Challenges related to fitting new technologies into existing companies' production lines. Security issues related to companies' and customers' data.	Rauch et al., 2015i Kühnle, 2015; Rauch et al., 2015
6	Improved product monitoring through the application of sensor technology.	Srai et al., 2015		
7	Optimised production, consumption and service through the application of sensor technology.	Kühnle, 2015		
8	Improved development of future products through the application of "digital brain".	Lerch & Gotsch, 2015		
9	Better understanding of user behaviour through the data collected by sensors.	Ardolino et al., 2017		
10	Potential reduction of the time-to-market through the ability to manufacture in small lot sizes.	Durão et al., 2017	High initial investment costs, related to adoption of new technologies, their maintenance and upgrade. Energy consumption of advanced manufacturing technology is higher per unit. Challenges related to training of employees who are required to have a wide range of technical and design skills.	Srai et al., 2015 DS1 Pearson et al., 2013; Srai et al., 2015; DS1
11	Small-scale production of more complex products and their components provided by Additive Manufacturing technology.	DS1		
12	Consumption of less material and less waste at the point of manufacturing using Additive Manufacturing technology.	Ford et al. 2015		
13	Optimisation of recycling and closed-loop systems in order to enable circular economy using Additive Manufacturing technology.	Ford et al. 2015; Moreno & Charnley, 2016		
14	Simplified and optimised design of products produced using Additive Manufacturing technology.	Ford et al. 2015		
15	Self-disassembly and self-repair of product components available with the application of 4D printing technology.	Momeni et al., 2017		
16	Volume reduction of packed 4D printed products.	Momeni et al., 2017		
17	Low cost desktop 3D printers equipped with advanced materials (e.g. metal powder)	DS1	Perception that 3D printing certain components is not reliable.	DS1
Localisation of manufacturing units:				
18	Reduced transportation costs and delivery times.	Durão et al., 2017	Difficulties related to managing same quality delivery at various manufacturing units.	Srai et al., 2015

19	Reduced environmental impact of transportation, caused by only digital production files and raw materials being shipped over long distanced.	Gyires & Muthuswamy, 1993		
20	Last mile low-emission delivery implemented by companies to their customers.	Ford & Despeisse, 2016; Srai et al., 2015		
21	Manufacturing in real time in facilities at home, workplaces or at any point of urgent need.	DS1	Regulating small number of large scale production is easier than regulating a large number of small production sites. Issues related to energy consumption and toxicity of 3D printing processes.	Pearson et al., 2013; DS1 DS1
22	Combination of production and entertainment in manufacturing facilities in public spaces.	DS1		
23	Production in-store with manufacturing units on high street.	Foresight, 2013; DS1		
24	Home manufacturing of products which are no longer produced by companies.	DS1		
25	Production of products and their components carried out anywhere in the world using local resources and access to technologies.	Srai et al., 2015	Challenges to sensibly adapt new manufacturing units to the local context. Difficulties and costs needed to manage production quality at various manufacturing units. Change of mind within the company is needed to maintain operational transition towards DM implementation. Limited independence of companies caused by other network units and their processes and objectives.	DS1 Srai et al., 2015; DS1 Pearson et al., 2013 Kühnle, 2015
26	Re-evaluation of a global network design of companies.	Rauch et al., 2015		
27	Facilitated movement and re-location of manufacturing facilities in case of market or environmental changes.	Rauch et al., 2015; DS1		
28	Worldwide manufacturing facilities for maintenance and production of spare parts.	Durão et al., 2017; DS1		
29	Improved responsiveness, flexibility and efficiency for the manufacturing of spare parts.	Durão et al., 2017		
30	Higher employment rate achieved by supporting local producers who employ local communities.	Pearson et al., 2013; Srai et al., 2015	Challenges related to training of employees.	Pearson et al., 2013; Srai et al., 2015; DS1
31	Low capital cost of entry to distributed network.	DS1	Concerns of companies related to processes fragmentation caused by offshoring and outsourcing of operations.	Foresight, 2013; DS1
32	Opportunity for developing countries to produce goods on their own demand.	Basmer et al., 2015		
Customer-orientation:				
33	Small-scale manufacturing of only products required by customers.	Rauch et al., 2015; Srai et al., 2015	Reduced efficiency of manufacturing processes compared to centralised mass production facilities.	Matt et al., 2015
34	Resilience to changes in demand caused by moving from centralised production of single product to small-scale production of multi-products.	Rauch et al., 2015; DS1		

35	Reduced warehousing costs related to unsold products, caused by on-demand production.	Rauch et al., 2015		
36	Open-source innovations encouraged by customer involvement in design and production processes.	Srai et al., 2015	Lack of regulations increase risk of illegal copying of objects through access to digital files and open-source information.	Foresight, 2013; DS1
37	Free open-source libraries from which designs can be downloaded and improved by everyone.	DS1		
38	Customer involvement in production of personalised products.	Rauch et al., 2015; Srai et al., 2015	A risk to move from consumption of products to consumption of production. Challenges related to encouraging customers to adopt the new system of consuming and producing. The choice of location of openly-accessible manufacturing facilities must take into account the radius in which people are reached. Home and DIY production distinguish by limited manpower, tools, skills and investment capacity. Not all parts of products are suitable for DIY manufacturing.	DS1 DS1 Basmer et al., 2015 Bonvoisin et al., 2015 Bonvoisin et al., 2015
39	Customers able to use digital design tools and send a production request to local manufacturing facility.	Srai et al., 2015; DS1		
40	Open-access workshops, which allow users to get involved in product development processes.	Matt et al., 2015; Srai et al., 2015		
41	New community-sharing places to learn skills: repair cafes, makerspaces, co-working spaces etc.	DS1		
42	Distribution of knowledge and share of skills.	DS1		
43	Education of consumers, which provides a better understanding of production and efficient use of products.	Srai et al., 2015		
44	Personalised services supporting personalised products.	Kohtala, 2015	Higher cost of personalised/ bespoke products and services compared to traditionally mass manufactured equivalent. Potential conflicts within organisations caused by choices to offer standardised, personalised and inclusive or bespoke products.	Srai et al., 2015 Srai et al., 2015
45	Facilitated companies' enter to niche markets.	Rauch et al., 2015		
46	Mass customisation and cost-effective bespoke production.	Srai et al., 2015; DS1		
47	Long-lasting companies' relationship with customers, caused by proximity use of digital technologies.	Srai et al., 2015	Concerns of privacy issues of companies' data caused by application of cloud manufacturing and ICT.	Srai et al., 2015; DS1
48	Facilitated collaboration between producer and customer.	DS1		

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Training the Next Generation of Designers for a Sustainable Future: Action Research on the Circular Design Internship

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This paper introduces the first internship programme in University of Limerick (UL), Ireland, which is a part of two-year collaborative action research of four subsequent internships, co-funded by the Erasmus+ Programme of the European Union. The research focuses on training novice designers for challenges and real-life complexities in addressing issues of sustainability through design. The internship aims to create the environment for interns to self-learn and experience tools and techniques for Circular Design and present the potential of these tools and techniques in real-life innovation processes. Through this internship, interns were able to experience real-life challenges of creating innovative design solutions to address issues of sustainability and to develop their practical approaches to overcome these challenges. The internship is structured to convey *general design practice* and *design for sustainability* competencies to the interns, while gathering their insights throughout this internship and providing directions for improvement in the following internships in Universitat Politècnica de Catalunya (UPC) in Spain, NHL University of Applied Sciences (NHL) in the Netherlands, and Linköping University (LiU) in Sweden.

sustainability education, design education, action research, industry collaboration

1 Introduction[1]

There are different levels at which universities can build the relationship between design practice and sustainability. Some of these suggested approaches are: mainstreaming the sustainability inherently throughout the design education (O'Rafferty *et al*, 2014; de Eyto *et al*,2008), introducing modules focused on sustainability incorporating design practice (Boks & Diehl, 2006), and acting as

[1] The work under discussion in this paper took place from September to November 2017 and is part of a larger three-year research project.

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intermediaries in industry through utilising the expertise of academics on design for sustainability (Küçüksayraç, Wever & Brezet, 2017). Integrating principles of sustainability, and its design-related competencies, throughout design education is a more holistic approach that can result in deep learning over an extended period of time. Such integration, however, should involve differing perspectives of academic staff in a holistic manner, while at the same time ensuring that core competencies related to design education are still being conveyed to future designers (O'Rafferty *et al*, 2014). In order to ensure that issues of sustainability are addressed properly and not just as an additional consideration in design courses, a more hybrid approach should be developed and adopted in education (O'Rafferty *et al*, 2014; Boks & Diehl, 2006). In addition, continued professional development of academics is also necessary to keep up with ongoing changes and advancements around the topic of sustainability (O'Rafferty *et al*, 2014). Collaboration and knowledge exchange among different institutions to build educational capacity (O'Rafferty *et al*, 2014; McMahon *et al*, 2012) and between universities and industry to transform business practices (Küçüksayraç *et al*, 2017) is crucial.

During the United Nations Decade for Education for Sustainable Development 2014, the role of higher education institutions was discussed widely through capacity building (O'Rafferty, Curtis & O'Connor, 2014; Lozano, 2006), changes in learning outcomes (Shephard, 2008) and facilitating change in practice (Zilahy & Huisingh, 2009). As for adoption of sustainability in general education as well as university-level design education, there are many barriers that can be grouped under overcrowded curricula and limited expertise or awareness of staff (Sterling and Witham, 2008; Boks & Diehl, 2006; de Eyto,2010). However, these challenges need to be overcome through a collaborative approach in education and novice designers should be trained to address issues of sustainability inherently in their future design practice. Following this line of thought, this paper will introduce an internship programme that builds such a collaboration among institutions and businesses, while enabling novice designers to experience this complex relationship first hand in developing sustainable design solutions that can transform business practices.

As part of the Learning for Innovative Design for Sustainability (L4IDS) Erasmus+ Knowledge Alliance project, four European institutions with design departments [University of Limerick (UL) in Ireland, Universitat Politècnica de Catalunya (UPC) in Spain, NHL University of Applied Sciences (NHL) in the Netherlands, and Linköping University (LiU) in Sweden along with four design led SMEs (Small to Medium Enterprises) and three National Design Agencies] aim to develop a training and exchange programme for Circular Design with an adoptable schedule conforming to the structures of these schools. The aim of the programme is to promote a culturally-diverse, interdisciplinary working environment for students from varying backgrounds (i.e. Product Design, Business, Materials Science). There are two main goals for this internship:

1. to develop an adaptable training programme with standardised educational tools and techniques, which can be integrated into many existing design departments around Europe. This, in turn, can build interdisciplinary capacity within those departments to train future designers with a comprehensive understanding of sustainability, as well as ways of undertaking innovative design practice to tackle its issues.
2. to create training opportunities for novice designers and other disciplinary students on working in multi-cultural training environments and tackling the issues of different local contexts and local industry, through setting up student exchange programmes and bringing industrial partners into the training programme.

On September 1st, 2017 the first Circular Design internship started in UL, Ireland with the attendance of 10 interns (i.e. three interns from UL, three from NHL, two from UPC and two from LiU). With the start of this internship, a long-term collaborative action research process also started to further develop and optimise this internship programme that can be adopted by other European Higher Education Design Schools.

This paper introduces the action research methodology, the components of this internship programme and the assessment of the first internship through the participating interns' feedbacks.

2 Action Research and Design Education

This internship programme is being developed by four higher education institutions in four different EU countries, who share similarities on their approach to design education (i.e. practice-based learning in studio environment) and present differences in structuring of curriculum and content (e.g. duration of bachelor education, courses, trainings, access to workshops, etc.). This complicates the development of a standardised internship programme with respect to the students differing backgrounds and inclusion of the programme in existing curricula. On the other hand, the focus of the internship (i.e. sustainability and circular design) clarifies the common educational goals that help structure the internship programme. Hence, four higher education institutions agreed upon adopting an action research methodology through iterating the internship programme by reflecting on and building upon the previous implementation of it, and providing reflections and guidance for the subsequent internships.

Action research is a commonly used methodology in educational contexts for the continuous development of curricula and educational content, as the distinction between them (i.e. development and education) is removed, and they are brought together as research (McKernan, 2008). The educators' role changes significantly as well; they become researchers that perform continuous self-evaluation and work on the problems they identified (McKernan, 2008). The development and the goals of this internship programme are beyond the capabilities of a single researcher. The attempt to create a programme repeatable within different curricula and content, no less an exchange programme to bring together interns of different understandings on issues of sustainability and the development of the programme requires a collaborative framework.

Figure 1 Collaborative Action Research Framework developed in Learning for Innovative Design for Sustainability Erasmus+ project, indicating the internship cycles.

In the case of education in general, collaborative action research brings together lecturers, human resources and researchers in an attempt to improve pedagogical practice and contribute to educational theory (Oja & Smulyan, 1989). However, in this case of developing an adaptable Circular Design internship programme, different institutions from different cultural backgrounds and pedagogical perspectives are involved and the development of the programme requires reflection of the involved researchers on the existing design education. Hence, in line with the action research cycle steps of reflection, planning and action (McNiff & Whitehead, 2006), the collaborative action research framework in Figure 1 was developed. The first internship programme was planned in UL from September 1st to November 30th, 2017. Upon its completion, researchers will reflect on the

internship and its outcomes, and this reflection along with all the internship material developed will be sent to the next institution (i.e. UPC, Spain). The educators/researchers in the second institution will review the materials, reflect on the first internship and further develop the internship structure and content. The outcome of this process will be a comprehensive internship programme to train the next generation of designers for a sustainable future, which can be conducted in different design schools all around Europe.

For this framework, the knowledge transfer among lecturers/researchers needed to be well-structured to ensure the continuation of the action research cycle thus reaching meaningful outcomes. The internship programme was developed according to key learning outcomes that were devised at the beginning of the first action research cycle:

- Creating the environment for interns *to self-learn and experience* the necessary tools and techniques for Circular Design.
- Facilitating learning for innovative, sustainable design *for both the interns and the industry partners* throughout the design process.
- Present the potential of innovative design tools and techniques for sustainability and circular economy as applied to *real-life innovation processes*.

To enable clarity for the interns and industry partners, and to let the interns experience an innovative design process from the beginning until the end, the internship programme is structured in four phases (i.e. Research, Ideation, Detailing and Prototyping). In the research phase, the interns gain the experience of collecting different kinds of input from various stakeholders and develop a focused design brief through understanding the context around their projects. In the ideation phase, they develop various design solution ideas to explore potential solutions and evaluate those ideas according to their design briefs. In the detailing phase, the interns develop their idea further to address all aspects of their design brief and finalize the design solution. In the prototyping phase, they build prototypes of their solutions and develop communication material to convey their solutions addressing the sustainability issues defined in their briefs to industry partners.

These phases also provide researchers with a structure to collect and analyse data throughout the design process. At the end of each phase, a group discussion with all interns is conducted to gather their insights and provide feedback to the next internship cycle. These group discussions revolve around their experiences throughout each phase, with regards to the design tools and methods they use, their communication with various stakeholders – including their industry partners –, masterclasses they take, and any other process they go through. These group discussions are voice recorded for analysis. The analysis is done according to the topics that emerge from these discussions.

3 Circular Design Internship in Ireland

In this section, the internship programme that was underway at the time of writing this paper is explained with regards to internship projects and internship structure.

3.1 Internships Projects

In the scope of this internship, researchers decided to find three industry partners with diverse needs, who are capable of realising projects of different scales, in order to diversify the kind of projects undertaken, to observe the outcomes for these projects of different scales and to understand the potential of the internship to train individuals for diversely-scaled design projects. As a result, a craft-producer company (Mamukko, Kinsale), a furniture design consultancy (One Off, Dublin) and a government institution (Southern Region Waste Management Office - SRWMO, Limerick) agreed to become industry partners for the internship programme, and three different design briefs were developed, which are summarized as follows:

- **Material Explorations** with Mamukko: Exploring the potentials of a reclaimed material – used fishing nets – and developing innovative solutions on reusing it along with leathercraft.
- **Retrofitting** with One Off: Designing bespoke, high-end office furniture with a take-back system and reusable products/parts/materials
- **Preventing Food Waste** with SRWMO: Reimagine the food waste management in/around Limerick, and develop solutions for prevention and reuse of food waste.

These projects present three distinctly different scales in terms of circular design. The *material explorations* project focuses on the reuse/recycle of a problematic material that is discarded in oceans, contaminating the sea and endangering marine life. The purpose of the project was to explore ways of introducing this material into SME production processes thus giving it a second life. The *retrofitting* project focuses on the problem of underused, high-end furniture with valuable materials being discarded before their potential lifespan ends and aims to explore ways of reusing the furniture or the materials used in the furniture with the limited organizational capabilities of a design consultancy. The *preventing food waste* project identifies the issue of excessive amounts of food waste produced by citizens and the cultural implications of this issue. The project aims to intervene into existing models of discarding food waste and its waste stream to explore ways of preventing food waste in the first place.

Although the challenges of each project were quite diverse, they were regarded in the scope of the Circular Economy. These projects were well-aligned to observe the implications of Circular Design at different scales and how this internship programme can train the next generation of designers to respond to the diverse challenges imposed by a Circular Economy approach. It should also be noted that the industry partners for these projects were aware of the global and local issues related to sustainability, however, they needed assistance to respond to these challenges in the context of their businesses. The outcomes of this internship did not have to be applicable right away, rather these industry partners were interested in the Circular Design process and the opportunities it presented for their businesses. The enthusiasm of the industry partners is important to support the design process, and concurrently, the interns.

The internship programme was announced in the four partner universities, calling for students of varying backgrounds that were interested in issues of sustainability and wanted to experience design for sustainability in real-life contexts. The industry collaboration, interdisciplinary nature and multi-cultural approaches of the internship were clarified in this announcement. Students applied to this internship through a portfolio, an academic reference, and a short video addressing their interests in design for sustainability and their expectations from the programme. The applications were assessed according to academic and design performance, evidence of teamwork, interest in design for sustainability and demonstration of motivation to take part in this internship. As a result of this assessment, 10 interns from different backgrounds (i.e. Product Design, Business, Materials Science) were selected to participate. It should be noted that these participants were novice designers and accordingly the internship needed to provide two kinds of learning experience: *general design practice* and *design for sustainability.* In the next section, how the internship is structured to convey these is presented.

3.2 Internship Structure

As mentioned previously, the Circular Design internship was structured according to four phases (i.e. Research, Ideation, Detailing and Prototyping). Table 1 presents the general design practice related and design for sustainability related competencies the training programme aims to convey to interns, and the content created for this purpose. The table is divided into four parts in parallel to the internship structure on the left end side, and the content of the internship is presented on the right end side.

Table 1 Internship structure and its relation to skill development

	General Design Practice Competencies	Design for Sustainability Competencies	Internship Content
RESEARCH	Understanding the capabilities of industry partners & stakeholders	Assessing the potentials of these capabilities for sustainability	- Masterclass: Stakeholders and Material Flows - Open Educational Resources for data collection - Data Analysis Workshop
	Scoping the project, through research outcomes	Defining limitations and opportunities for sustainability (i.e. sustainability criteria)	- Assignment: Focused Design Brief - Presentation: Research outcomes to industry partner
IDEATION	Deciding on how to tackle the design problem	Developing a practical approach to sustainability	- Assignment: Approaches to Sustainable Design - Open Educational Resources for idea-generation - Mock-ups - Meetings with industry partners
	Generating ideas and assessing them		
At the time of writing this paper, the internship was at this stage. This paper includes reflections on the first and second phases.			
DETAILING	Selecting design solution ideas for further development	Assessing ideas according to sustainability criteria and clients' capabilities	- Presentation: Design ideas to industry partners
	Further developing the design solution	Understanding the implications of the design solution for sustainability	- Masterclass: Sustainability in the Broader Context
		Ensuring the design details are in line with sustainability criteria	- Assignment: Assessment of Final Design Solutions
PROTOTYPING	Using a digital fabrication lab and workshop equipment	Exploring potential sustainable production tools and techniques	- Health and safety training - Masterclass: FabLabs and Circular Design
	Developing design communication material	Conveying sustainability issues and sustainable design solution effectively and in a relatable way	- Masterclass: Presentation and Pitching - Presentation: Finalized design solution to industry partners and supervisors

As can be seen in Table 3, *masterclasses*, *open educational resources* and *assignments* were utilized as educational tools throughout this internship. *Masterclasses* are one-day activities conducted by outside experts on general topics of design for sustainability followed by workshops on how this information applies to the specific projects. They aim to provide fundamental information on different aspects of design for sustainability to the interns and create starting points for their further exploration of the subject.

Open educational resources are readily available tools that convey information, methods and techniques on sustainability in general and on specific aspects of design for sustainability. A comprehensive and categorized list of these tools was developed by the supervisors of the first internship in UL and expanded upon by the other project partners. This list of educational resources was provided to the interns at the beginning of the programme and they were prompted to explore different sections of this list during the different phases of their projects. Interns have utilized these resources to find applicable research and analysis methods, to explore different approaches to

sustainability, to generate and evaluate ideas, to help make decisions, and to assess their design solutions.

Finally, *assignments* were used to ensure the progress of the projects. These assignments were not graded and aimed to facilitate progression of the projects by providing deadlines and articulation of the work carried out by the interns. They also proved useful for the action research aspects of this project, as the assignments enabled supervisors to document the process in a structured manner.

In addition to the above-mentioned tools, there were scheduled industry partner meetings to ensure client exposure and buy-in. The interns were encouraged to arrange additional meetings with their industry partners regularly to gather feedback and move ideas forward. Furthermore, department workshops and local FabLab training were included in the schedule to familiarize the interns with the fabrication capabilities they have access to for mock-up building and prototyping. Finally, supervisors met the project teams twice a week to answer any questions they might have or anything they may need. These meetings were not structured as *critiques* that can be seen widely in design education, but more like discussions about the interns' design processes, outcomes and next steps forward.

4 Discussion on the internship process

At the time of writing this paper, the Circular Design Internship was approaching the end of the third phase (i.e. detailing). Up to this point, two group discussions were conducted with the interns to gather insights and the researchers had the chance to observe the outcomes of these first two phases (i.e. research and ideation). Interns' insights on different aspects of the first and second phases of the internship provided much material for discussion, affirmed many aspects of the internship and presented directions for improvement in the following cycles of collaborative action research. In this section, the internship programme will be discussed through the topics raised by the interns in these group discussions.

4.1 Self-learning and Guidance

The internship programme was structured to guide interns in exploring how design practice can respond to sustainability issues and to develop personalized approaches to sustainability for different projects and issues. The variety of challenges in the project briefs supports the importance of developing practical, project-specific approaches. It often proves difficult for novice designers to sift through the wide-ranging and abundant information and example studies on sustainability and design available to them. On the one hand, the interns require core knowledge on design for sustainability and guidance on how to reflect that knowledge in their practice. On the other hand, they need to learn how to acquire deeper knowledge and to assess its credibility and practical implications. Masterclasses, assignments and open educational resources were structured keeping these in mind, and interns' insights were collected on these as well as the way they are structured in group discussions.

All of the interns agreed upon the illuminating aspect of the first masterclass, as it provided them with core knowledge to guide their explorations of the different considerations on sustainability and design. Through discussing the practical implications of the core knowledge they gained, the interns mentioned that they could understand the way theoretical knowledge can be applied to design processes, causing them to reflect on their projects brief from more critical perspectives. The first masterclass on stakeholders and material flows helped them question the relationships among stakeholders and their importance for developing innovative, sustainable solutions. Some of the interns regarded the first masterclass as crucial (1) to make sense of sustainability concerns and design for sustainability, and (2) to guide them through the research phase of the project.

It should be noted that the first masterclass was the only structured informative session in the research and idea-generation phases of the internship programme. From then onwards, the interns were encouraged to explore further knowledge on design for sustainability, its tools and techniques through assignments and open educational resources. Although interns generally found the task of

finding knowledge on design for sustainability educative and illuminating for research and idea-generation, their opinions on this process of self-learning varied. Some of the interns mentioned that they felt lost at times, trying to assess the applicability or credibility of the information, tools and techniques they found. As novice designers who do not have much – if any – experience with design for sustainability, this task of acquiring knowledge involved the trialling of found information on their projects to assess its implications and benefits (if there were any), which was mentioned as time-consuming. Lectures were suggested as a more time efficient way of acquiring knowledge. On the other hand, some of the interns found this self-learning process more engaging and exploratory. They placed emphasis on the importance of assessing information, tools and techniques, through which they could develop their design approach to the project at hand. The twice-weekly supervisor meetings were helpful for this process, in gathering feedback and consulting on the approach they were developing.

4.2 Idea-generation and Decision Making

The challenges defined by clients and supervisors for each project, to be addressed through the three-month project, were quite deliberately broad and open. The purpose of this was to provide flexibility for the interns to focus on a more specific aspect of these challenges and to train them on how to frame their design projects with respect to the research they conducted, the requests of their clients, their capabilities and team design approach. Being able to assess these three and decide on a direction to take was thought to be an important aspect of this internship programme. To this end, a workshop on data analysis and an assignment to create focused design briefs were included in the programme.

Figure 2 Interns categorizing the research data they collected, in data analysis workshop.

The data analysis workshop was conducted towards the end of the research phase of the project. The purpose of it was to demystify the existing processes of production, distribution, consumption and disposal for each project, through categorizing the data they collected according to actors, their actions and outcomes, and organizing the categorized data in the form of timelines to reveal possible design intervention points (Figure 2). The data interns gathered from the field initially overwhelmed them, as the relations among stakeholders were too complex to deconstruct for sense-making. Hence, this exercise was found to be illuminating as the interns began to grasp the complex relations behind the existing and often unsustainable processes for each project. Design intervention points they uncovered as a result of this analysis helped them decide on which areas they should focus. They evaluated each intervention point with respect to their capabilities as a team, the amount of time allocated for the project and the stakeholders they can influence. This was the first major decision the interns had to make, as they selected the intervention point at which their future design solutions could make a difference. This analysis workshop led to the focused

design brief assignment, in which they were asked to define their scope and plan to undertake the project, leading to an innovative design solution with potential real-life impact.

Upon defining their scope and building a tentative plan for their projects, the supervisors primed the interns towards developing their design approach for sustainability. At this stage, the interns explored different approaches and their practical implications through the approaches to sustainable design assignment. Through the assignment, supervisors provided the interns with a list of existing approaches to sustainable design, asking them to find out basic information about them. Later, each team was asked to select three approaches, which were inspirational for their own projects, to gather more detailed information on these design approaches, and to suggest the practical implications of these approaches on their projects.

The interns found this assignment useful as it inspired them to generate design ideas for their project and provided them different perspectives on the potential of design in facilitating change for sustainability. While some of the interns found the assignment engaging and inspirational, others felt that they may not have reached to right information sources and it was time-consuming to explore many approaches in the right way. Going back to the discussion in the previous section about self-learning, the purpose of the assignment was to gain experience in acquiring knowledge through various resources. This was an exhaustive task for some interns, and they mentioned they would have preferred lectures on different approaches to sustainable design. However, through these decision making (i.e. analysis of research outcomes and focused design brief assignment) and idea-generation steps (i.e. approaches to sustainable design assignment), the interns developed innovative approaches and ideas for their projects, which have been well-received by their clients up until the end of the second phase.

4.3 Client and Stakeholder Exposure

The interns interacted with clients and stakeholders intensively throughout the first and second phases of the internship. This was challenging from two directions: (1) interns didn't have any previous experience in communicating design and sustainability relationship, and (2) the clients and stakeholders already had differing approaches and insights on what sustainability was and what role was occupied by design. These presented challenges in gathering data from stakeholders and communicating ideas to clients, which were important experiences for the interns throughout the programme.

During the research phase, the interns tried to gather information and insights from several stakeholders to grasp the relations among them and to understand the context of their projects. However, getting in touch with the stakeholders was mostly difficult due to the busy schedules of the stakeholders or their lack of interest on issues of sustainability. These issues were mostly overcome with the intervention of clients who introduced the interns with their stakeholders and facilitated the meetings.

The interns' insights on their interactions with stakeholders can be categorised into three groups: secretive, assertive and helpful. Interns mentioned that some of the stakeholders, when they found out the sustainability aspect of the projects, refrained from sharing information or giving insights about their processes. The interns believed these stakeholders were secretive as their practices did not reflect any concern towards sustainability. The assertive stakeholders are the ones that present a strong, often deeply embedded, perspective on how their practice should be and therefore their practices are beyond intervention. The interns believed these stakeholders were hard to reconcile with, and any design solution that involves a major change in their practices would be hard to realize. The final group is characterized by sharing information and knowledge, as well as providing a critical perspective on possibilities for change. The information they gathered from this group was crucial for them to make sense of the processes, to position these and other stakeholders throughout the processes, and to figure out how they can intervene in this process to develop realizable, sustainable design outcomes.

While the clients' interest in adopting sustainable practices was their common goal in this internship, their attitudes towards the projects were completely different throughout different stages of the internship. The interns talked about their clients' insights on different research outcomes, approaches and ideas from various perspectives, which provided insights on the progression of the projects. The clients of this internship programme were from three distinct backgrounds (i.e. craftsman, designer and governmental) with different sets of skills and capabilities. The interns needed to understand the capabilities and limitations of these clients through company visits and assess how these capabilities and limitations are related to the design solutions they developed. These capabilities and limitations were also visible on their perception of what the outcomes of this internship could or could not be. The interns mentioned the problems they faced while communicating their approaches, the potential outcomes and their real-life applications. The clients' expertise led them to evaluate these potential outcomes sometimes from a rather pessimistic perspective on their applicability, and other times with enthusiasm beyond the expectations of the interns. Although the variety of feedback from the clients was often found to be confusing, all the teams decided to adopt approaches that addressed the challenges through design solutions for immediate application and long-term application. The decision to implement the solution in its entirety or in parts was left to the client.

5 Conclusion

Much of the literature suggests why and how we could implement sustainable and circular design in industry; but practical examples exploring the realities of what this means and the resultant compromises, confusion, conflict and complications, are limited. It is necessary to introduce novice designers in education to the complexities of sustainable design and circular design, and the challenges in introducing it in real-world contexts. University is a great environment for this purpose as it provides the flexibility to build collaboration with industry and to enable novice designers to experience these challenges first hand. Through self-learning approach of the internship, interns learn how to access and critically reflect on the changing and advancing knowledge on sustainability and design, and then apply it to their work practice. Such an internship programme provides interns and their educational teams the opportunity to conduct the projects and offers some insight into the process and the potential for sustainable design to become a reality. As a result, a resilient approach to problem-solving for design for sustainability can be developed and the interns can be prepared for the real-world decision making.

The results presented in this paper only cover the first two phases of the first internship, however, it provides insights and considerations about the relationship between design departments, industry and novice designers, and presents many directions for improvement through the next internship. The Internship programme was beneficial to the interns, researchers, educators and industry partners, yet it is not without its challenges. Given these challenges and the successful elements to emerge from the first internship, the collaborative action research model ensures that the learning will be brought forward through the developments and improvements implemented in the subsequent internships planned for delivery in the next two years.

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The Fashion Collection Recalibrated – a Design Tool Furthering Sustainable Strategies

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At present the fashion and textile industries are under political and environmental pressure to make their business models more sustainable. In response, transformative thinking within the industry is pushing forward a sustainable paradigm shift. One consequence is that traditional design tools are challenged to incorporate and contribute to the solutions. In this paper, we focus on the fashion collection, which is traditionally understood as a range of garment designs, that are seasonally determined. As the notion of the fashion collection is under-researched, the aim of the paper is to investigate ways in which the fashion collection may be recalibrated as a design tool furthering sustainable strategies. Therefore, we studied collection building practices at three companies, representing different sustainable business and design strategies. The main contribution of the study is insights on how the collection as a design framework is applied by the companies. The collection transpires as a transformative design tool that aids designers and companies in different ways to fulfil their strategy and maintain their business.

transformative design tool; fashion collection; sustainable design strategy; circular thinking

1 Introduction

At present the fashion and textile industries are under political and environmental pressure to make their business models more sustainable. This is common knowledge that appears in popular and research literature, the news press, practice and education. As a consequence, the traditional design tools are undergoing changes that can incorporate the challenges and contribute to the changes. In this paper, we wish to investigate if the fashion collection as a design tool is still relevant. Therefore, we set out to explore ways in which the notion of the fashion collection is possibly recalibrated in three Danish clothing companies.

Traditionally the fashion collection is understood as a range of garment designs that are seasonally determined (Renfrew & Renfrew, 2016). However, the collection as a design tool is still under-

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researched since a majority of the literature on fashion collections can be found in text books serving as guidelines and inspiration for design practitioners. At the same time, the companies in the industry are adopting new business strategies. This is not only pointing towards more sustainable strategies since the fast fashion system itself is also moving away from seasonally tied collections towards a continuous flow of collections over a year and more 'day-to-day' design and production. However, we find that there is a need for knowledge about how companies in the fashion and textiles industry conduct this transformation – or as we prefer to call it: recalibration – from the context of a linear system into other, more sustainable systems. The aim of the paper is therefore to discuss ways in which the collection may be recalibrated as a design tool furthering sustainable strategies.

In this paper, we study three companies and their endeavors challenging the fashion collection as a design tool in a sustainable context. In a previous paper, we investigated how the collection, as a particular design framework, functions as a strategic driver for garment longevity furthering sustainable fashion design (Ræbild & Bang, 2017). The paper was based on a single case study of Vigga, a highly-segmented company in the garment industry focusing on baby clothing. We compared the case of Vigga with a thorough study on the traditional linear way of applying the fashion collection conducted by one of the authors (Ræbild, 2015). In order to give a broader and more consolidated perspective we add two cases: Aiayu, which is a small-scale high-end company focusing on women's clothing and home accessories and Selected, which is a mid-price fast fashion brand offering clothing for women and men. Our aim is to demonstrate three different strategies for recalibrating the collection as a tool for furthering a sustainable business strategy.

We have chosen the companies as they are representing different levels of circular business models within the range of product life-extension, recovery and recycling and circular supply-chain (Lacy & Rutqvist, 2015: xxii-xxiii). Firstly, Vigga offers a subscription service of clothing for babies and young children, as well as maternity wear. The company explicitly wishes to further sustainable development through garment longevity, re-use and ecological materials. Secondly, Aiayu focuses on garment quality, local craftsmanship, ethical production and ecological materials as a sustainable business strategy along with a repair service. Finally, Selected is an individual fashion brand under the Danish fast fashion concern Bestseller. Selected designs for a minimalistic and yet trendy expression. The company has a material approach to sustainability i.e. their strategy is to source new or recycled materials with low environmental impact.

In the discussion, we exemplify how some of these changes are due to a transformative thinking pushing the dominant fast fashion paradigm towards an ecological based mode of thinking and doing.

2 Theoretical Framework

The paper addresses ways in which the fashion collection as a design tool, can further sustainable strategies in the fashion industry. We therefore set out from the current discourse on design and sustainability in the fashion and garment sector, i.e. how design and designers can take part in changing the way we make and use textiles and garments, in order to lower negative social and environmental impact (see e.g. Niinimäki, 2011; Fletcher & Grose 2012; Gardetti & Torres 2013; Fletcher & Tham 2015). Moreover, we align with the notion that design has developed its perspective on sustainability from being primarily an activity at a product level to expanding to service and socio levels and beyond, as Ceschin and Gaziulusoy (2016) make evident. Hasling (2016) similarly sees sustainable design as a broadening of interconnected sustainable perspectives in fashion and textiles design, from materials and processes, to products and use, services and systems, businesses and strategies, and culture and experience. Thus, in exploring the interconnection between collection building and sustainability, we look broadly at effects beyond the material and product level.

The included company cases use different types of approaches to sustainability in their design strategy and practice. In order to understand these approaches, we draw on a wide range of knowledge. Aiayu's approaches generally fall under the umbrella term Slow Fashion (Clark, 2008), as for example local production (ibid.), repair and maintenance (Gwilt, 2015; Laitela, Boks & Klepp, 2015) aesthetic sustainability (Harper, 2015), embedded storytelling (Clark, 2008, Fletcher, 2016), Zero waste (Rissanen & McQuillan, 2016) and transparent product history (Niinimäki, 2013). Vigga's approaches are based on a circular system thinking (e.g. Botsman & Rogers, 2011; Lacy & Rutquist, 2015) and includes rental service (e.g. Fletcher & Grose, 2012; Petersen & Riisberg, 2017), technical durability (Annis, 2012), aesthetic longevity (Clark, 2008), mono-material (Gwilt, 2014; Vezzoli & Manzini, 2010), customisation (Niinimäki, 2013, Pine & Gilmore, 2011), and environmentally friendly materials (Fletcher & Grose, 2012). The last case, Selected, is still in the early stages of implementing more sustainable production practices into their fast fashion business model. As H&M, they are working with a primary material focus including the sourcing and use of environmentally friendly materials (ibid.), mono-material design (Gwilt, 2014; Vezzoli & Manzini, 2010) and labelling (e.g. Aspers, 2008), but have not yet developed any product/material take-back systems.

Lastly, the concept of the fashion collection plays a key role in the paper, as we investigate the collection as a potential transformation tool that can aid designers and companies to shift from linear business models based on fast shifting trends and aesthetic obsolescence, towards more sustainable models. The collection as design phenomenon appears relatively under-researched. From a practice-based 'how-to' perspective Renfrew & Renfrew (2016) define a collection as 'a range of garments brought together to tell a story' and 'designed for a season or particular occasion' (ibid:9). They offer guidelines tied to design and manufacturing processes, but do not address how the specific content of the collection is decided upon. The notion of the collection has also been argued as part of a particular fashion thinking methodology (Nixon & Blakley 2012) where temporal and spatial sampling practices builds a collection. Yet, how the concrete collection content is developed and decided on by the designers is less described. In this paper, we set out from a number of collection strategic design parameters identified in a larger empirical study recently conducted on linear fashion design practice (Ræbild, 2015).

3 Methodology

The paper builds on three cases. They are all Danish companies with design activities situated in Denmark. The data, derives from three semi-structured interviews (Kvale & Brinkmann 2009) of approximately 60 minutes each. The Vigga interview took place in November 2016. It was conducted with one of the founders at the Vigga premises in Copenhagen, Denmark. It should be noted, that the data produced in the Vigga case, has been key in building the first part of the Collection Framework (Ræbild & Bang, 2017), which we here aim to expand. The Aiayu interview took place in October 2017. It was conducted with the company's main designer in the Aiayu showroom in Copenhagen, Denmark. The Selected interview was conducted October 2017 via skype in Denmark with two employees, the sustainable sourcing manager and the design and buying manager. The interview data has been supplemented and in Vigga's case updated by information on company websites. Interviews have been followed up by email correspondence, when we have needed further clarification of interview data.

The questions in the interview guide centred on main collection-practice related topics:

1. The concept of the collection. Do the company use the term collection in the design practice, and if so, how? If not, then what stands instead?

2. Design development. How do the company develop, structure and maintain collections (or other forms of garments series)? Trend influences. Types of garments, functions, materials, price levels or other influencing factors? How and when do the company change content in the collections e.g. temporal pace.

3. Feedback including user feedback. Do the company receive/collect feedback? If yes, how do the company handle the information? Does it influence the design development? If yes, how?

We have deliberately refrained from asking questions to do with sustainability, but kept focus on the collection concept. This decision is made, in order to let any potential connections between collection practices and sustainability strategies emerge from the interviewees themselves. In this way, we have tried to avoid a particular direction in the answers, i.e. foreseeable bias in the data.

The data from each case has been analysed individually and categorised against collection building parameters used in linear fashion design practice (Ræbild, 2015). In terms of means, we have applied tables and manual color-coding, rather than a computational approach, as our focus has been on contextual meaning (Tanggaard & Brinkmann 2010; Schembri & Sandberg 2011). The outcome of the analysis has informed the proposed framework for sustainable collection practices (see section further below).

4 Collection Practice and Sustainability Strategies

Figure 1 Vigga. Subscription package and maternity wear. Source: Press images from the Vigga website

The Vigga company (figure 1) was founded in 2014 and launched in 2015 as a product service system based on subscription and ecological materials. The CEO and the designer are co-owners and co-founders. The business model is highly dependent on the designed garments, in terms of durability and aesthetic longevity, as each item is expected to be used by different consecutive subscribers. The total length of time each item is active was in 2016 estimated at 82 weeks. Vigga designs clothes for babies and young children up to the age of 2,5 years as well as maternity wear. They offer 8 sizes for boys, girls or unisex. The packages contain 8, 16 or 24 items and they can be individually edited. The range is developed so the package depending on size covers a certain percentage of the basic needs of a child – i.e. 20%, 70% or 100%. Each size is estimated to be in the subscribers' possession between 1 – 6 months. Including maternity wear, the company holds 500 styles in their garment portfolio. Vigga works with a slow and fluent replacement of styles in their collections, as items are renewed when worn out, as opposed to the linear system, were items are replaced by fixed temporal systems, often seasonally tied. Thereby, focus in the collection building lies on how to allow for a slow adjustment of the garment design, incorporating feedback from users as well as the returned garments themselves concurrently. In terms of individual user needs, Vigga has developed an add-on service, were individual extra packages can be rented. These can be packages of i.e. wool garments or outerwear. Vigga stresses two things as vital for their success: long-term relationship with manufacturing partners, holding similar values in terms of sustainability, and a high level of user/company interaction in many forms.

Figure 2 Aiayu. Bolivian lamas and hand knitted production. Source: Press material provided by Aiayu

Aiayu (formerly Aymara) (figure 2) was established in 2005 as a knitwear design company with an uncompromising intent not to put profit over ethics and generally act in a holistic way (Fashion Forum 2011). The company began by collaborating with Bolivian manufacturers, using local craft, know-how and materials (lama wool). Aiayu has since expanded on types of materials following the strategy from Bolivia of combining a locally produced material, with local knowhow and production. Currently they work with two yearly collections, named Volume 1 and Volume 2. Each collection has a knitted part (wool) and a woven part (cotton). The Lama wool is still produced in Bolivia. It has been supplemented with yak wool produced in smaller workshops in Nepal. The cotton part is ecological, and is manufactured in India. Each Volume holds approximately 40 items in wool and 40 in cotton. Aiayu strives to work with non-seasonal collections but have a slight decrease of wool styles in the summer Volume. The company has developed an additional 'Home' line, containing bedlinen, pillows and other interior design products. According to designer Maria Wolf, this line was created to aid their manufacturers in keeping a steady workflow in the production and eliminate strong fluctuations in the production facilities. As with Vigga, also Aiayu places strong emphasis on building solid and respectful company/manufacturer relationships, and they have kept the same partners throughout. With a focus on high-end quality material and craft, the items are not cheap. The company therefore aim for a long product life, and offers a repair service. Users can send or hand in broken knitwear and have it repaired by a specialist. It is also possible to have a repair kit sent home. The repair service provides the company with insights on actual product longevity. They get knitwear sweaters in for repair which are 7 years old or more. Another add-on in the product-line that has evolved over time, are the ad hoc designs made from production scraps. This can e.g. be patchwork quilts or woven rugs. Aiayu's primary market is Scandinavia and Europe, but they also have retailers in USA, Taiwan and Australia.

Figure 3 Examples from SELECTED's collection working with sustainable fibres. Source: images provided by SELECTED.

Selected (figure 3) was introduced in 1997 as a men's brand integrated in the Danish Bestseller concern's brand Jack & Jones. In 2008, the women's line was launched and Selected became an individual brand with stores worldwide and a web shop. In 2016, it was decided to transform Selected into a brand with a strong focus on sustainability. The first collection building on this strategy will be launched in Spring 2018. Selected launches 6 yearly collections for men/women. 50% of the turnover comes from the collections. 40% comes from 'never out of stock', which are popular models such as jeans, t-shirts or other basic garments. The remaining 10% of the turnover comes from 'day-to-day' business to continuously secure that the brand is up to date. Day-to-day business refers to express collections and exclusive collaborations with big key accounts etc. The company has adopted an ASAP-ASAP strategy to reach the goal about moving in a sustainable direction – As sustainable as possible, as soon as possible. The primary goal for the moment is an intensive focus on the fibre sourcing. The company has a specific strategy for cotton preferring certified organic cotton or recycled cotton. Included in the strategy is an aim to substitute virgin polyester with recycled polyester. Wood based fibres must be FSC or PEFC certified (responsible wood sourcing certification system) with LENZING as the preferred supplier for Modal and Viscose. Another goal is to increase the amount of TENCEL®, which is based on the fibre lyocell. Finally, there is an effort on increasing the amount of recycled wool and an expressed interest in sourcing organic wool. As the sustainable sourcing manager Camilla Skjønning Jørgensen says, "We are always on the look for new innovative more sustainable fibres with proven less impact on the environment. At current stage, we source for non-leather alternatives with less impact on the environment and we are trying to source recycled nylon. All more sustainable fibres must be certified, and certifications must be sent to the buyers."

5 Framework for Sustainable Collection Practice

In this section, we have placed findings in terms of collection practices in a table (table 1). The first column from the left lists the linear collection parameters as defined by Ræbild (2015). The following three columns holds practice examples from the three cases that refer to the same parameters, as well as new emerging parameters within each company. The second column from left lists identified circular collection practice examples from Vigga (Ræbild & Bang, 2017). The third column lists identified slow fashion collection practice examples from Aiayu and the fourth column lists collection practices from Selected, i.e. with a focus on sustainability through material sourcing.

Table 1 Framework for Sustainable Collection Practices.

Linear (Seasonal collections and fast fashion)	**Circular** (Subscription service)	**Extended lifetime** (Slow fashion, repair service and fair trade)	**Sourcing** (Environmental friendly materials)
1. **Inner to outer** Grading of range with regard to proximity to the body.	Inner to outer proximity to the body, but in this case outerwear is an optional add-on choice.	Middle proximity to the body, e.g. sweaters, tops, dresses, shirts and trousers. No outer-or underwear. No skin-tight styles Cotton shirts considered inner layer.	Middle and Outer proximity to the body, e.g. trousers, dresses, shirts, t-shirts, sweaters, suits and outerwear. Shoes and accessories. No underwear.
2. **Cool to warm** Grading of range with regard to temperature: Material properties/ Shifting seasons.	Temperature is regulated through cotton garments that can be layered and supplemented with seasonal add-ons, which can be either a material, say wool, or a garment type, say outerwear.	Temperature is mainly regulated through thickness of the wool knit. Cotton styles for less warm elements.	Temperature is regulated through layering and garments made of materials with different properties. All collections and day-to-day deliveries mirror the actual season.
3. **Basic to complex** Grading of range with regard to level of design complexity.	The collection is made up by relatively 'classic' and basic design, that is interpreted in the current time spirit. The right balance between aesthetic longevity and in the moment relevance play a big role.	The collections are characterised by simple shaping and subtle details. Complexity can be added through the textile knit design.	The collections are characterised by a minimalistic expression with a focus on quality. Quality lies in the 'classic' silhouettes and the choice of materials.
4. **Colour range** Defining colour range with regard to: a. newness /continuity b. colour scales/expression	The colour range is continuously developed in an organic process, in which company aesthetics, user wishes and the longevity perspective is weighed against each other.	The colour range is 'fluent' i.e. follows the fluent collections. Avoids trendy colours. Use 50 % natural colours in the knit (no dyes). Limited colour range with few new colours per collection.	The colour range is 'classic', e.g. white, black, grey, brown, blue and primarily 'subdued' colours, with a few accent colours such as a bright orange.

5. **Material range** Strategize material use with regard to: a. newness/continuity b. Material properties/ expressions	The material range is built with a focus on longevity. i.e. a choice towards 'classic' materials of high quality, durability and Eco certified (GOTS). Materials that has high flexibility combined with form stability (of shape).	The material range is limited. Focus on simplicity, local knowhow and fair-trade. Novelty through yarns and surfaces. Hand knit as aesthetic expression. All cotton is ecological. Focus on sensorial experiences.	The material range expresses the brand strategy, e.g. classic, & minimalistic. Materials of a relative high quality (according to price level). Some mixed materials e.g. wool mix and the use of elastane.
6. **Price range** Boundary price grid used to negotiate 1.-5. In every style within range during the design process.	Not specifically addressed in the data. The packages are set at a specific price level that reflects the price range.	Mid to high price-level. Hand knit lies at the top due to labour. Added thinner knit to lower price on knit and stretch the price range.	Mid-price level.
7. **Style role** a. Strategize types of garments to be included (collection typology). b. Define role of each style within the collection.	Basic garments for specific basic wardrobe needs. Each style has to fit into a package solution. Each style role must be easily understood by user, Optional add-on roles such as outerwear.	Basic garments that are not completely basic. Fit and cut must suit and flatter many body types Small quantity of trend-aware styles that secure interest from buyers.	Classic styles are mixed with trend based styles. Timeless design with surprising details.
8. **Temporal role** Define lifespan of each garment design: Quick trend-based special delivery, 'carry over' or stable basic?	All styles are developed from a 'longevity' perspective, with an overall 'fluent' temporal loop within the same universe/style. Styles are replaced with new styles when the old ones are worn out. Design elements can 'carry over' between styles and sizes.	All styles are developed with a focus on material and aesthetic longevity. Fluent seasons to prolong both use and sales window. Many stable basic styles. Many long-term best-sellers that works all year round. Carry minimal stock. Do not hold sales.	All styles are developed as trend-based special delivery using as sustainable fiber/fabric as possible. There are 6 yearly collections, never out of stock garments and day-to-day products.
9. **Material groups** Organise design & production around larger material groups: e.g. Jerseys, Heavy wovens, Denim.	There are two main material groups: Cotton for basic packages and wool for add-on choice. It is basically knitwear. Weave and print is used to a lesser degree.	Two groups described as Knit (lama, and yak wool) and Cotton (woven, ecological). Material groups are based in geography/ origin of material and accompanying knowhow. Reduces carbon footprint due to minimised transport.	The goal is to implement organic or BCI cotton, TENCEL®, FSC/PEFC certified Viscose and/or recycled polyester, and recycled wool and certified down. There is a long-term emphasis on lowering the use of acrylics and elastane.

10. **Performative groups** Organise and develop range with regard to various strategic needs e.g. directional, show, continued basics.	Singular strategic focus: To develop garments for longevity, circulation and re-use. Sub-groups pertaining to basic subscription packages. Sub groups pertaining to add-on options.	All product groups have developed from the ethical production and fair-trade strategy. Weight: cotton brings aesthetic 'lightness' to the heavier wool styles in retail. Hand knitted items perform storytelling.	The strategic focus is to develop garments for men and women with a Scandinavian, classic and timeless expression.
11. **Feedback loops** Strategize information feedback loops from e.g. Shops, buyers, sellers, users, manufacturers and implement in design.	Multiple strategic feedback loops, e.g. manufacturers, material tests, user surveys, user workshops, social media communities etc. Feedback information from studying the garments themselves, in the flux between company and user.	Feedback from sales. Feedback from repair service: 'reading the garment' and talking to users. Feedback to costumers through website and labelling: They must also make an effort in maintenance and use phase.	Main feedback between sourcing staff and suppliers and between Selected and their customers through a marketing, communication and consumer facing strategy. Labelling is a part of the communication strategy (from spring 2018).
Emerging attention points	1. Flexibility in fit and function (performative groups).	1. Production: Ethical workflow, fair-trade, social responsibility, zero-waste (material groups; performative groups).	1. Sustainable fibres/ fabrics (material range).
	2. Technical durability (material range).	2. Design for user-body diversity (style role).	2. Communication strategy about sustainability (feedback loops).
	3. Balance logistics vs. user wishes (style role; feedback loops).	3. Design for repair (temporal role).	
	4. Package range (performative groups; style role).		

6 Discussion

In the discussion, we have decided to look at the specificities for each company with a certain focus on instances where the collection plays a role. In a sustainable perspective Vigga's intention is to build a subscription service, Aiayu's main focus is to make use of the production opportunities and Selected's strategy is to source as sustainable as possible. Thus, the Vigga and Aiayu companies was built on ideas trying to challenge the traditional business model for fashion brands, whereas Selected is 'born' as a traditional fashion brand aiming to change it from within. In this respect, it is interesting to investigate and discuss the possibilities for a brand within the fast fashion in comparison with brands that are started on a more or less idealistic idea yet still with an expectation of conducting business on the existing market.

Looking at the framework and the way the three companies build their collections, we can first and foremost see that they all use the same parameters as found in the linear practise. By studying the table further, differences and commonalities begin to emerge in terms of how the collection parameters are calibrated towards the individual company strategies. As example the 'Basic to Complex' parameter comes forth as a way for all three companies to direct their design towards aesthetic longevity. Simplicity, basic and classic are key and common descriptions, even if the companies have very different sustainability strategies and very different aesthetic expressions. On the other hand, a parameter such as 'Material Range' surfaces the inherent differences in sustainability approach. For an ecologically based subscription service such as Vigga, materials are organised around possible logistics and maintenance, technical durability and user desires. For the slow fashion brand Aiayu, the material groups depend on local global collaborations with manufacturers and craftsmen, and an overall wish to minimise range, but increase material quality in terms of technical durability and sensorial properties. Conversely, Selected, has many material groups sourced globally in their search for more sustainable alternatives, to previously used materials. Another place were differences flag up in the way the collection is recalibrated, has to do with time. The 'Temporal Role' shows that Vigga design styles as a general rule are meant to be used non-stop by consecutive users for approximately 1,5 years. This is a relatively short lifespan, but with maximum usage. Thereby the design needs to cater more for shifting users' taste, than shifting trends. Aiayu also aim for product longevity. All their styles are meant to transcend seasons and in-the-moment trends. Selected still apply to a linear thinking in terms of temporal style roles, and develop in a span between stable basics and quick day to day trend based items.

Interestingly is that both Vigga and Aiayu claim that they are not working with collections. However, they still use parameters from collection building referring to the traditional fashion system when branding and positioning themselves in the garment sector. The way in which they are different from the traditional system is an important part of their story telling. Thus, they are in a need to constantly make a standpoint towards the traditional way of thinking and working with collections even if they can still use and apply aspects of it. Selected, on the other hand has identified a market for sustainable fast fashion and they use labelling and information to tell their story. Thus, they are not in the same need to position themselves outside the established fashion system.

Analysing the cases, we can identify a continuum between a radical and a traditional approach to collection building. Vigga is not working with a linear system at all, since the garments (due to the subscription service) has an expected lifetime that extends the normal lifetime of garments in the shop. Aiayu claims that they are working with non-seasonal volumes rather than collections. This is, in their view totally different from traditional collections. The fact that they (to some degree) need to be able to compete in a fast fashion world building on a linear collection system causes the volumes to appear as two yearly collections. They basically still need to have a collection-like framework when communicating with retail and manufacturers. Finally, Selected does not try to break with the existing system as such. Instead they work inside-out, aiming to minimize environmental footprint through material sourcing. Hence, we can see that the three companies use the collection as a transformation tool in different ways and in a way so they can fulfil their strategy and maintain their business.

The strategy towards more sustainable business models has caused development in all companies. Vigga is extremely good at using user-feedback to develop the subscription service. Since we made the study in 2016 they have implemented a high freedom for the customer to edit the package composition. Already when we made the study they had added more units to the collection (wool) and launching new product lines (maternity clothes) due to user feedback. Aiayu has experienced radical development due to local production opportunities and has launched a home collection. Furthermore, they have added an ad-hoc product line based on zero-waste, whereby leftover materials are used for rugs and blankets. They have also opened a flagship store, which has caused an increase in the repair service. Even Selected is highly flexible within the linear model where they

constantly need to find ways to integrate another way of sourcing materials in a way that allows the designers to design and meet the brand goal of identity, aesthetics and function. As such we believe that the collection is serving as a flexible framework, that can include and support new initiatives. The question is if the notion of the fashion collection step by step is on its way out as a design tool as the more sustainable business models are implemented.

However, in this study and for the moment being we can clearly see three different ways where the collection plays a role as a potential transformation tool that can aid designers and companies to shift from linear business models based on product obsolescence, towards more sustainable models.

7 Conclusion and further Perspectives

Taking a starting point in three companies within the clothing sector our aim was to investigate if we could demonstrate three different strategies for recalibrating the collection as a tool for furthering a sustainable business strategy. Analysing the interviews, we were able to identify how they challenge and change the parameters that are identified as the traditional ingredients of working with a linear collection. In the discussion, we have been able to identify the parameters which played the most significant role for recalibrating the fashion collection as a design tool.

With only three cases it is not possible to generalise. However, we argue that there are some indications of ways in which it especially makes sense to focus on the fashion collection as a design tool leading towards a more sustainable strategy.

We can see that even though it may not be explicitly addressed (Vigga), addressed as something else (Aiayu) or addressed as a traditional way of working with the collection (Selected) all companies are working with the notion of the fashion collection as a framework for designing. Interestingly, all the companies have experienced a need to recalibrate the fashion collection, and adapt it to their needs. This is especially clear looking at the parameters: Basic to Complex, Temporal Role and Material Groups. We therefore argue, that at present the collection is still useful as a driver for the transformation of the fashion and textiles industry into a more sustainable one. We can also see that the way the collection is recalibrated is strongly dependent on the strategy and goal. To conclude the paper, it is interesting to see how flexible the fashion collection appears to be. It can be adjusted by the use of the parameters, e.g. change the focus, concentrate on selected parameters, turn up and down for the means, developing them etc. It will be interesting to follow the use of the fashion collection in the coming years. It might turn out that the notion of the fashion collection may be obsolete and that something else will take its place as an important design tool.

Discussing the impact of using the fashion collection as a design tool for furthering sustainable strategies there are some issues worth considering. Sustainable impact depends not only on the type of material or production, but also on how we can generally lower the total number of garments produced and consumed. This is naturally a paradox to most companies striving for sustainability, (unless they are based on a circular take-back system as e.g. Vigga), because they live of selling new garments. As designer at Aiayu Maria Wolf puts it: “we want the costumer to only buy what she needs, because it is not sustainable to buy something and then only use it twice. But at the same time, we live of selling”. The framework informs us on how the collection parameters can be calibrated to support different sustainable strategies, but it does not inform us on people’s behaviour in terms of consumption.

For example, we know that consumers are beginning to buy more sustainable garments, but what we don’t know is whether the buying is on top of or instead of former purchasing habits. Maybe they buy the same amount – just Eco certified or in another way with a sustainable stamp. Maybe many of the sustainable garments ends in the wardrobe being rarely or never used due to some not yet identified parameters. We do not know if the consumers are happier and more content with the more sustainable commodities. Do they experience better fit, wellness, comfort or pleasure? On the other hand, what we do know is that the more sustainable materials have a lower impact on the

environment and for several of the certified materials count that they are healthier to wear close to the body. We also know that there is a higher degree of supplier driven innovation in the case of Vigga and Aiayu and thereby (and hopefully) a better and more healthy life for the material suppliers. In Selected's case it is close to the same that it must be healthier to produce more sustainable materials, but since it is more traditional sourcing (just after another type of materials than usual) it is in a more indirect way than direct supplier driven innovation.

The question is what will happen if the fashion business moves from trend-based design to a higher degree of user involvement? Furthermore, we lack knowledge about use over time. There are a vast amount of studies pointing towards longevity as one of the main solutions, but in reality, there are only few studies about this.

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Towards a Circular Economy: exploring factors to repair broken electrical and electronics products by users with pro-environmental inclination

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User repair can prolong product lifespan and support, in turn, the transformative Circular Economy agenda. Current research concerning user motivations and propensity to repair differs as to the extent at which users' environmental concerns influence repair propensity. Because of this, the focus of this study is on potential individuals with pro-environmental inclination, as a mean to identify the factors supporting and hindering repair. To this end, an in-depth survey exploring factors influencing repair propensity for electrical and electronic goods was executed. Findings from 208 respondents affiliated with pro-environmental communities identify innovativeness and frugality traits as significant factors influencing repair propensity. Qualitative analysis has shown the significance of financial considerations in deciding to repair or replace, and how access to helping relationships alleviate most of the barriers to repair, including lack of access to repair shops and lack of knowledge and skills. The findings of this study provide much-needed insight into repair behaviour. Furthermore, the insights provided will aid researchers and policymakers to develop appropriate interventions to support repair.

circular economy, consumer behaviour, repair, product lifespan

1 Introduction

The generation of huge volumes of waste electrical and electronic equipment (WEEE) as a result of overconsumption is a growing environmental problem across the world (Babu, Parande & Basha, 2007). In Europe, 11.5Mt of WEEE was generated in 2015, with 1.5 Mt originating from the United Kingdom (Baldé, Wang, Kuehr & Huisman, 2015). Repair is a viable option for diverting and recovering materials from the waste streams (Bekin, Carrigan & Szmigin, 2007; Brook Lyndhurst, 2010; Cooper, 2010; ERM, 2011; King, Burgess, Ijomah & McMahon, 2006; Nicole van Nes & Cramer, 2005). It can extend product lifespan, delay replacement purchase, and the production of e-waste. Repair is the least environmentally detrimental option to restore an item compared to

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remanufacturing and refurbishment (King et al., 2006). The user can perform repair and support the transformative Circular Economy zero waste reduction agenda set out by the European Union (EC, 2015).

Currently, the majority of users lacks enthusiasm for engaging in repair behaviour (Brook Lyndhurst, 2010). It is partly because design strategies such as "*material efficiency and miniaturisation, glue-based joint mechanism, higher levels of on-chip integration and new technologies for power storage and printed electronics*" (Mashhadi, Esmaeilian, Cade, Wiens & Behdad, 2016, p. 1) make any attempt to repair difficult. It is also partly because the user is influenced by strategies of consumer behaviour, marketing and communications research which are used to fuel overconsumption as opposed to retention (see Abela, 2006; Hamilton, 2010; Kilbourne, 2004; Kjellberg, 2008; O'Shaughnessy & O'Shaughnessy, 2002). Pro-environmental users are recognised to display stronger product retention tendency, including greater attempts to repair items to meet their values and fulfil their lifestyles choices (Haws, Naylor, Coulter & Bearden, 2011; Haws, Winterich & Naylor, 2013). Yet, research on the factors influencing repair propensity put forward conflicting outcomes as to the extent to which environmental concerns influence repair behaviour (Lilley, Bailey, & Charnley, 2013; Scott & Weaver, 2014; Terzioglu, Brass & Lockton, 2015).

Previous research explored design strategies for influencing product durability (van Nes & Cramer, 2005) and postponing product replacement (Mugge, Schoormans & Schifferstein, 2005). It also explored the role of community repair (Bekin et al., 2007), the state of the repair market (Chismar, 2008; Twigg-Flesner, 2010) and user replacement's behaviour (Abelson, 2009; Cooper, 2010; van Nes, 2010) to advance understanding of the user. Research on the factors influencing repair propensity investigate the behaviour of individuals who had different level of repair propensity. More research is required on the factors influencing repair propensity on a group of individuals which appears at first to be the most inclined to embrace the Circular Economy Agenda set by the European Union for sustainability reasons, yet appear to fail to engage with the behaviour. The research is for policy-makers, researchers and environmental and repair advocates in selecting the means to support users to adopt repair behaviour.

2 Literature review on factors influencing repair propensity

The following section presents the factors influencing repair propensity. The review draws from existing literature on the topic (Lilley et al., 2013; Scott & Weaver, 2014; Terzioglu et al., 2015) and the lessons from data mining on repair experiences (Mashhadi et al., 2016).

2.1 Perceived Inconvenience of repair

The user can perceive repair to be inconvenient because elements outside the user's control can make the repair process difficult to navigate. These elements include the lack of repair outlets (Lilley et al., 2013); a heightened negative perception of manufacturers and repair industry (Scott & Weaver, 2014); and users' lack of knowledge and skills. Repair companies, manufacturers and retailers can mismanage users' expectation by delaying the repair, having inconsistent access to spare parts and delivering poor customer service (Consumer Reports, 2001; Scelfo, 2009). The creation of a network providing spare parts can alleviate the shortage of spare parts (Lilley et al., 2013; Mashhadi et al., 2016; Terzioglu et al., 2015). Manufacturers and retailers also pass higher costs onto the user (caused by the high cost of infrastructure to process repair and decreasing skilled workforce). One solution is for manufacturers to outsource warranty services to other organisations which lengthen the repair process (Scelfo, 2009) or to pass on the cost directly to users (Klausner, Grimm & Horvath, 1999; McCollough, 2009; Twigg-Flesner, 2010). Users finally lack the skills and knowledge to understand devices, diagnose problems and comprehend service manuals (Chismar, 2008; McCollough, 2009). Community repair events provide a space where the user can reduce the required effort to learn a new skill and cost.

2.2 Lack of trust in repair shops

Users have been seen to lack trust in repair shops' efficacy (Scott & Weaver, 2014) and often are dissatisfied with the received repair services (Consumer Reports, 2001). Scott and Weaver (2014) suggested that it negatively impacts on repair propensity. The user can also not trust repair shops because of their lack of transparency on their pricing. The user can also fear to be overcharged by repair shops, discouraging repair (Lilley et al., 2013).

2.3 Product design inhibiting repair

The design can prohibit the user to repair. The introduction of products with ever-increasing embedded electronics; design features such as plastic or metal shells which sustain damage when forced; the sealed assembly which does not allow access to inner parts; and the use of glue to join mechanisms can all affect engagement in repair activities (Chapman, 2009; Guiltinan, 2009b; Lilley et al., 2013; Mashhadi et al., 2016; van Nes & Cramer, 2005; Terzioglu et al., 2015).

2.4 Perceived cost of repairs and replacement

The user can consider costs and benefits to decide whether repair or replacement is the most satisfactory option to meet his/her needs (Cooper, 2005; Okada, 2001). Some elements may influence the user's judgement as to whether they should replace an item or repair it. The user can perceive the broken item to hold greater value than a replacement item (Okada, 2001). If a product falls outside the statutory guarantee period or the warranty does not cover it, the user can perceive the cost of repair as being higher than replacement (Cooper & Christer, 2010; Twigg-Flesner, 2010; Utaka, 2006). Experts can advise replacing the item if the cost of repair is higher than replacement (Scelfo, 2009). The user can also favour new items being introduced within the marketplace because they have enhanced performance and reduced retail prices for household consumer goods (Cooper, 2010). It increases the perception that the broken item is technologically obsolete and influence replacement as opposed to repair (Cripps & Meyer, 1994; Guiltinan, 2009).

Lilley et al. (2013), Scott and Weaver (2014) and Terzioglu et al. (2015) found that the perceived cost of repair and replacement can influence repair behaviour. Terzioglu et al. (2015) found amongst the non-professional repairers that finance/time/labour loss were key motivations to repair small household appliances and electrical items. Scott and Weaver (2014) found that the cost of repair and replacement were more important with individuals with lower repair propensity level. It aligns with Lilley et al. (2013) who found that individuals who do not fix items were more likely to discard a product if the cost of replacement is low.

2.5 Relationships between attachment to item and repair

Emotional attachment brought about by memories and, experience and emotion to an item influencing him/her to retain, maintain and repair the latter. Terzioglu et al. (2015) consider the theme of everyday use and essential need to describe the relationship of attachment that can exist between an individual and items they have within the household (e.g. a boiler). Extensive research on product attachment has been carried out to support product design (Mugge, Schifferstein & Schoormans, 2010; Mugge & Schoormans, 2008; Page, 2014). Lilley et al. (2013), Scott and Weaver (2014), Terzioglu et al. (2015) recognise attachment as a factor positively influencing propensity to repair.

2.6 Environmental concerns

Concerns for the environment and engagement in the sustainability agenda can encourage repair. Scott and Weaver (2014) considered environmental concerns as a factor influencing repair propensity and measured it using Ellen's (1994) scale onto their sample. The scale measures environmental concerns by considering the individual trade-offs between the cost and benefits of individual action on environmental problems and the immediate personal rewards. Scott and Weaver (2014) found that environmental concern did not correlate with repair propensity. On the other hand, Lilley et al. (2013) identify it as an important factor for their profile of users who repair

most often. Terzioglu et al. (2016) also identify it as an element which influences the likelihood of repair in small electrical items.

2.7 Frugality

The user can have frugality traits which influence product retention. It can enhance their stewardship traits by using the item more efficiently and encourage them to be thriftier in the way they use financial resources. Frugality traits relate to repair and replacement decisions made by the user as they consider the economic pros and cons (Bayus, 1991; Okada, 2001). It was put forward by Scott & Weaver (2014) as a hypothetical factor influencing repair. Scott and Weaver (2014) recognise stewardship as a sub-element of frugality to correlate with repair propensity.

2.8 Product Retention Tendency

It refers to the tendency of the user to retain possessions through a desire to avoid waste (Haws, Naylor, Coulter, & Bearden, 2012). Product retention tendency may influence inclination to repair items.

2.9 Use Innovativeness

The user can be receptive to, and creative with, using and adapting a product in new ways to suit a new purpose. Price and Ridgway (1983) refer to it as a personality trait and call it 'use innovativeness'. It includes the following aspects: creativity-curiosity, risk preferences, voluntary simplicity, creative re-use and multiple use potential. Scott and Weaver (2014) found use innovativeness to be one of the most significant factors correlating with repair propensity. Lilley et al. (2013) and Terzioglu et al. (2015) both highlight personal satisfaction from the challenge in trying to repair and the possibility to display skills as a motivation to repair. It aligns with aspects of risk preference and creativity curiosity within use-innovativeness.

2.10 Demographics – age, income, education

Users with higher incomes have been seen to replace more than to repair (Bayus, 1991; McCollough, 2007, 2010). Lower-income households tend to focus on immediate fiscal need. They can be unable to make use of a guarantee and choose to discard the item rather than to repair it (Lilley et al. 2013). Age has been correlating positively with repair (McCollough, 2010). Educational attainment has conflicting results on whether the higher educational attainment relates to early or delayed replacement (Bayus, 1991; McCollough, 2010). Scott and Weaver (2014) posit that income and education both relate negatively to repair whilst age correlates positively with the repair of items. In Lilley et al. (2013), the repairing users were predominantly holders of tertiary and vocational education, providing them with the skills and knowledge necessary to repair.

2.11 Product care

Increased product care is a potential outcome exhibited when users with a higher repair propensity compare the economic cost and benefits of maintenance, against the economic cost and benefits of replacement (Boyd and McConocha, 1996; Okada, 2001; Scott and Weaver, 2014).

2.12 Product Acquisition Usage

The user may consider purchasing a repairable item because he has higher repair propensity level (Scott & Weaver, 2014). Lilley et al. (2013) recognise that individuals who repair are more likely to purchase premium items which are perceived to be of higher quality. When the user considers the product reparability at the initial purchase, it impacts positively on the likelihood of repair (Guiltinan, 2009).

2.13 Conceptual Framework

The conceptual framework developed by Scott and Weaver (2014) highlights three broad categories to classify the factors (Market, Product, Consumer) and a category highlighting repair outcomes from repair propensity including acquisition choice for reparable items and greater product care (see

Figure 1 for classification of the factors and definition). It does not include product design consideration, yet it offers a positive baseline for comparison in future studies.

Figure 1 - Scott and Weaver (2014) - Conceptual model for repair propensity

2.14 Literature review conclusion

The review of the literature identified a number of factors influencing repair propensity. Innovativeness and the perceived cost of repair and replacement are critical factors influencing repair propensity. However, there were conflicting findings as to the extent to which environmental concerns influence an inclination towards repair.

3 Methodology

From the literature review, a survey was designed to enable systematic capture of quantitative and qualitative data (Robson, 2002). It was distributed both online and offline. The intention was to gain a high volume of data in a relatively short amount of time. The survey aimed to assess the factors influencing user's repair propensity adapting aspects of studies by Lilley et al. (2013), Scott and Weaver (2014), Terzioglu et al. (2015) and Mashhadi et al. (2016). It was done to allow bases for comparison and discussion on the outcomes. The first part of the survey assessed the factors influencing repair propensity. The second part of the survey collected users' repair experiences

3.1 Sampling

A criterion purposive sampling technique was used (Patton, 2001). It refers to *''selecting cases that meet some predetermined criterion of importance''* (Patton, 2001, p. 238). The sample had to constitute a fairly homogeneous group. The purposive sample is also a technique for the most effective use of limited resources (Patton, 2001). Working with an organisation called Footpaths, a carbon reduction community programme (Footpaths Leicester, 2017), the survey was distributed at the Green Festival of Making and Mending in October 2015 Leicester and sent through Footpaths Leicester mailing list to engage with individuals who have pro-environmental inclinations. A control question was included in the survey to ensure the respondents' affiliation and involvement with environmental communities.

3.2 Quantitative analysis

For the analysis of the factors, to obtain a value for each element, the answered questions were averaged out per categories to find the mean. A correlation analysis was then carried out for each category against the repair propensity mean. The mean for data lines with missing values was not

included in the correlational analysis. In the second analysis, 4 out of 7 significant variables were analysed together into a regression model to identify the variables that were most significant. Similar to Scott and Weaver (2014), product care and consideration of repair during acquisition were not included in the regression analysis because they are an outcome of repair propensity. Multicollinearity for the sample was examined using the Variance Inflation Factor (VIF) which indicated an absence of multicollinearity effects with VIF statistics all under 2.0, well below the guideline of 10 (Hair, Anderson, Tatham & Black, 1998).

3.3 Qualitative analysis

For the qualitative analysis of users' repair experiences, a thematic analysis was carried out to identify further factors influencing repair propensity. Thematic analysis is a foundational tool within qualitative research. It is flexible and offers the opportunity to draw a rich and detailed account of data (Braun & Clarke, 2006). The process of coding includes six phases. It is done to create meaningful patterns. The phases are: familiarisation with data, generating initial codes, searching for themes among codes, reviewing themes, defining and naming themes, and producing the final report.

4 Findings on the factors influencing repair propensity

The results of the quantitative and qualitative analysis of the factors influencing repair propensity are presented.

4.1 Quantitative results

The correlation analysis provided an initial understanding of factors that correlate the most and the least with higher repair propensity. Receptiveness to creativity and innovation was the most significant factors. The intention and behaviour associated with trying to keep an item for a long time through product care, the certain attachment to the item's value both financial and emotional and the need to preserve resources because of frugality traits correlated with the inclination to repair. Finally, the data indicated that a lack of trust in third-party repairers encouraged users to engage in repair activities themselves.

Consideration of repair at acquisition does not correlate with repair propensity. The lack of offers for repairable items and the premiums price put on those that exist may discourage repair. The perceived cost of replacement discourages repair. Stewardship traits did not correlate with the inclination to repair. In previous research, it was a significant factor influencing repair propensity. Environmental concerns correlate negatively with repair propensity which raised questions about the nature of the sample and the questions asked to assess environmental concern.

The table below highlights in ranking order the factors that correlated the most significantly with repair propensity:

Table 1 - Correlation analysis results in ranking order

Broad Factor Categories	Ranking order	Factors influencing repair propensity	Correlation	Sign (2 tailed)	n
Consumer	1	Innovativeness	.462**	.000	192
Repair Outcome	2	Product Care	.222**	.002	198
Product	3	Relationship between attachment to item and repair	.202**	.004	201
Consumer	4	Frugality including thriftiness and stewardship	.172*	0.16	194
Market	5	Lack of trust in repair efficacy	.164*	.020	201
Consumer	7	Thriftiness	.140*	.048	201
Product	8	Product Retention Tendency	.126	.076	200
Consumer	9	Education	.117	.97	201
Product	10	Cost of repairs	.093	.191	201
Market	11	Inconvenience of repair	.085	.231	201
Consumer	12	Income	.080	.260	208
Consumer	13	Stewardship	.076	.281	201
Consumer	14	Environmental Concern	.074	.294	200
Consumer	15	Age	.015	.838	201
Product	16	Perceived cost of replacement product	.010	.890	201
Repair Outcome	17	Consideration of repair at acquisition	-0.18	.803	201

For the regression analysis, thriftiness was taken out from the analysis to reduce multicollinearity with the frugality variable. The two variables that were the most significant were innovativeness (t=6.819. *p* <.001) and traits of frugality (t= -2.841, *p* <.005). The table below presents the results of the regression analysis:

Table 2 - Regression analysis results

	Beta	t	Sign
Innovativeness	.646	6.547	.000**
Frugality including tightwad and stewardship	-.262	-2.841	.005*
Relationship between attachment to item and repair	-.073	-.955	.341
Lack of trust in repair shops	-.014	-.172	.864

Note: * p <.005, ** p <.001

Hence, the creativity and receptiveness to innovation is a strong predictor of whether someone is going to try to repair or not. Traits of frugality were also seen to be significant. Amongst the frugality trait, thriftiness correlated further with repair propensity than stewardship.

4.2 Qualitative results

Thematic analysis was carried out as to identify what encourages and discourages repair. Two themes were extracted from the analysis: access to resources and product and service features.

4.2.1 Access to resources

Users' level of access to the following resources influences the degree to which they consider repair to be more or less convenient:

- Financial resources
- Skills and knowledge to repair
- Peer and family Support
- Repair shops

- Tools and Parts
- Time

For half of the respondents, financial considerations were the main criteria influencing repair or replacement. On the one hand, a repair was considered to save money and reduce the cost of replacement:

> *''It is possible to repair, and costs less than a replacement''*
>
> *''Repair saves money''*

On the other hand, the cost of repair and the cost of replacement were considered to have a significant impact on whether respondents chose to replace an object rather than repairing it. Replacement parts can be more expensive than new products which discourage repair. Cheaper products rather than replacement parts are found in the market discouraging some respondents to repair. One participant reported that a new motherboard for his computer was "*the same price as second hand [Apple] Mac*". In some cases, respondents did not use their knowledge or experience to determine the cost of repair. They presume that it will be more expensive to repair than to replace:

> *''I presumed repair cost would outweigh price of new one''*

Repair requires some technical skills and knowledge. For a quarter of the respondents, the lack of skills and knowledge discouraged from engaging in product repair:

> *''I'm not good at understanding how things work mechanically''*
>
> *''I don't really have the skills''*

Contrastingly, in a few cases, respondents indicated some enthusiasm for developing repair skills. Some respondents indicated that by repairing an item they would learn a new skill:

> *''do some research and try my best to fix it on at least learn from my mistakes''*

A number of respondents were concerned about the safety of trying to repair an electrical item. It discouraged them from trying to repair items on their own. One participant indicated that she would rather ask someone with more experience:

> *''I would NEVER try to repair an electrical item. I would get someone else to do it''*

The extent to which the user's peers can support repair influences perception on whether repair is convenient or not. For a quarter of participants, they relied on third parties to obtain information or help in trying to repair an item. Some participants relied on their family and acquaintances for support in repairing items:

> *''I get my husband to tell me what to do''*
>
> *''I'll ask a friend for help if I was unsuccessful''*

The reliance on third party's help to repair strengthens the bonds between community members. It also reflects the inconvenience that repair presents. As such, many respondents reported that they did not know where to find repair shops. For a few respondents, the lack of tools, parts and information also discouraged repair. Finally, a number of respondents were constrained by time to engage in repair.

4.2.2 Product and service features

Product and service design and features influence the degree to which respondents value or devalue the item

- Perception of reparability and expected product lifespan
- Purpose of the item
- Age of the item
- Initial value of the item

- Item features
- Offered services by retailers

The perceived reparability or irreparability of an item influenced the repair propensity of most respondents. Amongst them, more than half anticipated that their item can be fixed. A few reported that their item would last longer if fixed. Others considered that their item was irreparable. The judgement made on the item's reparability was in some cases based on knowledge, in others on assumptions. One participant used his experience to determine whether an item could be repaired:

> *''From experience I know that leaking kettles are rarely fixed successfully''*

Another didn't make an attempt to repair because he did not know if the item could be repaired:

> ''[I did not repair it because] *I did not know if it could be repaired''*

The item's perceived purpose influenced many respondents to repair or not. The majority disliked the redefinition and association of the item's purpose with ''waste'' as a concept. It created some dissonances in the user. It encouraged them to repair. Many respondents expressed through their dislike of waste their environmental concerns:

> *''I hate waste and fear for the planet''*

In a few cases, respondents used demeaning terms to describe the item. It was a means to redefine the purpose of the item from useful to not. It aids in justifying disposal. In one case, the item is associated with 'waste' to support the user's decision to not repair:

> *''it was a hunk of junk when I bought it - ugly and unreliable''*

Services such as warranties and returns guarantee also encouraged replacement rather than repair. One respondent returned an electric bathroom scale to John Lewis, rather than choosing to repair it because it was still under guarantee.

Product retention tendency and product replacement preferences influenced some respondents' perception of the item's value. In the majority of cases, respondents indicated that they would rather repair than replace to retain the item:

> *''I would far rather repair than buy another item''*

> ''[it] *means it does not need replacing''*

Age was an important element influencing disposal of an item for many respondents. The user defines the perishability of a material object. The older the item was the more likely the item was replaced. One respondent explained that he did not repair his toaster because it was of an appropriate age to be thrown away:

> *''the* [toaster] *was old enough and has aged enough to be thrown away''*

In a few cases, the newness of the item influenced replacement as opposed to repair. The acknowledgement that the item is new allowed respondents to defer the responsibility to the retailers in handling the item. The retailer is perceived to retain some ownership of the item. If the item is recently purchased and do not meet expectations, it can be returned instead of repaired:

> ''[I did not repair it] *because the product did not function as described, and it was very recently purchased''*

The initial value of the item can influence some respondents to repair. The more expensive the item was, the more likely they were to try and repair it and vice versa. In two cases, stored data influenced decisions around the repair. One respondent explained that they repaired their computer because of the data it held. In another case, a lack of trust in a third party to deal with sensitive data on a device discouraged repair:

''I was not happy about someone I didn't know repairing it as it had sensitive data on it (research data, stored passwords etc.)''

Although negligible in number, it is important to consider the rise in items with embedded data and electronics which may deter users from repairing items.

5 Discussion

The main purpose of this research was to provide insight into the repair behaviour of individuals with pro-environmental inclination, in response to conflicting results in previous research on the extent to which environmental concerns influence repair propensity. Insights were gained through a survey collecting qualitative and quantitative data. The following sections discuss significant factors influencing repair propensity.

5.1 Updated Conceptual Framework

Figure 1 presents the factors influencing repair propensity in light of the literature review, findings and discussion. Product and service features were added to the product and service factors. Safety concern were added to consumer traits. Consumer capital, in other words, the consumer access to resources and assets to repair were added to the framework. It can be used for future references to study repair propensity.

Figure 2 – Updated Conceptual Framework on the factors influencing repair propensity

5.2 Frugality traits

Frugality traits were a significant factor influencing repair through the qualitative analysis. Frugality traits include both the latent construct of stewardship and thriftiness. Stewardship is identified by Scott and Weaver (2014) as an important variable influencing repair propensity. In the studied sample, thriftiness with money correlated further. Financial considerations were also one of the main factors influencing repair through the qualitative analysis. Frugality traits for individuals with green attitudes encourage careful use of items and product retention tendency. Work on frugal consumption (Lastovicka, Bettencourt, Hughner & Kuntze, 1999) and product retention tendency of green consumers (Haws et al., 2012; Haws, Winterich & Naylor, 2014) suggest that the engagement with those behaviours is to extract the full value of the item. It sheds light on the high correlation of product care as a sought outcome from higher repair propensity. It is recognised that pro-

environmental users use frugality traits as a mean to echo and display their identity. It was found amongst climate change activists, regardless of their level of affluence (Boucher, 2017).

It explains to a certain extent the reason why the consideration of repair at acquisition as a sought outcome was not correlating with higher repair propensity in the sample. It differs from previous research where individuals with higher repair propensity were more likely to purchase reparable items (Scott & Weaver, 2014; Mashaadi et al., 2016) and premium brand (Lilley et al. 2013). Frugality traits may discourage the purchase of expensive items. The findings contribute to the debate on the extent to which frugal behaviour amongst the affluent is the way forward to achieve sustainability (Alcott, 2008; Boucher, 2017). It also highlights the need to increase economic and financial literacy amongst users. It will support them to make spending decisions that support the emergence of sustainable consumption and production systems. It also would support them to think about their behaviour in economic term beyond their own personal financial circumstances. Further investigation of economic literacy, beliefs and attitudes amongst pro-environmental users and other layers of the population may help in understanding their repair decision process and identify areas for interventions. Questions also arise on how design can be used to increase economic literacy for sustainable investment.

5.3 Innovativeness & Safety Concerns

Innovativeness was also a significant factor influencing repair propensity to investigate repair. Curiosity and creativity drive innovative individuals to explore areas of interests; and they tend to prefer risk over comfort (Price & Ridgway, 1983). As the lack of skills and knowledge and safety concerns are significant barriers to repair, understanding the factors supporting the acquisition of skills and risk-taking behaviour amongst individuals with innovativeness traits could help in developing interventions to support individuals with lower repair propensity. Changes in legislation also need to occur to support user to engage further with repair without the fear of breaching product safety legislation and engaging in litigious affairs with organisation (Chismar, 2008)

5.4 Environmental Concerns

Environmental concerns within the sample did not correlate with repair propensity. In the qualitative analysis, environmental concerns were expressed through the dislike of waste and its impact on the environment. It highlighted some limitations in measuring environmental concerns using the Ellen (1994) scale which was used by Scott and Weaver (2014). The translation from attitudes towards the environment, to behaviour, is far more complex and does not limit itself to trade-offs between personal immediate rewards and environmental benefits. It echoes the extensive research carried out on the gap between environmental concerns and pro-environmental behaviour in the last 40 years (e.g. Kollmus & Agyeman, 2002). It highlighted a complex set of factors embedding values, personality traits, and internal and external factors which may influence the adoption of pro-environmental behaviour (Kollmus & Agyeman 2002).

5.5 Attachment and Group Affiliation

The relationship between attachment and repair also correlated with repair propensity. Terzioglu et al. (2015) highlights emotional attachment to small electrical appliances as a motivation to repair. Considering the work by Mugge and Schoormans (2006) on the concept of product attachment and its relationship with identity and group affiliation, it is important to consider whether individuals with pro-environmental inclination retain an item to fulfil expectations through their group affiliation or whether it is more strongly influenced by frugality traits.

5.6 Market, Consumer's capital access and social support

In relation to infrastructures that support repair, the lack of repair shops, tools, parts and information in the marketplace make warranty services offered by retailers more appealing than repair. It echoes findings from a number of research studies (Mashaadi et al. 2016, Terzioglu et al. 2015, Sabbaghi 2015, Lilley et al. 2013). On the other hand, the consumer can have his own assets, or in other word, the capital to carry the repair including skills and knowledge, tools, time, financial

resources and access to peer and family support. The emergence of community repair is a positive example of structural support for repair (Bekin et al., 2007; Charter & Keiller, 2014). Access to peer and family support provides access to skills and knowledge and resources. It is valuable to diffuse knowledge and increase resilience in a community. Further research needs to investigate the value being exchanged in informal repair relationships.

6 Conclusion

The research explored factors influencing repair propensity in a sample of individuals with pro-environmental inclination using an extensive survey. Innovativeness and frugality were significant factors within the quantitative analysis, and financial considerations and access to peer and family support were prominent factors influencing repair in the qualitative analysis. Future qualitative research with participants is needed to further explore how social factors support the repair and acquisition of repair skills as well as the extent to which limited understanding and literacy around the economy at macro and micro level may limit the consumer in their decision to repair. The study is limited in terms of generalisations as it targets a specific group of individuals, however it does provide valuable insight that could help direct resources and investment within pro-environmental organisations.

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Re-framing Product Circularity from a User Perspective

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Much of the discussion regarding product circularity is framed from a production and business perspective. This paper argues that the current narrative needs to be complemented with a re-framing of circularity from a user perspective and that issues of consumption should be considered in more depth. Such a re-framing is proposed based on an exploration of the consumption process and a discussion regarding what different paths of consumption may entail for people. The paper also delves into the process of product exchange between multiple users over time. It underlines that products can be designed so that they can be transferred in tight loops from one user to another, i.e. from Use2Use, which typically entails environmental advantages in relation to circular production initiatives. Overall, such a perspective suggests an enabling approach, i.e. designing products and services that create preconditions that enable people to circulate products. New opportunities for supporting product circularity from a design perspective are suggested followed by recommendations for future work.

product circularity; circular product design; sustainable consumption; circular economy

1 Introduction

Household consumption in industrialised societies has steadily increased over the last decades, contributing to a rising resource throughput creating significant environmental pressures (EEA, 2015). As a result, it is becoming more and more critical to find new ways of transitioning to more sustainable consumption and production patterns (United Nations, 2016). Such opportunities are explored in the sustainable design and circular economy (CE) literature, which highlights opportunities for narrowing, slowing, and closing material and energy loops to reduce the rising resource throughput (see, for instance, Bocken, de Pauw, Bakker, & van der Grinten, 2016; Go, Wahab, & Hishamuddin, 2015).

Narrowing resource flows from a product and production point of view, i.e. designing products so fewer resources are used per product, can be considered insufficient in itself as it risks resulting in an increased consumption rate due to rebound effects (Cooper, 2005). Several authors thus argue the

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need to also slow the resource throughput by increasing the lifespan of products (Bakker, Wang, Huisman, & den Hollander, 2014; Cooper, 2005). Strategies for slowing the throughput of products, such as designing for durability and reparability, are argued to have potential to extend and/or intensify the utilisation period resulting in a slower flow of resources (Bocken et al., 2016). In contrast, the third opportunity commonly discussed is aimed at closing resource loops instead of slowing down the throughput. It covers strategies for looping resources in technological and biological cycles based on the Cradle-to-Cradle design philosophy (McDonough & Braungart, 2010).

Much of the discussion around these three opportunities for reducing the throughput of resources is framed from a production and business perspective (see, for instance, the review by Go et al., 2015) Even though innovations in production and business are essential for reducing resource throughput and for bringing about a transition to a circular economy, changes in consumption is equally important (De los Rios & Charnley, 2016; EEA, 2015). Much literature discussing innovations for the circular economy however lacks a profound consumption and user perspective (De los Rios & Charnley, 2016; Lofthouse & Prendeville, 2017; Piscicelli & Ludden, 2016; Welch, Keller, & Mandich, 2017). Focusing only on the production and business opportunities, without also considering the user in the circular economy, may limit the possibilities for new innovations that are both commercially profitable and attractive to users. Lofthouse and Prendeville (2017) argue that gaining a better understanding for issues of consumption has potential to open up greater opportunities for innovation and success.

Recent discussions have picked up on the importance of considering the user in the circular economy. For instance, many papers in the review by Camacho-Otero, Pettersen, and Boks (2017) address users' acceptance of circular business models. These papers unquestionably address important aspects and contribute valuable insight, but they often overlook user and consumption related aspects in favour of business and production related aspects.

Considering the user in the circular economy should not only be about addressing people's attitudes towards, and acceptance of, particular business models and design strategies, but to immerse in issues of consumption from a user perspective. As Lofthouse and Prendeville (2017) highlight: "*If we do not understand users, how can we expect to design business models that they aspire to?*" (p.214). People don't care about circular business models per se (cf. Rexfelt & Hiort af Ornäs, 2008), instead they may reflect on questions like: *Do I dare to buy a second-hand phone? Is it better to sell my car and join a car pool? Should I declutter my closet and donate clothes to charity?* Gaining a better understanding of such issues may aid the exploration of new opportunities to support product circularity.

In order to contribute to a more profound understanding of issues of consumption and the user in the circular economy, this paper aims to explore what a user perspective on product circularity may entail for design. The paper will first address consumption and user-related issues that are often overlooked in CE literature and discuss how these aspects can help re-frame the current production focused narrative. Next, a user perspective on the circulation of products is presented. The paper will conclude with a discussion on what such a perspective may involve regarding design opportunities and challenges for enabling circulation of products.

2 Consumption and user-related aspects in need of further attention

As highlighted in the introduction, important issues of consumption remain underexplored in the current literature on circular economy. This section will address some of these aspects and discuss how they can contribute to the re-framing of product circularity from a user perspective.

2.1 Consumption as a three-parted process

The focus on production and business opportunities, instead of issues of consumption, in the CE literature is not surprising given its strong heritage from ecodesign (Lofthouse & Prendeville, 2017). In its early days, ecodesign had a strong techno-centric focus and design opportunities were often

framed in relation to stages of a product life-cycle. Thus, the role of consumption and user involvement was often limited to a use or utilization stage in the product life-cycle (see e.g. Brezet & Van Hemel, 1997; European Comission, 2014; van Hemel, 1995). This tradition of framing the discussion of design and innovation opportunities in relation to the stages of a product life-cycle is also evident in CE literature today, which often frames people's consumption in relation to a use phase, often preceded by a distribution phase and followed by a collection or end-of-life phase. Even though some frameworks point out opportunities for product re-use, they are still based on a simplified framing of consumption that does not sufficiently take into account issues of consumption from a user's point of view.

If looking outside the CE field, some publications provide a more nuanced narrative. These refer to consumption as a process that can be considered to cover three main phases: acquisition, use, and disposition (Antonides & Van Raaij, 1998; Jacoby, Berning, & Dietvorst, 1977; Lehtonen, 2003; Lucas, 2002). Even though the importance of considering all three phases is stressed, the spotlight is however often on the process in which people purchase goods or services. In consumer behaviour literature specifically, a marketing perspective rather than a user perspective is often applied, and people are often seen as objects rather than subjects (Antonides & Van Raaij, 1998). When considering consumption in relation to circularity, additional issues of consumption become relevant to recognise. In regard to acquisition, it must for example be acknowledged that products can be acquired without any financial transactions (through e.g. receiving gifts and borrowing) and that people themselves can exchange ownership of, and access to, products without any company involvement. Even though these types of issues are highlighted in literature on sharing and collaborative consumption (Botsman & Rogers, 2011; Matzler, Veider, & Kathan, 2015), they should receive further attention.

Additionally, disposition has also been given less attention than it deserves (Lucas, 2002). Lucas describes how complex the disposition process really is:

> *In the general economy of the household or the person, shedding off possessions can be as complex a process as acquiring them, and acts such as giving away, recycling and discard, need to be examined as different responses to this process. In many cases, there is a variously strong reluctance to discard; hoarding unused, unneeded objects is a common practice… (Lucas, 2002, p. 17)*

Hence, understanding the complex process of product disposition is key since certain disposition paths are prerequisites for product circularity.

In sum, addressing consumption as a three-parted process – consisting of acquisition, use, and disposition – can provide valuable insight for exploring new opportunities for supporting product circularity.

2.2 Paths of consumption

When looking closer at the phases of acquisition, use and disposition, they can be understood as processes in which people make decisions and engage in activities over time in relation to one or more products. Even though some common consumption decisions and activities are discussed in CE literature, for example activities such as maintaining and repairing products during the use phase, many other decisions and activities are still underexplored or given too little attention despite being highly relevant from the perspective of product circularity.

For instance, in regard to acquisition, people may engage in different activities that succeed the recognition of need but precede the actual acquisition of a product, such as gathering information and reflecting on options. When it is time to make a decision about how to acquire the product, they can, for instance, choose to gain ownership by buying it or to gain temporary access by renting or borrowing it. Regardless of the reasons behind the choice of acquisition method, it inevitably leads to a particular path of consumption that may require additional activities and/or decisions. Once the

product is obtained the user can, in addition to utilising the product, engage in different activities to manage the product, such as making adjustments or repairing it. In due course, the user will contemplate the disposition of the product in regard to three general choices: keep the product, permanently dispose of it, or temporarily dispose of it. Jacoby et al. (1977) argues that if the decision is to keep the product, the user can continue to use it for its original purpose, repurpose it, or store it away for potential future use. In contrast, if the decision is to dispose of the product, a number of different disposition paths can be considered, for instance, the user can sell it, trade it, or loan it to someone temporarily.

A range of aspects influences which paths and modes of consumption people find desirable. In relation to acquisition and disposition specifically, the literature typically highlights aspects related to the product, the consumer, and situational influences (see e.g. Guiltinan, 2010; Jacoby et al., 1977; Lehtonen, 2003; Van Nes & Cramer, 2005 for more detailed discussions). However, most of these aspects are primarily discussed in terms of how they influence *what products* people choose to consume, and not *in which way* they choose to consume. Nevertheless, when exploring opportunities for product circularity, aspects that influence which path of consumption that people choose become vital to understand, especially in terms of which activities and other consequences a particular path involves, in comparison to other paths. If a path is perceived as having relative advantages over other paths, it will become more desirable (Rexfelt & Hiort af Ornäs, 2009).

Adopting a new consumption path may afford users opportunities to engage in desirable activities, as well as be stripped of such opportunities. Users can also be forced to engage in undesirable activities, as well as be relieved from them (cf. Rexfelt & Hiort af Ornäs, 2009). There are a multitude of activities that a consumption path may involve: inspection of the product; bargaining with someone; planning ahead when to use something; pricing a product; meeting a seller; and cleaning a product, just to name a few. At the risk of having to engage in undesirable activities, users might avoid certain consumption paths (e.g. selling used products on the second-hand market) and choose a more convenient option (e.g. dispose of it as trash or store it in the garage).

Even though people's consumption is discussed in terms of decisions in this paper, it is important to note that people's actions are not always a result of active decisions; like people's actions in general, some things "just happen". When buying a new mobile phone for instance, the old one may be put in a drawer without any extensive reflection and left there for years as a result of inaction.

In sum, people make many decisions and engage in many activities throughout the consumption process that influence resource throughput. Hence, understanding people's decisions and activities holistically throughout the three stages is essential when exploring opportunities for product circularity. The likelihood that a user chooses a particular path of consumption must be judged in light of alternative available paths. Each path necessitates different strings of activities to be undertaken, heavily affecting their respective attractiveness.

2.3 Tight loops between users

Due to the current production and business narrative and the tradition of framing opportunities in relation to the stages of a product life-cycle, the CE literature emphasises circular production loops to a larger extent than circular consumption paths. Consequently, opportunities for design and innovation are most often discussed in terms of circular production and post-production initiatives focused on re-processing products and recycling materials. Even though these types of loops are important, there is potential to also enable tighter loops between users focused on increasing product utilisation over time. Such loops do not only have potential to reduce the product throughput but can also reduce the resources and costs commonly associated with circular production and post-production initiatives (Ellen MacArthur Foundation, 2013).

Since a large number of products are only needed and used for short periods of time, often with long periods of hibernation in-between, increasing product utilisation presents an untapped potential for reducing the number of products put on the market. Even though people may use a particular

product to satisfy their needs at a certain point in time, changes in needs or conditions over time can reduce the rate of product utilisation and even render the product obsolete. Low utilisation and low needs fulfilment will increase the risk of the product ending up in prolonged storage (Lehtonen, 2003; Lucas, 2002). Prolonged storage not only limits a product's potential to fulfil needs, but may also lower its value and technical utility over time, making it less attractive to others. Low needs fulfilment can also trigger product replacement and directly increase the resource throughput (see review by Van Nes & Cramer, 2005).

When considering the negative effects of low utilisation and low needs fulfilment on resource throughput, it becomes relevant to address these aspects in more depth and explore opportunities for circulating products in tighter loops between users. Some measures that enable tighter loops have previously been suggested, such as new business models that advocate access instead of ownership (see e.g. Gruen, 2017) and services for sharing and collaborative use of products (see e.g. Botsman & Rogers, 2011; Leismann, Schmitt, Rohn, & Baedeker, 2013).

3 Introducing the Use2Use perspective

While the previous section highlights the need to address product circularity from a user perspective, this section discusses what such a perspective entails for design. An overall approach for addressing consumption and user-related aspects is introduced and followed by a discussion regarding what design opportunities that can be considered especially relevant for enabling circulation of products from a user perspective.

3.1 Take the consumption cycle as a base for exploring opportunities

As argued above, there is potential to explore new opportunities for supporting circulation of products by taking a user perspective on product circularity, i.e. by considering people's entire consumption process including the variety of options and activities related to different paths. Taking such a perspective requires a shift in focus; rather than solely exploring opportunities from a production and business point of view, they should also be explored from a user's point of view. Hence, basing the exploration of opportunities on the product life-cycle, which is typically done in CE literature, is not sufficient. Instead, opportunities should also be explored in relation to the consumption process. To aid such explorations and the development of innovations that reduce resource throughput, a consumption cycle adapted for product circularity is proposed in Figure 1.

The consumption cycle frames consumption from the users' point of view; instead of viewing consumption only as a use stage, preceded by marketing and sales, and succeeded by end-of-life processes, Figure 1 divides the consumption process into the three main phases *Obtainment, Use,* and *Riddance*[1]. The figure deliberately excludes producers, providers, and other players, as they do not have to be involved in people's consumption processes (even though they often are). Instead, different paths of obtaining, using, and ridding products, which can be carried out by a single person, but also jointly by a household or a larger collective, are in focus. The consumption cycle thus highlights alternative modes of consumption and provides an overview of the main options people have throughout the process, i.e. possible paths of consumption. The paths are grouped according to whether they influence people's ownership or access to a product as this typically frames which paths that are possible to carry out and/or are desirable to consider.

The figure highlights people's main paths but does not illustrate the consequences associated with particular paths. However, as argued in the previous section, these are essential to understand as they influence how people prioritise and choose between paths. Hence, explorations of opportunities for supporting product circularity should not be based solely on people's main options, but also on an understanding of what those options entail for people. As people's consumption

[1] Regarding choice of words: Obtainment is used instead of Acquisition to put less emphasis on buying products and more on other ways of gaining ownership or access to products. Riddance is used instead of Disposition to put less emphasis on creating waste and more on making them available for someone else.

processes are linked to each other it is also essential to consider what transaction costs, such as time, effort, and money, that may be associated to the exchange of products between users in relation to particular paths.

Figure 1 The consumption cycle with examples of different paths of consumption.

3.2 Address the exchange of products between users

The paths of consumption illustrated in Figure 1 describe different scenarios for how products can be circulated in tight loops from one user to another, i.e. from use to use (Use2Use). The exchange of a particular product between two users can be realised in many different ways depending on what paths of obtainment and riddance that are considered desirable by the users involved. For instance, as illustrated in Figure 2, a user that has purchased a product may choose to offer someone else temporary access, and then later resign ownership by giving it to a third user. If in good condition, the product can be used in multiple use-cycles before it reaches a decayed stage in which component or material recovery is the only option. Such tight loops between use-cycles have potential to increase both product utilisation and need fulfilment while also reducing the product throughput.

Figure 2 Products can be circulated in tight loops and used in multiple use-cycles before recovery is needed.

Figure 3 Examples of how exchange agents can support the transfer of ownership or access between users.

The loops between use-cycles illustrated in Figure 2 could be realised directly between the users without any intermediary or through the involvement of exchange agents. As shown in Figure 3, different types of exchange agents can facilitate or enable the exchange of products between users. Exchange agents can support the transfer by, for instance, providing a channel through which people can connect and carry out the exchange or by temporarily taking over ownership and ensuring that the product is in good condition before it is transferred to a new user.

Companies can thus take on many different roles for enabling product circularity, some which will be more relevant than others depending on the particular company. For instance, even though some

companies may consider it crucial to develop new business models and circular offers, this may be unnecessary for others if they can design products that fit into another company's successful circular business model. For instance, companies involved in building new homes could adapt these so they are suitable for sharing and fit with the business model of Airbnb.

3.3 Design for Use2Use

A Use2Use perspective has many implications for design: it highlights new design strategies for enabling and facilitating product circularity, as well as points to a number of aspects that need to be further explored in order to develop products and service offers that are relevant and desirable from a user perspective.

One central design strategy is to enable and facilitate exchange between users, i.e. *Design for Exchange*, either by designing circular service offers or by designing products that directly facilitate exchange. To Design for Exchange, gaining in-depth insight regarding the decisions, activities and other consequences that particular paths of consumption entail for people is essential. If the design of services and circular offers, i.e. the modes of provision, is based on such insights it has potential to increase users' appreciation and adoption of the associated modes of consumption. For instance, insight on required but undesired activities that are related to a certain path highlight opportunities for exchange agents to offer services that incorporate those activities. Some new and innovative companies have already successfully applied this tactic. Sellpy, Simplet and Tiptapp are services that not only assist in selling products that people no longer need, they also take care of the transport, sorting, and sometimes the cleaning of the products, as these activities have been identified to hinder people from resigning ownership. In addition to designing the modes of provision, products can also be designed for exchange, for instance by making it easy for people to:

- inspect and evaluate a product's condition, completeness, and cleanliness prior to and during the exchange
- package, carry, and transport a product
- understand how to install and use a product
- adapt a product to their needs
- maintain a product's condition by proactively changing parts that are most prone to wear and tear
- prepare for exchange of ownership or access

Which particular aspects that are crucial to address may vary between products but also between paths and exchange occasions. However, since people may choose any obtainment or riddance path, it can prove valuable to explore design opportunities in relation to all paths illustrated in Figure 1.

Another design strategy is to *Design for Multiple Use-Cycles*. Tight loops between users will increase the number of exchange occasions as well as the number of users per product, which presents challenges for design. If tight loops between use-cycles are to be realised, new questions are thus essential to address from a design perspective: *How can products be designed in such a way that they are durable and attractive to multiple users over time instead of one user for a prolonged time? How can need fulfilment and a satisfying user experience be ensured not only for the first user, but also for the 2nd, the 10th or even the 100th user?* Furthermore, when considering how the product should be designed to be useful not only for the first user but for multiple users throughout multiple use-cycles, it becomes relevant to question which user need(s) it is designed for. *Should it be designed to fit a particular need, cater for the multiple needs of future users, or be customisable to needs that emerge over time?*

In order for tight loops to come to pass, products and services must not only be designed so that they are attractive to future users but also so that users will want to circulate the products to others; i.e. they must be designed for detachment. The strategy *Design for Detachment* can be applied by, for instance, envisioning how people can be supported to:

- recognise when they no longer need a product
- avoid forming emotional bonds to a product
- assess the benefits of resigning ownership or access to a product
- erase (or leave behind) traces of use and personal information
- identify when to resign ownership or access to a product so it can benefit someone else

In sum, a Use2Use perspective points to several design opportunities that can be explored to enable and facilitate the circulation of products from one user to another. While some of the highlighted opportunities have been discussed previously in literature, or even been implemented by companies, others have not.

4 Discussion

This paper introduces the Use2Use perspective as a complementary lens through which opportunities for product circularity can be explored. The overall contribution of such a perspective and its implications will be discussed in this section along with aspects that remain to be explored in more depth.

4.1 Shifting to an enabling approach

This paper argues that the current knowledge and views on product circularity need to be complemented with a re-framing of circularity from a user perspective. It also argues that the current framing is done from a production and business perspective. Questions like "How can we make users accept our circular business model?" are still common in research and industry, indicating that some user-related aspects are considered. Nevertheless, companies are most often interested in whether an innovative business model can be *pushed* out on the market or not. However, a new offer from a company just adds another option to the almost endless number of options available to people at any given moment in time. While people for instance may have heard about Uber, what Uber constitutes for their everyday lives is just another option for transportation that they may consider using. Hence, the primary focus on people's acceptance of business models has limited power in integrating a user perspective on product circularity.

A question that is more important to answer from a user as well as an environmental point of view is "how can we enable people to choose more sustainable paths of consumption?". This *enabling* approach does not mean that there is no room for innovative business models, but they should be designed so that they provide preconditions that enable people to circulate products. In order to accomplish this, exploring and understanding the users' paths of consumption is key.

How attractive people consider the different paths of consumption to be is influenced by their preconditions, which are partly determined by the design of available products and services as well as the current context or infrastructure. In order to create preconditions for circularity a systems approach thus needs to be applied and all three – products, services, and infrastructure – must be designed so that they together enable people to circulate products. No company can aspire to accomplish this alone, but each company can find their role in contributing to creating enabling preconditions for paths of consumption that people aspire to.

4.2 New design opportunities

Even though the implications of applying a Use2Use perspective need further exploration, this paper has nevertheless highlighted new design opportunities for slowing and closing product loops that previously have received little attention in literature.

In regard to design opportunities for slowing the product throughput, strategies already discussed in literature include, for instance, the need to design products for longevity, durability, and product life extension activities such as repair and maintenance (Bakker et al., 2014; Cooper, 2005; Haug, 2016; Hebrok, 2014; Van Nes & Cramer, 2005). Since these strategies are frequently discussed, they have not been the focus of this paper even though they are essential also from a Use2Use perspective.

Previous research also argues for slowing the product throughput by designing for attachment as a product life extension strategy (Cooper, 2005; Page, 2014; Van Nes & Cramer, 2005). Some concerns connected to this strategy are however raised in literature. Lehtonen (2003) argues that product attachment can be considered a cause for why people do not dispose of products. Van Nes and Cramer (2005) similarly reason that bonding with all of our products would be a real burden and that increased attachment with all products is unwanted. They therefore stress that the strategy to enhance product attachment should be well considered and applied delicately. When considering the strategy of designing for attachment from a product circularity point of view, it can be argued that it risks decreasing the potential for reducing product throughput. If products are designed for attachment regardless of if people have a long-term need for the products or not, the strategy may reduce both utilisation and need fulfilment resulting in a market pull for additional products. This paper therefore argues to also consider the opposite strategy, i.e. Design for Detachment, which has also recently been suggested by Choi, Stevens, and Brass (2017). For some product types, this alternative strategy may be more suitable as it can be used to encourage tighter loops, and increase utilisation and need fulfilment, which may reduce the overall product throughput.

In regard to design opportunities for closing product loops, literature commonly focuses on strategies to design products for circular production initiatives, in which components and materials are re-processed, and strategies to design products for circular post-production initiatives, in which products are refurbished and remanufactured in-between use-cycles (see e.g. Go et al., 2015; Pigosso, Zanette, Guelere Filho, Ometto, & Rozenfeld, 2010). From a Use2Use perspective, designing for refurbishment and remanufacturing are also important strategies to ensure that exchange agents can uphold products' performance and durability over multiple use-cycles. However, designing for even tighter loops is preferable for many types of products since tighter loops have potential to reduce both the product throughput and the resources and costs associated with re-processing (Ellen MacArthur Foundation, 2013). Even though re-use loops are often argued for in literature, it is rarely discussed how products can be designed to enable and facilitate such loops. In contrast, the strategies Design for Exchange and Design for Multiple Use-Cycles proposed in this paper suggest how products can be designed to facilitate the transfer of ownership or access between multiple users over time.

4.3 Use2Use related aspects to explore in future work

While the proposed Use2Use perspective provides new insights into product circularity, it also indicates some areas in need of further exploration. One central area is eliciting user needs and requirements for circular consumption patterns. Traditional user studies focus on people's needs and use of products/services during the use phase, but that perspective needs to be complemented with further methodological support to elicit needs in relation to all three phases of consumption. This includes exploring how needs change over time, both changes within a single use-cycle and long-term variations connected to different stages of life.

In addition, a better understanding of the exchange of products between users is needed, as well as of the consequences and activities that the different paths of consumption involve. Besides understanding those activities, methods and guidelines for how to design with them in mind needs to be developed. Today, such tools are scarce.

Another important aspect that needs further attention is how different types of products relate to the various consumption paths. While some products may be inherently more suited for certain paths, others may bring about undesirable user activities that can cause people to consider the same paths less attractive in particular situations and for particular products.

5 Conclusions

This paper argues that the current conceptualisation of product circularity needs to be complemented with a re-framing of circularity from a user perspective, which addresses issues of

consumption in more depth. Consumption needs to be understood as a three-parted process: obtainment, use, and riddance. The consumption process encompasses a range of possible paths, each influencing how consumption is carried out. Besides understanding these paths it is equally important to understand how users relate to them. The likelihood that a user chooses a particular path of consumption should be seen in light of available alternative paths. Each path comprises different activities that users may engage in and which will affect the attractiveness of the path. Designing products and services with these activities in mind in order to enable users to obtain pre-used products and transfer them to new users is key to making circularity happen. By addressing product circularity from such a Use2Use perspective, i.e. considering people's consumption processes and the exchange of products between users, this paper has highlighted new design opportunities and the specific strategies: Design for Exchange, Design for Multiple Use-Cycles, and Design for Detachment.

This paper has merely touched upon some of the many important aspects of consumption and some of the relevant design opportunities that may be of interest to consider in relation to product circularity. Hence, the Use2Use perspective deserves more attention and this paper will hopefully stimulate future research on the role of the user in the circular economy.

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Section 18.

Design for Behaviour Change

DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
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Editorial: Design for Behaviour Change

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Addressing some of the biggest challenges in society, from physical inactivity to demands on healthcare, will require a change in how people behave in relation to themselves and others. The question of how to bring about this change is a prominent one for policy-makers and parents alike, with increasing recognition that information alone makes little difference. There is a need for practical solutions that help people overcome or go with the grain of their behaviour to turn good intentions into action.

Existing approaches include using regulation to eliminate or restrict choice, changing the physical environment in which choices are made, and providing tools to guide people through the decision-making process. The mindsets, methods and skills involved vary between approaches and each has different implications for the rights and responsibilities of individuals, and ethical considerations.

While designers inherently influence behaviour through their work, Design for Behaviour Change (DfBC) is a growing area that specifically focuses on the role design plays in influencing people's experiences, decisions and behaviours. While many of the methods and skills involved are shared with other disciplines, there are particular attributes that make the design approach distinct, in particular an open and iterative approach to development that values the wants and needs of the people for whom the solution is intended.

This track explores a) how DfBC relates to other approaches and disciplines, particularly behavioural science – the empirical study of how and why people behave the way they do; b) the development of new tools and methods to support DfBC; and c) how these methods have been applied to change specific behaviours. Together, they will help us construct a more coherent framework of how and when DfBC methods can, or should, be used and combined with other methods to be a catalyst for change.

The papers in this tract fall roughly into these three categories. Elizarova & Kahn explore a new methodology for solving complex problems that combines customer journey mapping and the COM-B model, for use by both designers and behavioural scientists. The COM-B ('capability', 'opportunity', 'motivation' and 'behaviour') model is used extensively to develop behaviour change interventions, however it is only one of many models.

In order use approaches from behaviour science, designers must navigate these models and determine which to use given the circumstance and underlying theory. Tromp, Renes & Daalhuizen address this challenge by presenting a set of heuristics for designers to determine which of nine behavioural design methods to use, given the task at hand, their personality traits and preferred paradigm for understanding behaviour.

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Van Lieran, Calabretta & Schoormans build on the popular 'nudge' approach from behavioural science by proposing the use of 'rational overrides' in service design. Consisting of a toolkit of five templates, two card sets and two databases, this involves introducing micro-moments of friction into the customer journey to disrupt mindless automatic interactions, prompt moments of reflection and more conscious decision making.

Rather than integrating methods from behavioural science, Ronteltap, Bukman, de Jonge & Roscam Abbing investigate the use of existing design methods in DfBC, specifically the challenges of using personas to improve designs for behaviour change strategies in the public domain. They call for researchers to share their experiences of using personas in the order to address the challenges and create more standardised ways of development.

Arslan, Mols & Hummels introduce a novel tool called Teglen, to support reflection and behaviour change on both a personal and organisational level. The findings of their qualitative empirical study with civil servants in Eindhoven show that reflection benefits from the combination of cognitive and creative elements integrated in a dynamic and structured approach, with more research needed to explore the potential long-term benefits.

Levy explores opportunities to enrich the design of everyday rituals through a descriptive framework to 'read' and compose such rituals, developed using an autoethnographical approach. The value of the first-person perspective and the main dimensions of the framework are defined (place and time, essentiality, and strength) and discussed, drawing attention to the need for quick iterations and the consequences of design decisions.

John, Flyn & Armstrong apply models of design for behaviour change to two healthcare projects – the design of remote care for chronic heart and liver disease and reducing the rate of hospital acquired infection through better hand hygiene. They highlight factors such as ingrained social norms and low aptitude, exposing a systematic behavioural breakdown between need and desire, and the need for designers to better understand this complexity.

Karahanoglu, van Rompay & Ludden explore the use of design for behaviour change strategies in the context of sports and exercise. They draw out the need and importance of a shift in focus from new to existing exercisers when designing for physical activity tracking. They discuss the differences in the needs and underlying behavioural drivers of this audience, and the significance of designing for lifelong sports experience.

Finally, while DfBC is normally concerned with providing guidance towards a specific behaviour, Boon, Rozendaal & Stappers propose an alternative approach that emphasizes ambiguity and open-endedness, rather than directionality. Using two case studies in paediatric healthcare, they describe how interactions with ambiguous and open-ended playthings gave rise to the intended behaviour outcomes, opening up a new space for behavioural design.

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Tegelen: supporting individual and group reflection through a dynamic, structured and tangible tool

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The municipality of Eindhoven is exploring her new role in a transforming society, just as other local governments. This role requires (behavior) changes on personal, organizational and societal levels. In this paper we shed light on how reflection for civil servants can be stimulated and supported through design. We present our qualitative empirical study carried out in the municipality of Eindhoven, which resulted into the reflection tool called Tegelen. Herein, we introduce a novel approach to support reflection for both personal as organizational usage, within individual and group sessions. Evaluating the concept in context showed that reflection benefits from the combination of cognitive and creative elements integrated in a dynamic and structured approach. Moreover, we experienced that embedding academic insights accompanied with the design process itself can support designers working in non-design environments to create trust and engagement with stakeholders. Longitudinal usage and further research is needed to explore the potential of Tegelen to support to reflection and stimulate behavior change in the long run.

reflection tool; behavior change, personal development; organisational development

1 Introduction

Just as other local governments, the municipality of Eindhoven is exploring her new role and approach in a transforming society in a globalized world (Castells, 2008). Like more cities in the western society, Eindhoven is facing many challenges that include the aging population, the changing jobs in the future, the refugee crisis and the decreasing socio-economic inclusion (Appadurai, 2006; McAfee, 2013; Oosterwaal and Torenvlied, 2010; Wallerstein, 2003). Politics researcher Diamond states that these challenges cannot be solved by governmental institutions or (citizen) communities only. Instead, they require local collaborative engagement that reflects the contextual needs (2013, p: 14-16). However, this transformation is not only about a change in our collaboration but actually requires a paradigm shift. Kuhn (1970) refers to paradigms as the beliefs,

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values, models and examples to guide a community of academics and practitioners. The importance of reflection in such transitions is also recognized locally. Strategic Design consultant Vera Winthagen 2017, from the Municipality of Eindhoven, states that municipalities have to obtain a more horizontal position with equal collaborations. Herein, reflecting on and in action is one of the essential skills that support growth and change (2017, p: 16, 18, 74-75). This shift asks for a transformation of the municipality, including the civil servants. It requires a change in their beliefs, attitude and ultimately their behavior and way of working.

1.1 Reflection forms the fundament for change

In essence, transformation asks for a mind and attitude change in the personal, social and societal spheres. According to anthropologist Appadurai (2006) personal change is triggered through one's consciousness, felt urgency and the feeling of empowerment. The latter is a process during which human activity alters from a passive to an active state that can support collaborative engagement and attitude change (Diamond, 2013; Sadan, 1997). Many academics state that the skill of reflection forms the foundation to create empowerment and consciousness that can lead to change (Appadurai, 2006; Bay and Macfarlane, 2011; Cattaneo and Chapman, 2010; Dewey, 1910; Korthagen and Vasalos, 2005; Mezirow, 1990). Sociologist Mezirow (1990) puts forward that being critically reflective on one's biases and beliefs opens the door for perspectives changes and paradigm shifts (p: 12-13). Philosopher Dewey argues that reflection supports how people approach, understand and change (1910, p: 8). Baumer (2015) includes that reflection lays the ground for deep learning and development since it involves envisioning alternatives or novelties. Based on these views we can conclude that reflection can stimulate and support (behavior) change. We use this as a starting point for the case study.

1.2 Aim and contribution

Change can thus be triggered through reflection. But how does reflection itself work? How can it lead to concrete grips for change? Could design play a role in this? Our aim is to explore how reflection for civil servants can be stimulated and supported through design. First of all we discuss theoretically how reflection works and inform about the importance of giving room for inspiration and creativity in this skill. Subsequently, embedded in a large body of theoretical work, we want to introduce a novel and more integrated way to approach reflection captured in our tool called 'Tegelen'. Herein we offer structure in the reflection process through an analogue method accompanied with a facilitator. The tool offers guidance through reflection questions and includes inspiration cards to trigger curiosity and the exploration of different perspectives. It can be used in individual as well as group sessions, focused on personal, social and societal challenges. In this paper, we present the theoretical foundation of the tool, its development, evaluation and discussion.

The qualitative research and case study presented in this paper was carried out in the municipality of Eindhoven. The municipality of Eindhoven has been working with designers since 2004, mostly in the context of societal challenges. Through the years their need has grown for internal design activities to introduce and integrate design thinking as a way of working. The first author spent a year working in the municipality as part of her Master's graduation project with bountiful freedom to explore opportunities for learning. Herein she focused on supporting life long learning in the context of personal and organisational change, through the skill of reflection. The case study clarifies that Tegelen can help people and organizations to reflect in the context of personal and organisational change. Moreover, through this paper we want to contribute how designers working in non-design environments can create engagement and change through their processes, rather than only through their designs.

2 Theoretical background

2.1 To start off: what is reflection?

Being able to design for reflection requires in-depth knowledge of what this skill entails. We approached the topic from different perspective since reflection has no unified definition (Baumer et al., 2014, p: 93; Denton, 2009, p: 838, Mols et al., 2016, p: 53). According to philosopher Dewey (1910), reflection is about looking at a matter from different perspectives so that nothing is left unnoticed. It is about having 'evidence' and reasoning why something is or isn't believed in. Sociologist Mezirow (1990) explains that reflection helps to adjust and correct biases. He introduces 'critical reflection', which entails "a critique of the presuppositions on which beliefs have been built" (p: 3). It is about assessing one's frame of reference through looking at the networks of arguments related to ethics, norms and orientations. These define one's horizons of expectations and are subjacent for how people think, behave and develop. Bay and Macfarlane (2011) expand on Mezirow and connect it to power relations and structures, since questioning and challenging these creates the ground for change. Korthagen and Vasalos (2005, p: 48) argue that 'core reflection' is often required, which taps into one's environment, behavior, competencies, beliefs, identity and mission. Denton (2009, p: 834 - 844) brings another perspective and says it is the human ability to form relations between ideas and thoughts. This results into higher-order thinking and awareness of one's own thought processes. Baumer et al. (2014) have reviewed a large body of research and include the following: "reviewing a series of previous experiences, events etc. and putting them together in such a way as to come to a better understanding or to gain some sort of insight" (p: 94). All interpretations of reflection thus entail some sort of 'looking at things' from different perspectives, by assessing the ground these 'things' are reasoned upon. This implies that reflection is a process that converges and diverges through the exploration of arguments. These definitions will recur later on in the article as they supported the design direction and decisions.

2.2 How does reflection work?

Dewey points that reflecting is an ordering of thoughts with a certain flow, leading to a unified conclusion. Through guidance and application of people's observations and senses, this type of thinking becomes possible (1910, p: 3-4). While this sounds logical and ordered, the thought process can be experienced as complex and chaotic. According to Dewey reflection requires a sort of intellectual curiosity that brings people in the mindset to explore and investigate the situation at hand. He touches upon the fact that unfortunately people lose their curious mindset as the years go by, which weakens the urge of becoming the researcher of one's understandings and beliefs (p: 9-10). Many academics explain that reflection is mostly triggered by a state of doubt or a certain dilemma that doesn't match the person's (meaning) perspective (Baumer, 2015, p: 590; Dewey, 1910, p: 4; Korthagen and Vasalos, 2005; Mälkki, 2010; Mezirow, 1990, p: 13-14). This implies that reflection can be difficult and actually requires a step outside of our comfort-zone, something that we as people generally dislike. Mälkki expands on why reflecting requires confronting our painful emotions. She concludes with suggesting that one needs to accept these feelings as a precondition to reflect (2010, p: 54-56). How the confrontation with these emotions can be supported is not pointed out and reflection remains mostly approached in a cognitive and structured manner. The difficulty of painful emotions, our decreasing lack of intellectual curiosity and the chaotic way people's mind works is not being elaborated upon. We see opportunity in addressing to trigger curiosity, emotions and stepping out of the comfort zone through design.

2.3 How is reflection nowadays supported?

Some academics make the process approachable by dividing it into phases. One is the ALACT model of Korthagen (2005, p: 49), which subsequently exists of action; looking back on the action; awareness of essential aspects; creating alternative methods of action and trial. Baumer put together a more concise process consisting of breakdown, inquiry and transformation (2015, p: 585). His research points that there is much to be achieved in the discussion and the actual design or reflection. Other models, such as the 'now what, so what' model (Rolfe et al., 2001), Kolb's learning

styles (1975) or the Onion Model (Korthagen, 2005) focus on descriptions of phases without explaining how to achieve this (curious) mindset. Existing reflection tools are mostly in the context of teaching, such as sentence starters and pyramid shapes to look at situations from different layers. Or they include card sets with very concrete questions that aren't always applicable. Regarding design that stimulates reflection, there are currently three strategies that recur most often: dialogue; information and expression driven design (Mols, 2016, p: 54-55). The strategy of dialogue driven refers to the support of reflection through the spoken or written word within dialogue, such as the well-known teacher - student or therapist setting. Information driven design is mostly about presenting one with data to trigger reflection as seen in personal informatics or the quantified self-movement. Lastly, the expression driven design strategy focuses on externalizing thoughts and feelings for example through journaling, storytelling or personal writing. Baumer et al. (2014) advises designers to grow conscious about strategies to support and encourage this. They claim "the area is ripe for work on both understanding and designing to support reflection not only as an individual, cognitive activity, but also as a social process" (p: 98).

2.4 A design space

All together these insights made the scope of our main question more specific and put forward that there is much uncharted terrain in the context of designing for supporting the reflection process specifically. It shows it is wise to approach this skill as a combination of cognitive, emotional and creative elements. People who are reflecting should be helped to think outside their standard patterns, to trigger intellectual curiosity and stimulate them to step out of their comfort zone. Furthermore it becomes apparent that a dynamic process to offer guidance in structuring the flow of thoughts and reasoning can create grips in an otherwise chaotic mental activity.

3 Process

3.1 Approach

We answer the main question based on the research and design process as a whole. Herein, designing something meaningful is only possible if end users are involved early in the process. In this case study most activities have been done through the Participatory Design methodology (Iversen and Leong, 2010; Sangiorgi, 2011). This approach allows users to express their values, while creating engagement and a common language. The literature research was followed by field research to comprehend the daily work, life and development of civil servants who are the end users in this context. It was decided to combine semi-structured interviews and co-reflection. The latter is a method for a dialectical inquiry between users and designers (Tomico et al., 2009). It exists of getting acquainted with the context through the user while envisioning a new sort of reality, by reflecting on concepts to explore the design space.

3.2 Conducting fieldwork

In total, 25 civil servants were interviewed from four departments: Strategy, Spatial Domain, HR and the Social Domain. All had different job descriptions ranging from policy making to execution, which resulted in a qualitatively rich and broad representation. First the daily life and work was elaborated upon, after which the topic of self-development and reflection was discussed. Lastly the initial concepts named 'the Reflection Room' and 'the Reflect-App' were introduced, envisioned and co-reflected. A visual mind-mapping (dialogue) tool to stimulate the discussion supported all conversations. Figure 1 shows a civil servant envisioning her scenario of use. In figure 2 the dialogue tool with the written comments can be seen. Within each interview the following topics were integrated: personal background, (daily) work, their career, self-development, support in development and reflection. The insights were thematically clustered in categories such as 'the undercurrent', 'experiences with earlier methods', (supporting) reflection and the feedback on both concepts.

Figure 1: A civil servant envisions her scenario of use.

Figure 2: An interview supported with the dialogue tool

3.3 Results

The co-reflected concepts made clear that civil servants feel that group reflections would help themselves and the municipality greatly. Most employees stated that there was being jumped from innovation to innovation without truly evaluating and pondering. Currently, very little time and attention was put into reflecting and learning. Although reflecting could help them to stand still, evaluate and adjust, especially when done in a structured, guided yet flexible manner. The interviewees put forward that they saw value in individual but mostly group sessions, as this would support collaborations and exploring their new role. Several brought forward that the documentation of insights is important since most of the time things are discussed but not written down. The majority of the interviewees were in favor of supporting the process of reflection in a creative setting, accompanied with inspiration and suggestions. The fieldwork furthermore provided insights on the undercurrent that civil servants feel, including the cumbersome experiences with managers, the work pressure and the changes that came with a major reorganization two years earlier. The background of this lays in the scenario discussed in the introduction. Just as many others, this local municipality is experimenting with their new role in society and tackling the challenges of today and tomorrow. This helped to understand that whatever that was going to be designed, it had to be 'friendly' and not disruptive as many are tired of the tools and novel ways to work that have been introduced in a short amount of time.

4 A novel way to support reflection: Tegelen

4.1 The foundation of the concept

In our design we wanted to integrate the empirical and theoretical insights as described above. Baumer et al. (2014, p: 97) point that many designers who are working around the topic of reflection do not include a thorough definition and explanation of how the actual reflection is integrated within their proposed concepts. Inspired by this observation we present our concept by making more explicit connections to the insights from literature and fieldwork. It became clear that there was a design opportunity and need to create a tool that combines structure and inspiration. This tool would support creative and cognitive thinking, preferably through a generic method that includes and balances abstract and concrete elements.

4.2 Tegelen, an analogue and generic reflection tool

Ultimately this resulted into 'Tegelen', a generic reflection tool that exists of a process, reflection questions and inspiration cards. This is an analogue and interactive tool that can be used by a facilitator in individual and group reflections, depending on the needs of the people involved. Tegelen is suitable for every single topic, regardless of whether it is something from the past, present or future. The envisioned scenario of use is both for personal and organizational development. Its goal is to stimulate and support reflection by integrating a playful and dynamic yet

structured approach. The tool exists of hexagonal cards for a playful look and feel, resulting in a pallet of questions, answers and insights that appear on the table. To bridge the cognitive and creative part that is involved in reflection, we envisioned an analogue style for the process. After several explorations the hexagonal cards were divided in several colors to make distinction between phases. Both the process cards, as the reflection questions and inspiration cards were designed in the same way, printed and cut on PVC and brought together in a case. Through this, a unified and visually attractive style was developed that resulted into a coherent tool.

A session itself can last between 1 or 2 hours, depending on the available time and wishes of participants. Herein, the role of the facilitator is to guarantee an inclusive and safe atmosphere for participants and guidance in the process. The integration of a facilitator is based upon the large majority of the interviewees who put forward that they would prefer an outsider to support the session. This person is not absorbed in the matter at hand and therefore better capable to ask probing questions. Especially when something painful or very relevant comes up, the facilitator can step in to ensure that everything is discussed. Preferably, the participants are standing around the table to create a more dynamic atmosphere. In short, Tegelen exists out of a process, reflection questions and inspiration cards as shown in figure 3.

Figure 3: The tool being used during a reflection session, existing of the process (coloured tiles), inspiration cards, reflection questions and tiles on which users write their insights or answers on questions.

4.3 The process

The literature research inspired us to create a backbone upon which the reflection process is built. Dewey (1910, p: 3, 11) explains this process as an ordering of thoughts build upon each other that lead to a conclusion. This resonated with the way we as designers diverge and converge in our processes, such as explained in the Double Diamond model (2015). The process was envisioned in an analogue style to create engagement and room for creative and cognitive interaction through tangible cards. These would contain elements that would help exploring perspectives and moving towards a 'unified' conclusion. Furthermore it would be valuable if the gained information could be re-structured to stimulate dynamic exploration. We separated guidance into two elements: reflection questions and inspiration cards. The proposed process includes the following phases:

1. Choosing a topic and starting up: this phase is about determining a topic to reflect about accompanied by a warming-up exercise with inspiration cards as an ice-breaker to trigger dialogue and a curious mind-state (see figure 4).
2. Determining the goal: to stimulate concretizing, this phase is about choosing a goal for the reflection session to concretize and give body to the direction of the session (figure 5).

3. Making an inventory and looking back: in this phase users do an inquiry while looking back in the context of the topic. This is necessary to gain a broad and in-depth understanding from different perspectives and reasoning. See figure 6, which includes some reflection questions.
4. Looking ahead and concretizing: here, participants are mostly discovering and envisioning future opportunities and alternatives. It is the door to change as participants concretize their own discovered findings, as shown figure 7.
5. Concluding and coupling back: in this phase the door to (future) action is opened while looping back to the goal of the session. This step was implemented as the fieldwork showed that people like to know 'what they get out of' things they use, meaning that the session had to concretize towards the end (see figure 8).
6. Evaluating the session: to ensure a solid ending in which participants can leave the session with a content feeling we integrate a short evaluation as shown in figure 9.

Figure 4: phase 1 – Choosing a topic and starting up, herein users do a warming-up activity with the use of the inspiration cards by making free associations with the chosen subject.

Figure 5: phase 2 – Selecting a goal. The image includes some suggestions: 'discovering wishes & needs', 'improving & creating solutions', 'understand & develop' and 'discovering possibilities'.

Figure 6: phase 3 – Making an inventory and looking back. The image also shows some reflection questions, the row at the bottom says: 'what went well?', 'can you discover patterns?' and 'what are needs herein?'

Figure 7: phase 4 – Looking ahead and concretizing. The top row of the included questions states: 'can you think around possible obstacles?' and 'what has the most priority?'

Figure 8: phase 5 – Concluding and coupling back. The bottom row of questions say: 'what kind of possibilities are discovered?', 'what is the next step?' and 'to what extent is the goal achieved?'

Figure 9: phase 6 – Evaluating the session. The included questions ask: 'does something need to go different next time?', 'how did you experience this session?', 'to what extent was it a successful session?'

4.3.1 The reflection questions

The phases include suggested reflection questions to support participants in approaching the subject from different perspectives and building reasoning (see figures 4-9). They were inspired by Dewey's observation (1910, p: 8-9) that this requires training mental habits through methods of inquiry, suspended conclusions and methods to explore situations. Mezirow (1990) points that making meaning and sense of experiences is about making interpretations of them (p: 1). This inspired us to support people in creating these clarifications and building of insights. Korthagen and Vasalos (2005, p: 63-64) expand on the importance of taking time to investigate, analyze but also envision future scenarios. Denton (2009, p: 841) points that Socrates took time to recollect experiences. This supported us to envision general reflection questions, which become relevant through the topic. Depending on the available time and size of the group, the facilitator decides how many questions each participant can select and discuss. Every phase ends with selecting the most important insights.

4.3.2 Inspiration cards

The decision for inspiration cards comes from our incomprehension that many writings around literature revolve around cognitive elements, while emotions are equally important. Through several expert meetings about learning and coaching we decided to offer different methods to support inspiration and approaching the emotional side. Some people are triggered through textual ways, while others prefer photos, illustrations or materials. Subsequently, they would act as softening the painfulness of reflecting (Mälkki, 2010; Mezirow, 1990) since they offer a head start to discuss. Moreover, the inspiration cards would stimulate talking about emotions and supporting dialogues about the undercurrent. Their usage is both to answer the reflection questions and to explore alternatives or new scenarios. The inspiration cards include the following triggers: photos, illustrations, textual and haptic styles. The photos are chosen intuitively to stimulate people to talk about their feelings. The illustrations include doodles that represent different scenarios and are less explicit than the images. The textual triggers are verbs and sentences that are directed and more in the provoking area. Lastly the haptic set contains materials that exist of different structures.

Figure 10: Some example of images from the inspiration cards. They range from concrete images such as 'people making music' or 'a bird in a cage', to abstract ones as 'street stone structures'.

Figure 11: Several examples of the illustrations, as part of the inspiration cards. Some are about people, others about situations, objects or activities.

Figure 12: Some textual triggers as part of the inspiration cards. They include words as 'connected or 'promising' or statements as 'what a nonsense!', 'can we take it a bit slower?' or 'I think ... should happen'.

Figure 13: Several examples of the haptic set. Some are soft or sturdy, others more stretchable or transparent.

5 Evaluation

5.1 Setup of user tests

The tool is designed through two iterations, that are both qualitatively tested in context as well as evaluated with experts in and outside the municipality. The tool is largely left unchanged content wise in the second iteration, but is mostly adjusted in the visual style and structure of the process. All user tests were filmed with consent and ended with a group discussion around their experiences, usability and improvement points. The first iteration was tested during an individual session with a civil servant from Strategy, a group session with four employees from Personnel & Organization and finally a group session with eight civil servants from an intervention group of one of the company coaches. All participants were completely novel to the process and concept. The tool was also tried out by one of the authors and evaluated with experts on reflection and the design of tools. The second iteration was tested during two group sessions: one with a group that was familiar with the first iteration and another that had a fresh experience with it. The first author was the facilitator in all user tests. During all sessions the topic of the reflection was decided upon agreement in the group. The topics that were chosen are: a collaboration problem between a civil servant and her manager; budgetary challenges and the visibility of the related department; supporting employees to become more conscious about their self development. The video recordings of all sessions and notes from the discussions afterwards were analyzed and categorized in 'overall experience on supporting reflection through Tegelen'; 'reflection phases and questions'; 'the inspiration cards' and the 'role of the facilitator'.

Figure 14: Iteration 2 in use during a group reflection session with civil servants from the HR department.

5.2 Results

5.2.1 The overall experience and process of Tegelen

The evaluation first of all shows that Tegelen supports and stimulates reflection. We conclude this based on self-reported experiences from participants on individual written feedback forms, group discussions after sessions and observations by the facilitator (through video documentation). Civil servants experience that Tegelen offers guidance in a structured, yet dynamic manner. Like many others, participant 7 for example mentioned, "I like how the combination of everything has a playful side to it. The questions and inspirational cards helped us to talk about the undercurrent, which should happen more often". The majority put forward that running through the process offers them broader, more in-depth and alternative ways to approach the topic. P4 (iteration 2) for example explains this by saying: "I think this tool makes it easier to reflect, I like that we have to put cards on the table and write reasoning."

One of the results is that the outcome of the session greatly depends on the concreteness of the chosen topic. P8 (iteration 1) rightfully noted, "I wonder what difference it makes if we are very abstract from the start or very concrete as the start influences everything else." Indeed, some sessions remained very abstract while others ended concretely with a communication or action plan, while others resulted into takeaways for a future scenario or insights that were taken to a meeting. When the topic at hand is a present-day situation or something from the past, the process naturally evolves in a reflective mindset and process. In this scenario most time is spent in the 'inventory and looking back' phase. If the subject is something that will happen in the future, the session logically turns more into a brainstorm with an emphasis on the 'looking forward and concretize' phase.

5.2.2 Reflection phases and questions

The combination of reflection questions and the free use of inspiration cards furthermore stimulate making new connections to gain insights. Participants experienced that the reflection questions helped to explore and investigate the topic from different perspectives. Similar comments such as the one of P3 (iteration 1) was heard quite often: "Shuffling through the reflection cards made me truly stand still and think about whether the question was relevant". P2 (iteration 1) added: "Some questions were not relevant at all, while others triggered me to think in new ways." Setting a goal was experienced as very helpful because it gave body to the session and supported drawing a conclusion. Furthermore it turned out to be a relatively easy way to decide whether the session was

a success, something that participants appreciated. Writing down arguments was experienced useful to maintain understanding of the discussed things. Many mentioned things as the comment of P1 (iteration 2): “I see great value in writing things down as we never do that, what we discuss always remains floating in the air.”

5.2.3 Inspiration cards

The sessions showed that the inspiration cards support in making the unspoken undercurrent apparent while triggering thinking outside standard thought patterns. P4 (iteration 1) mentions that, “It really touches upon the stuff that is behind the surface… normally we stay in the verbal side, but this triggers other things”. Another statement mentioned multiple times is similar to what P1 (iteration 2) says: “the inspiration cards really supported me to think about and include my feeling around the topic, I found that very helpful”. Halskov and Dalsgard (2006) point that design artifacts, such as the inspiration cards, can become part of the dialogue as means to express and focus. They include that bringing together unrelated elements is an important factor in making cross-links and sparking inspiration while bringing a creative exchange between participants in their workshops. Their insights resonated exactly with our experiences in the effect of the inspiration cards. For example, P10 (iteration 2) states, “I really like how the tool triggers in so many different ways, I don’t think I would have had the same ideas and tinkering without them (the inspiration cards)”.

5.2.4 The role of the facilitator

The user tests clarified that the facilitator plays an essential role in the overall (group) process and shouldn’t be excluded in the approach. P5 (iteration 2) for example said: “I found it useful that you kept us sharp and helped focusing, you ask through and involve us all”. Within individual sessions the role of the facilitator also include another aspect. This participant mentioned, “your facilitation helped me to stay grounded and not fall into a monologue with myself”. These experiences showed that within group session the facilitator mostly focuses on supporting the process and ensuring involvement, while in an individual session it is added with being a reflecting partner. This implies that especially in individual scenarios, the facilitator should remain professional yet sincere, without losing track of time or the actual guidance.

6 Discussion

6.1 Impact of the reflection tool

In general, participants put forward that they feel empowered because they obtained more overview, understanding and different perspectives around through the use of Tegelen. Moreover, it helped them to create grips to change a situation or do things differently next time. The goal of the tool however is not only to offer participants support during a session itself, but to have an impact afterwards that ultimately results in behavior change. This would need a longer trajectory of reflection sessions. Herein participants will need to be stimulated to implement the gained insights in their daily life and work. It is expected that the integration of a tool like this would ask for support from top-down as well as bottom-up in the organization. We believe longitudinal use and research is required to discover how the insights can be implemented in the related context. A digital platform might help to create a database and (re)collection of topics and outcomes of the reflection sessions. In the remainder of this paragraph we discuss the aims stated in the introduction and the arisen opportunity around sociality in reflection.

6.2 Embedding academic insights to ground design and built trust

The crossroads of the academic and the ‘practical’ world such as governmental organizations forms an interesting place to experiment and strengthen a reciprocal exchange. The literature supported us to obtain in-depth understanding of what reflection entails and how there could be designed for it. Subsequently, it informed about requirements and the opportunity to integrate the triggering of curiosity, feelings and creativity to support reflection. Sharing and communicating the (academic) pillars on which our concepts are built, can support us to validate and improve. From the practical

perspective of designers working in public contexts, grounding and validating work is something that always remains a challenge. This counts especially in the more social, transformative side of (design) trajectories. The fact that most decisions were both theoretically and empirically supported helped explaining why and how the tool was designed. We noticed that this helped participants to embrace and trust both the concept as the overall process. This is an essential aspect to create the foundation to implement concepts into their related context. In essence, it becomes much easier to ground and validate our work if we have foot to stand on, especially as it can be cumbersome to test the actual impact of our proposed designs.

6.3 Creating engagement through the design process

Empirical research is a valuable mechanism to create engagement and inform non-designers in our process. Such activities involve stakeholders from the first-person perspective, which creates understanding and involvement. We experience that fieldwork provides valuable moments to let non-designers experience designerly ways to approach and tackle challenges. It brings them on board of a journey where the end result may not be visible but the road towards it is sincere, contextual and inclusive.

6.4 Sociality in and through reflection

Although it was not a specific aim, Tegelen supports both individual and group reflections, of which the latter is quite unique. Most existing methods are based on a 'one to one' or on an individual setting. The user tests offered ample insight that reflecting together has great added value, especially in situations of team collaboration or the exploration of a vision or work method. We observed that participants build on each other's arguments, which increases mutual understanding throughout that process. It supports creating a communal language by sharing (personal) perspectives, leading to connection and engagement between participants. This indicates that sociality created through group reflection can form an essential support for the approach that is required in multi-stakeholder collaborations.

7 Conclusion

We began this paper by highlighting that the societal challenges we are facing require a change in mind state and behavior to create public engagement in the whole public sphere. Herein, reflection can stimulate consciousness and empowerment leading to alternatives, insights or novelties. It is a skill that is applicable on personal, organizational, and social as societal spheres.

We contribute to the field of designing for reflection by informing about the importance of bridging the cognitive, emotional and creative aspects that are all equally important within this skill. Our interest to explore how reflection can be supported through design resulted into Tegelen, a tool that can be used in individual as well as group sessions. With the concept and the road towards it we have shown a novel way to approach and tackle reflection by bridging questions with inspiration and guidance with a dynamic method. It is a balance between offering structure and stimulating a dynamic flow of exploration and argumentation. The experiences of users put forward that the tool supports empowerment, mutual understanding and grips to tackle the topic at hand. Longitudinal usage and further research is needed to explore the potential of Tegelen to support to reflection and stimulate behavior change in the long run. Through the process and the design of Tegelen we show that individuals, employees and organizations would benefit from a structured support in reflection. Moreover, we have shown that group reflection can lead to sociality, mutual understanding and a shared foundation between participants. This can support the engagement that is required for (local) multi-stakeholder collaborations to approach challenges and discover roles. We believe that reflection is a skill that deserves more attention in personal and organizational change, and hope that Tegelen can contribute supporting this.

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Ambiguity and Open-Endedness in Behavioural Design

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Design is increasingly concerned with changing people's behaviours. A common characteristic to behavioural design approaches is their *directionality*: products provide clarity about or guidance towards the designer's intended behavioural outcome. In this paper we propose an alternative perspective that emphasizes *ambiguity* (i.e. affording multiple interpretations) and *open-endedness* (i.e. affording multiple courses of action). We build on two design cases in pediatric healthcare in which the aim was to stimulate young children's physical activity during hospitalization. Instead of commonly used exercise-based approaches, our focus was on physical activity in the form of spontaneous and unstructured play. We describe how interactions with ambiguous and open-ended playthings gave rise to intended behavioural outcomes. The findings are explained by drawing on Activity Theory, suggesting products can direct and leave things open on different levels of interaction. With our contribution we open up a new design space for behavioural design that reconciles designer's intentions with end user's appropriation.

appropriation; design for behaviour change; openness; research through design

1 Introduction

There is an increasing awareness in design research and practice that products are not merely *functional* to end users (i.e. products as *tools* or *means to an end*), but that they also *mediate* people's everyday life in sometimes unexpected ways (i.e. products as *mediators*; e.g. see Nardi & O'Day, 1999; Verbeek, 2005). Several design approaches have emerged that make use of this mediating capacity of products, aiming to achieve desirable changes in people's behaviour. A common strategy in these approaches is to deliver products that are clear in their purpose or that guide end users through a specific course of action towards some desirable outcome. In this paper we explore an alternative direction in which leaves room for end user's meaning making and self-directed action.

To shed some first light on such an alternative approach, let us take the metaphor of a restaurant. Think of the dishes available and their descriptions in the menu card. Restaurant A might offer traditional dishes, with the ingredients clearly indicated. Restaurant B, on the other hand, might

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serve more experimental dishes, with limited information about the ingredients. The latter situation may result in curiosity or wonder among the guests, prompting questions such as “What is this ingredient?”, “What’s this flavour?” or “How should I eat this?” In other words, Restaurant B offers a setting that gives rise to *ambiguity*: they invite meaning making and may result in various interpretations. Now consider how Restaurant C might offer a single menu of three courses versus Restaurant D having multiple dishes lined up at a buffet. In the second case, guests have the freedom to compose their menu and, if they desire so, go for a second round. The buffet of Restaurant D is more *open-ended*: it leaves open multiple courses of action.

The aim of this paper is to show how ambiguity and open-endedness, as described above, can be valuable assets when designing for behaviour change. In other words, returning to the metaphor: we explore whether and how restaurants can promote, for example, healthy or sustainable food choices, while leaving room for people’s self-direction and meaning making. This effort potentially opens up new possibilities for behavioural design to create space for end user’s appropriation.

2 Behavioural design and directionality

Over the years several approaches and tools have emerged in the fields of HCI and design research that can facilitate designers in changing behaviours of end users. Examples are persuasive design (Fogg, 2003), design with intent (Lockton, Harrison, & Stanton, 2010), or design for X behaviour, where X refers to a specific domain of interest, such as sustainable or socially responsible behaviour (e.g. Tromp, Hekkert, & Verbeek, 2011; Wever, van Kuijk, & Boks, 2008). Here we will use behavioural design as an umbrella term for these approaches, which are all in some way concerned with changing behaviours of end users as resulting from interactions of a designed product or environment. We see behavioural design as part of a broader field we label as *intentional design*, hinting at the wide range of intentions for change that designers might have, such as enhancing the experience of end users (Hassenzahl et al., 2013), encouraging reflection (Hallnäs & Redström, 2001), or regulating mood (Desmet, 2015).

A characteristic that is common to behavioural design approaches is their *directionality*. Ideally, users have a specific interpretation of a product’s purpose or message (i.e. products provide *clarity*) or they engage in a specific course of interaction (i.e. products provide *guidance*) as intended by the designer (e.g. see Jelsma, 2000; Lockton et al., 2010; Wever et al., 2008). For example, pedometer apps are generally designed to clearly indicate the amount of steps taken and, in some cases, how this relates to the advisable amount. A speed bump is a clear barrier for a driver to slow down. Or consider the ‘Never Hungry Caterpillar’ in a study by Laschke, Diefenbach and Hassenzahl (2015); this extension cord is designed in the form of a caterpillar that expresses its suffering when the device it is connected to is switched to stand-by modus. The purpose of the design was to improve energy behaviours and the study showed how most users had interpreted it accordingly. In these examples, clarity and guidance increase the likelihood for intended behaviours to occur. The designs are successful in their directionality insofar as they correspond with some concern of the end user. Road signs, for example, might trigger concerns about the safety of others, whereas a speed bump is more likely to raise worries concerning the bottom of the one’s car (see Tromp et al., 2011; Waelbers, 2011). In both situations, the design *directs* drivers to lower their speed.

In the above cases, it is desirable that end users obtain a clear understanding or intuition of what is the desirable or only way to go. This is very reasonable for a designer to pursue, in particular when designing for situations of risk or urgency. In many situations, however, it might be the case that there is no such need for directionality; it might even work counterproductive due to its restrictiveness or inability to engage users. Here designers might benefit from a more facilitative approach that leaves room for end users’ meaning making and self-direction. In this paper we discuss *ambiguity* and *open-endedness* as particularly relevant concepts for such an approach.

3 Ambiguity and open-endedness

Whereas traditionally design developed as a discipline that delivers clear and functional, or *usable,* products, the value of openness in design is increasingly acknowledged. From this point of view, a central question is how design can leave room or account for users' *appropriation* – i.e. the interpretation and use of a technology beyond its original design intention (Höök, 2006). Several open design approaches and relevant concepts have been proposed that might help designers to design for appropriation. Below we focus on the concepts of *ambiguity* and *open-endedness*, which offer a clear contrast to our earlier discussion of directionality in the form of clarity and guidance.

3.1 Ambiguity in design

Ambiguity refers to the possibility of something giving rise to multiple possible meanings. Similar to Gaver et al. (2003), we see ambiguity as a property of the relationship between an artefact (e.g. its accuracy of feedback or clarity of purpose) and end users (e.g. prior experience, norms, values or worldview).

The literature discusses several ways in which ambiguity may emerge and how it can be designed for. Gaver et al. (2003) illustrate how ambiguity may arise out of the way information is presented, out of an experienced incompatibility between artefact and context, or out of the interpreter's personal relationship with an artefact. Sengers & Gaver (2006) propose a number of design strategies to allow for multiple interpretations. For example, a designer could consider gradually unfolding new opportunities for interpretation or thwarting any consistent interpretation. Furthermore, they distinguish various levels of interpretation, from "What does this button do?" to "What is this system intended to be used for?" or "What role can it play in my life?" (Sengers & Gaver, 2006, p. 100).

3.2 Open-endedness in design

Open-endedness refers to something not having a planned ending and affording multiple courses of action. Similar to ambiguity, we view open-endedness as a property of the relationship between an artefact (in particular in terms of possibilities for action) and its user (e.g. prior experience, current needs, or behavioural dispositions).

In the literature we find several ways in which design can be open-ended. Moran (2002) introduces Everyday Adaptive Design, referring to the design activities that end users might engage in to adapt technologies for their own purposes. Designers can facilitate such activities by designing 'pliant technologies' that are modular or underspecified. Along similar lines, Seok et al. (2014) describe non-finito products as being intentionally unfinished, leaving room for creativity of end users in solving their problems. In the context of designing for children's play, de Valk (2015) describes open-ended play as play without predefined rules, leaving room for improvisation. She discusses ambiguity in interactive playthings as a way to achieve diverse ways of playing. Rozendaal et al. (2011) explore how open-endedness can be operationalized in design by tapping into a different human needs and bodily interactions to open up various routes to attain intended outcomes.

3.3 Ambiguity and open-endedness in behavioural design

It appears that the qualities of ambiguity and open-endedness are in opposition to the directionality common to behavioural design. This paradox surfaces in the words of Gaver et al. (2003, p. 235): "the [ambiguous] artefact or situation sets the scene for meaning- making, but doesn't prescribe the result." Contrastingly, the central purpose of behavioural design is the prescribing, or at least promoting, of particular interpretations or results. Similarly, it might be said, an open-ended product or situation does not guide the user towards a particular course of action. Instead, open-endedness might be better described as multi-directional.

In the following section we illustrate how this paradox of openness versus directionality is only apparent. We draw on two design cases in which the aim was to stimulate children's physical activity in hospital settings. Per design, we describe the intentions behind it, followed by a detailed

description of product characteristics that contributed to ambiguity and open-endedness, and how this, in turn, stimulated physical activity.

4 Design cases: Fizzy & Stickz

We reflect on two design cases that are part of an on-going 'research through design' project (Stappers, 2007) in the context of paediatric oncological healthcare. The main motivation behind the project is the following issue: chronically with cancer, due to their disease and treatment, often show low levels of physical activity. This inactivity potentially hampers children's physical development. In particular during hospitalization, children tend to engage in very little physical activity (e.g. Winter et al., 2009). A common approach in healthcare to deal with this issue is to involve children in exercise programs. Product and game designers have contributed to such exercise-based solutions, in particular in the form of *exergames* – games that require a certain level of exertion from the child (e.g. see Janssen et al., 2017; Sinclair, Hingston, & Masek, 2007). Exergames are particularly useful for therapeutic purposes (e.g. setting specific parameters) and may provide engaging experiences that keep children comply with the program. However, exercise programs and exergames are often structured in the exercises that they offer and the rules that are involved. This makes them less suitable for young children whose physical activity is characterized by short bouts of activity and generally occurs in the form of spontaneous and unstructured play (see Boon, Rozendaal, van den Heuvel-Eibrink, van der Net, & Stappers, 2016).

Stimulating physical activity in the form of free play, or what we refer to as *physical play*, became our primary target in the project. In the design process, two directions emerged. One was inspired by the concept of 'loose parts' – objects that can be moved and manipulated in children's play (Daly & Beloglovsky, 2015; Nicholson, 1971). Examples of loose parts are leaves, branches, pinecones, and pebbles that children may find in a park, but also screws, buttons, toothpicks or paper clips fall within this category. Common to loose parts is that they do not dictate a particular purpose or use to the playing child, leaving room for their imagination and creativity. The concept of *Stickz* was based on this idea: Stickz form a collection of large branch-shaped objects that invite to be carried and dragged around and that afford a variety of play activities (Figure 1). A second direction was inspired by Gibson's observation that the "richest and most elaborate affordances" are provided by animals of which the movements are spontaneous and self-initiated, or *animate* (Gibson, 1979, p. 135). We designed such animate qualities into an everyday toy, namely a ball. This resulted in Fizzy: a pro-active robot ball who's behavioural repertoire invites children to playfully interact with it and who's shape invites playing with it as a ball (Figure 2).

Figure 1 (left) Child constructing with Stickz. Figure 2 (right) Children running after Fizzy and Fizzy shaking wildly.

Below we describe the concepts in more detail. By reflecting on our fieldwork in hospital settings, we show how the prototypes of Fizzy and Stickz gave rise to ambiguity and open-endedness and how this contributed to stimulating physical activity. The intentions behind both designs are summarized in Table 1, distinguishing the underlying motivation or aim of the designs, the target

behaviour that was thought to contribute to this aim, and the primary means (in particular, product characteristics) that were initially expected to contribute to this behaviour.

Table 1 Design intentions behind Stickz and Fizzy

	Stickz	**Fizzy**
Motivation	Stimulating young children's physical development, in particular when this development is threatened by disease and treatment	
Target behaviour	Physical play: physical activity in the form of spontaneous and unstructured play	
Means	Collection of large, loose and branch-shaped objects, inviting gross motor activity during pretend- and constructive play	Ball with behavioural repertoire, inviting children to follow it around and engage in ball play (e.g. throwing, kicking, rolling)

4.1 Stickz

Stickz is a collection of soft branch-shaped objects that affords physical play through their sheer size and weight, in combination with their transportability. They are a translation of the sticks children may find in forests and parks, with which they can engage in pretend play (e.g. stick as sword) or as construction material (e.g. building a hut). Prototypes of Stickz were introduced to a semi-public waiting area in the hospital. In total, 21 children between the age of 2 and 7 years old participated in the study, including 12 boys and 9 girls, resulting in 3 hours and 32 minutes of playtime that was recorded on video and analysed. Children consisted of 17 childhood cancer patients and 4 siblings.

4.1.1 Openness and directionality in Stickz

Stickz were primarily ambiguous in terms of their relation to their context. Parents and children were often referring to Stickz as a forest or branches. Some parents and staff members referred to the Stickz, or interactions with Stickz, as messy (e.g. a physiotherapist says to a child "You're making a mess of it!"). The Stickz seemed somewhat out of place in a hospital environment that is normally more structured and organized. This ambiguity sometimes gave rise to hesitation to initiate interaction. For example, when a boy asked his mother what Stickz were, she told him it was art, and continued to move along. A second way in which Stickz gave rise to different interpretations was through their shape; these were interpreted in various ways during children's pretend play. Children used Stickz as guns, water guns, walking sticks, or pretending they are a character, such as a giant spider. Stickz were open-ended by giving rise to various play activities (e.g. pretend play, constructing, colour sorting). However, this effect was limited as constructing was the predominant activity that children engaged in. Despite this predominance, children could self-direct their play within the activity of constructing and pursued a variety of goals (e.g. building a hut, apple tree, or constructing for the sake of constructing). See Table 2 for a summary of Stickz' role in giving rise to ambiguity and open-endedness.

To a large extent, children were physically active through the collecting of Stickz and subsequent activities of constructive play. Both these types of activities required full body movements of the children. Children had to lift, carry and place large Stickz, requiring continuous exertion of the trunk and leg muscles for stability while walking. Collecting also occasionally involved throwing the Stickz from a distance. While constructing, children were often walking around the construction to decide upon where to place the next Stick. As constructions were built, children walked around or crawled underneath them; this, however, took up relatively little time. Scattered loose Stickz were sometimes used in a functional and experimental way: they invited various swinging and balancing movements. Some forms of pretend play with Stickz were intensive, involving running around, shooting at each other, and falling on the floor.

We suggest ambiguity and open-endedness in the interactions with Stickz contributed to children's physical activity in two ways. First, open-endedness of constructive play activities resulted in

children engaging with Stickz for a relatively long time. During this time, children engaged in collecting and carefully placing Stickz, involving physical activity in the form of lifting, transporting and placing. Also other activities required such exertion, as Stickz were often first collected beforehand (e.g. first collecting and then sorting according to colour). A way in which Stickz' ambiguity contributed to physical activity was by affording a particular kind of pretend play that involved running, using Stickz as pretend guns. A way in which ambiguity of Stickz seemed to discourage physical activity, was by being too unfamiliar or out of context, as reflected in interpretations of Stickz being art. To conclude, open-endedness in combination with the shear size and weight of the Stickz gave rise to multiple courses of action that resulted in a variety of physical activities. Ambiguity of shape resulted in playing with Stickz as pretend objects, such as a vacuum cleaner, gun or walking stick; these activities particularly involved locomotion.

Table 2 Characteristics of Stickz and Fizzy that explain ambiguity and open-endedness in interactions

	Stickz	**Fizzy**
Ambiguity	Stickz are messy and seem out of place in a slick and sterile hospital environment. Stickz, due to their shape, leave room for multiple interpretations.	Fizzy can be interpreted both as ball and creature. Fizzy's behaviour can be interpreted in multiple ways.
Open-endedness	Stickz afford multiple activities, such as constructive play, play fighting, pretend play, etc. In constructive play, Stickz allow a variety of constructions to be built. In pretend play, Stickz allow a child to play out various narratives	Fizzy affords multiple play activities, such as ball play and creature play. In ball play, Fizzy affords rolling, kicking and throwing. In creature play, children can explore and engage with Fizzy in their own way (e.g. following, keeping captive)

4.2 Fizzy

Fizzy is a pro-active robotic ball that invites physical play through its behavioural repertoire. It wiggles to get attention, rolls away when it is approached, shakes heavily when it is caught or picked up, and purrs when it is caressed. Fizzy was designed as a stimulating agent, creating space for young children's physical play in the confines of a patient room. Ideally, Fizzy invites the child to leave the room and meet other Fizzy's and children throughout the hospital. A Wizard of Oz prototype of Fizzy was introduced to children during planned visits in patient rooms. In total, 7 children between the age of 3 and 6 years old participated in this study, including 3 girls and 4 boys, resulting in 3 hours and 2 minutes of playtime that was recorded on video and analysed. All children were childhood cancer patients.

4.2.1 Openness and directionality in Fizzy

Children attached various meanings to Fizzy during play. The two main roles of Fizzy were that of a *ball* and that of a *creature*. These two roles disclosed a variety of play activities, ranging from throwing, rolling and kicking the ball towards one another (role of *ball*), to following, catching and caressing Fizzy (role of *creature*). Children easily shifted from one role to another in an almost continuous stream of play activities. Other roles that Fizzy played were that of a sensory object, used

for sensing and massaging, and a technical object, used for examination and experimentation (e.g. weighing Fizzy or theorizing about Fizzy's functioning). Another level of ambiguity emerged as children engaged with it as a creature. Children speculated or gave different interpretations of the meaning of the wiggling (e.g. "It's saying 'No, I'm not coming!'"), shaking ("He doesn't want to be caught!" or "That feels funny!"), purring (e.g. "He farted!" or "He's purring like a cat!" and "He really likes this [stroking]…") and rolling away behaviour (e.g. "Where does he want to go?" or "Bad ball!"). See Table 2 for a summary of Fizzy's role in giving rise to ambiguity and open-endedness.

For most children, Fizzy triggered various interactions that resulted in different forms of physical activity. Children crawled, walked and ran while following or chasing Fizzy throughout the patient room. Other common activities were rolling, kicking, or throwing the ball to one another. Some parents mentioned that their child had been exceptionally active. For example, a father expressed how his daughter had been "more active than the last four days [in the hospital] altogether!" For the older children (5-6 y/o) Fizzy was often too slow to be able to get away from the child, which resulted in less following behaviour, and subsequently less locomotor activity.

We suggest ambiguity and open-endedness in the interactions with Fizzy contributed to children's physical activity in three interrelated ways. First, the fact that Fizzy had a variety of roles attached to it, resulted in a rich diversity of successive play activities. This diversity of activities, involving both active and passive forms of interacting, kept the play engaging over a longer period. Second, the dominant roles of Fizzy stimulated physical activity: Fizzy as creature stimulated following and subsequently locomotion (walking, crawling, and running), whereas Fizzy as ball invited ball play that involved projection and catching (throwing, kicking, and rolling Fizzy towards one another). Third, Fizzy's pro-activeness resulted in curiosity and attention of the child, keeping the child engaged and inviting him or her to play.

5 Openness and directionality: a multi-level perspective

The above design cases illustrate that ambiguous and open-ended products can lead to intended behavioural outcomes. Furthermore, Fizzy and Stickz show that qualities of openness can *enhance* behavioural outcomes: the designs engaged children by offering multiple interpretations and they resulted in multiple courses of action that involve physical activity. Below we draw on Activity Theory to explain our findings, and show how openness and directionality occurred simultaneously in the interactions with Fizzy and Stickz.

Activity Theory offers an approach to interaction design that understands technology use in the context of human *activities*. Activities are viewed as being hierarchically structured, consisting of the *activity* itself, the *actions* that contribute to the activity, and the *operations* required for the activity and actions (Kaptelinin & Nardi, 2006, pp. 62–64). Activities concern the *motives* of people – i.e. the objects that excite or stimulate the subject. In play, the motive of the activity is located in the activity itself (e.g. playing hide and seek, for the sake of playing hide and seek). Actions are instrumental to activities, and are *goal-oriented* (e.g. selecting a suitable hiding place in order to decrease the likelihood of being spotted). Operations are routine processes that are oriented towards the *conditions* for action (e.g. running towards the hiding spot and changing to a squatting position).

Interesting for our purposes is that the hierarchical structure of activity allows us to view *openness and directionality as working on different levels.* With this multi-level perspective we can explain our findings with Fizzy and Stickz as follows: on the level of activity interactions were more open; children interpreted the designs in different ways over time (e.g. Fizzy as ball or as creature) and consequently engaged in many different play activities (e.g. ball play and creature play). On the level of actions, interactions were open as well: a variety of actions were possible within the activities (e.g. in creature play, following Fizzy, keeping it enclosed or trying to catch it). On the operational level, however, interactions were more directed towards physical activity: following Fizzy implies locomotion and trying to catch it requires additional coordination and agility. To summarize, while

children could self-direct on the level of activity and action, many of these activities and actions required gross motor operations (see Figure 2).

Figure 2 Interactions with Fizzy & Stickz are open on the level of activity and actions, and directed at the level of operations. The left part of this figure is adapted from Kaptelinin & Nardi's (2006) depiction of the hierarchical structure of activity.

6 Discussion and conclusion

This paper has shown that intended behavioural outcomes can be achieved and even reinforced by ambiguous and open-ended interactions with products. In one case with Stickz, we found that ambiguity might also work counterproductive by discouraging initial interactions. Overall, however, Fizzy and Stickz invited children to play, giving rise to various interpretations and play activities, while also stimulating children's physical activity. We explained our findings by drawing on Activity Theory: by conceptualizing behaviour as *multi-layered activity*, we showed how Fizzy and Stickz were directional on the operational level and ore open on the level of action and activity.

A central question is whether our findings are applicable to other contexts. An obvious limitation of our study is the fact that the design cases were concerned with stimulating children's physical activity in the form of free play – a phenomenon that is inherently open in terms of meaning making and possibilities for action. For other phenomena or target behaviours ambiguity and open-endedness might be less appropriate qualities. For example, driving behaviour is restricted by many rules and requires clear information for the driver. As mentioned earlier, in these kinds of urgent or risky situations ambiguity and open-endedness will probably work counterproductive. The same goes for formal or sombre settings or for end users who cannot easily bring about a state of creativity or spontaneity.

Another reason to question the generalizability of our findings is concerned with the *level of specificity* of the target behaviour. Physical activity as target behaviour is relatively broad; there are many different ways of being physically active, as illustrated in the interactions with Fizzy and Stickz. This makes an open approach to behavioural design quite appropriate and feasible. Other target behaviours can be more specific, for example, by being related to a specific product. When a designer is set to redesign a toilet button in order to increase water saving behaviour, applying ambiguity and open-endedness might not be of much help. The concepts might be better applicable in systems approaches to designing for change that move beyond individual products and users and shift the focus to, for example, social practices (Kuijer & de Jong, 2012) or ecologies (Mazé & Redström, 2008).

Future steps can shed light on some of the above limitations and on the scope within which designing for ambiguity and open-endedness makes sense. In particular in design for physical activity and non-sedentary behaviour we see possible applications. Two existing concepts point out the potential merits of this direction. The SweatAtoms system (Khot, Mueller, & Hjorth, 2013) gives 3d printed feedback to users about their physical activities, based on heart rate. One of their ideas is depicted in Figure 2, in which the feedback comes in the form of what might be perceived as an elegant flower-like ornament. At the same time, the data is still recognizable and interpretable in the

3d printed object. This dual role potentially gives rise to various meanings that users attach to it. SweatAtoms do not only allow for multiple interpretations, but are, in potential, extremely open-ended: users are given the space to experiment in everyday life to change their physical activity patterns. A second example is "The End of Sitting" by artist Barbara Visser and studio RAAAF in the Netherlands (see Figure 4). This concept for a work environment encourages changing work position and posture. The workspace as a whole is a perfect example of open-endedness, offering many possibilities for different postures, while being directional in discouraging sedentary behaviour (i.e. sitting and remaining in a single posture for a long period of time).

Figure 3 (left) SweatAtoms by Khot et al. (2013). Figure 4 (right) The End of Sitting by Barbara Visser and Studio RAAAF; photo by Jan Kempenaers. Both images are reprinted with permission.

Besides the potential of open-endedness and ambiguity in designing for physical activity, we are unsure about their application in other behavioural domains. We have particular interest in the direction of Design for Sustainable Behaviour, as this domain deals with behaviours of which the effects are less tangible and less embodied for end users, linking to more systemic and abstract issues such as climate change. Ambiguity, open-endedness, or other qualities of openness might prove to be relevant in facilitating more sustainable behaviours while simultaneously offering engaging experiences and respecting end user's autonomy. To conclude, this paper has shown an alternative approach to behavioural design that reconciles directionality of the designers and appropriation by end users. We hope this contribution invites designers and design researchers to explore possibilities for openness to contribute in their behavioural domain of interest.

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Align and Combine, Customer Journey Mapping and COM-B Analysis to Aid Decision-Making During the Design Process

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This paper explores a new methodology for solving complex problems that focus on changing end-users' behavior by combining customer journey mapping and COM-B analysis. This method visually representing gaps and opportunities in a sequential way aligned with barriers to behaviors, creating a unique tool that can be used by both service designers and behavioral scientists. Using such tools can help us gain a more thorough understanding of a problem space, leading to the design of efficient, cost-effective behavior change interventions, improvement in the target outcomes and the achievement of business goals. We illustrate this "align and combine" method by applying it to the case study of an insurance company that wants to address the high risk of dental complications among their diabetic membership cohort. We conclude that visually combining the service design and behavioral science approaches creates a symbiotic relationship, where doing one type of analysis complements the other, and vice versa.

design tools, design methods, behavior change, interdisciplinary

1 Introduction

Working in a design agency means exposure to multiple problems coming from different industries and sectors. Though the sectors are different, it is not hard to see repeating patterns. We work to solve complex, systemic problems that are intertwined with elements and touchpoints both inside and outside the defined sector (Buchanan, 1992). There is great benefit to seeing how everything is connected, but a side effect of such interconnectedness is the need to address each problem on multiple levels. Sometimes it feels like we are designing for an ecosystem within an ecosystem of another ecosystem. For example, when designing digital solutions for a health insurance client, we must consider how the insurance customer experiences this in relation to the websites of their pharmaceutical supplier and their healthcare provider, all of which exist within the larger ecosystem

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of the U.S. healthcare system. Proposed solutions have to consider both the front-stage that directly faces the customer, such as interaction with a web-based application, and the back-stage systems that support that application. Once we change something on the front-stage, we must be thinking of accompanying back-stage changes including the systems needed to support this service and any new actors (Glushko & Tabas, 2008).

Another pattern we see is demand for products and services intended to change end-users' behavior (Consolvo, McDonald & Landay, 2009). In many cases, the target behavior is related to health, finance, or education. One constant across all these sectors is that in order to change a behavior, we first need to understand it. We need to understand the source and the logic of behavior, as well as potential barriers and facilitators to the behavior occurring (Michie et al, 2008). In addition, we need to fully understand the context in which behavior resides. That context includes the person or target audience whose behavior you want to change, the specific behaviors, the settings in which these behaviors occur and the desired long-term outcomes enabled by executing target behaviors.

As a rule, these two patterns of complex problems – mapping out the front-stage and back-stage touchpoints and support systems for a service and designing for behavior change – are addressed by different professionals. Service and experience designers work on untangling the complexities of the system problems, analyzing the gaps and opportunities that exist within the defined ecosystem, and designing an improved experience for all the actors (Zomerdijk & Voss, 2010). Behavioral and social scientists, in their turn, are focused on untangling the complexities of behavioral systems – identifying sources of behaviors, behavioral determinants and building a logic model of change (Michie, van Stralen & West, 2011).

We know that addressing any one aspect of a problem may lead to measureable consequences in the other elements of the system. Designing a new Electronic Health Record is a good example. Even the simplest design change assumes a change on the front-stage (the interface where medical professionals interact with the EHR) and back-stage (securely storing and transmitting data to other 3rd party organizations). If we dig in deeper, we can see that these changes will impact medical professionals' experience of the entire system and their behaviors, their coding errors and intersystem interactions within the workplace, to name just a few.

Having collaboratively worked on both sides of this problem, we hypothesize that there is tremendous value in combining the analysis tools used by service designers and behavioral scientists. After all, each team is trying to solve the same complex problem and improve the experience for everyone involved in this process.

The objective of this paper is to examine the benefits of combining two methods – the COM-B model (Capability, Opportunity, and Motivational behavioral barriers and facilitators) of behavioral analysis and customer journey mapping. The combination can lead to a more thorough understanding of a problem space, leading to the design of efficient, cost-effective behavior change interventions that improve the target outcomes and achieve business goals. We describe a methodology of combining the two processes using a conceptual design case study. We hypothesize that using this combined methodology, more than COM-B or customer journey mapping alone, adds value by supporting the level of analysis and insights that allows you to initially design and iterate a product or service, as well as systematically evaluate its effectiveness.

2 Behavior Change and COM-B analysis

Behavior change intervention design is a set of processes and activities used to design an intervention (e.g. product, service) that aims to change a defined and modifiable behavior. Behavior change intervention design thrives at the intersection of behavioral and social sciences, motivational psychology, data science, human-computer interaction, and design (Sundel M. & Sundel S., 2017). It aims to understand target behaviors and systems interactions in their contexts, implement human-centered solutions addressing these behaviors, and evaluate their effects.

Let's have a look at some examples of behavior change interventions in the health sector. Within the prevention and wellness space, behavior change interventions frequently aim to reduce risks of disease or disease complication and promote health, e.g. increasing the level of physical activity or reducing the amount of stress. Within the healthcare space, interventions often aim to improve medication adherence or adherence to a prescribed diet or exercise regimen. Targeted behaviors are often complex, as they are comprised of several interactions among multiple systems. That's why behavior change interventions rarely target only individuals whose health outcomes we want to improve. In many cases they are designed with the ecological perspective in mind, as discussed by Rimer and Glanz (2005), and aim to influence multiple levels (intrapersonal, interpersonal, and community levels). For example, we may want a child to follow a healthy diet, but we know that the decision of what she eats is determined by the decisions and behavior of peers, parents, and school administrators.

Every good behavior change intervention starts with research because we need to understand behaviors in context in order to be able to identify the types of interventions that are likely to be effective at changing them. Ultimately, we want to create a holistic behavior change intervention targeting root causes of the problems. Research helps us understand these root causes through analyzing the behavioral and environmental barriers specific to our target population.

Purposeful behavior change projects call for a Logic Model. Our goal is to identify what is causing the problem, what, if anything, needs and can be changed, and for whom. Needs assessment is one methodology, as discussed in Bartholomew's (2016) Intervention Mapping protocol for developing theory- and evidence-based health interventions. Important outputs of analyzing the problem using this tool are a *Logic Model of the Problem* and *Logic Model of Change*. Another way to analyze and represent a logic model of behavior is through using the *Behavior Change Wheel* (BCW), a theoretically-driven framework based on multiple models of health behavior (Michie, van Stralen and West, 2011). BCW was designed to support systematic development of behavior change interventions.

The foundation on this framework is the COM-B model, a theoretical model to understand the predictors of behavior that was developed by Michie, van Stralen and West (2011). This model is based on nineteen existing frameworks of behavior change identified in a systematic review. The COM-B model was initially designed as a tool to explain the full range of possible influences that cause behavior, and ultimately systemize and improve the intervention design process.

Figure 1 Behavior Change Wheel (Michie, van Stralen and West, 2011)

COM-B derives its name from three domains: capability, opportunity and motivation. According to this model, any behavior is more likely to happen when the person has capability, opportunity and motivation to carry it out. The relationship between these factors and behaviors are reciprocal, which means that certain behaviors if taking place might influence capabilities, opportunities and motivations as well. The three domains could be broken down further. **Capability** includes psychological (e.g. knowledge) and physical (e.g. strength) abilities. **Opportunity** includes physical (e.g. time) and social (e.g. social influence) environmental factors. **Motivation** includes reflective (e.g. thinking) and automated (e.g. attitudes) motivation. The COM-B model helps us understand how these domains and subdomains interact with a person's behavior and vice versa.

The COM-B model is made up of non-temporal factors; that is, it does not make any determinations about an order in which the factors must be present for a behavior to occur. The model helps us understand which factors make the behavior more or less likely to happen in a systemic way, without providing the insight in the order of their occurrence. This is a limitation in the COM-B model.

If we want to address these factors in a product or service, it is crucial to know where in the customer journey these factors occur. For example, let's say we want to increase the frequency of lab tests done among patients at risk for heart disease. We could talk to our target audience and identify that lack of reflective motivation, low perceived risk of having a disease, low awareness of the symptoms, fear of needles, lack of knowledge of the lab diagnostic process, lack of opportunities due to low awareness about the health insurance benefits, and social stigma are the factors that serve as barriers to testing. However, nothing in this analysis helps us understand which of these barriers would happen first and would prevent patient from taking the first step towards the behavior. The COM-B model allows us to understand what needs to be changed, and how it needs to change. However, it doesn't show us where in the experience this improvement should happen. Enter customer journey mapping.

3 Experience Design and Customer Journey Mapping

Customer journey mapping is a set of visualization techniques that seek to describe a person's experience. Kalbach (2016) identifies this as one form of alignment diagram used to capture relationships between business value and customer experience. The experience being analyzed may be a task or series of tasks that involve interactions with products and services. These techniques are used to break the person's experience down into parts and subparts, revealing the steps from which the experience is made. The map will identify the touchpoints – those moments where the person comes into contact with products and services.

Carbone and Haeckel (1994) introduced the concept of "orchestrating" or "engineering" a customer's experience, motivated by the insight that a customer's experience of a product is sensory. A product produces an effect or result – attaching something to a wall, satisfying hunger, creating heat – but the customer's experience of that product is shaped by a series of perceptions before and after the encounter. Purposeful design calls for an experience blueprint which they define as "a pictorial representation of the experience clues to be engineered, along with specifications that describes them and their individual functions." (Kalbach, 2016, p.249)

Creating a customer journey map or service blueprint is a form of task analysis. The journey is made up of temporal events. Each of the phases and steps are represented as a sequence. While some journeys may include loops and branches, the basic journey is a sequence of encounters with the product or services in question.

Such diagrams can be used to analyze existing products or services – the way things are – or transformations of existing services – the way they should be. The case study "Mapping the Lab Test Experience" in Kalbach (2016) is similar to the behavior change example above. It illustrates the process of mapping the phases and steps in a user journey, applying a persona, a representation of

the goals and behavior of a group of users developed through research to simulate a customer's emotional response, and then filling out front-stage and back-stage processes to create a service blueprint. In the first step, the customer journey is broken down into phases representing experience boundaries. Each phase is then broken down into common steps. These steps are then aligned with the touchpoints related to the product or service. The experience designer identifies the customer's emotional experience by projecting a persona through the steps on the map, capturing the persona's response in speech bubbles and symbols (Pruitt & Grudin, 2003).

If the goal of this kind of analysis is to improve an existing product or service, the customer journey map can be used to identify pain or friction points such as moments of inconvenience, dissatisfaction or failure. These points in the journey can be identified as opportunities for improvement. The analysis can also identify gaps in the experience – places where the addition of a product or service could significantly enhance the overall experience. Kalbach points out that this kind of analysis tends to focus on "moments of truth", emotionally charged interactions that leave a strong positive or negative memory. By identifying such charged moments in a journey – dropping off a rental car on the way to catching a plane, choosing the drink to start your day, seeing and touching a piece of clothing you might want to purchase, taking medication for the first time – an experience designer can build out a strategy for applying resources to assure positive customer experience.

It is important for the purposes of this paper to also point out what the journey map is not. A customer journey map is not a logic model. We can reuse our Lab Test case study to illustrate this point as well. The representation of the customer journey is based on a combination of interviews with and direct observation of lab test customers. From that research, we can conclude that the customer's experience of a lab test begins with an awareness of a health problem, leading to a choice to see a doctor, leading to a prescription for a lab test, etc. However, nothing in this analysis explains why the customer chooses to see or not see a doctor, or accepts or rejects the prescription for the lab test. In short, the customer journey map allows us to identify a step where we want to improve a customer's experience, but it does not show us how to change a customer's behavior.

4 Benefits of combining two types of analyses

Both customer journey mapping and COM-B analysis represent problem solving tools. Both tools help team members understand the problem space. However, there are a few important differences.

In the case of COM-B analysis, we are focusing on understanding the root causes of behavior, and the factors that contribute to the outcome. Once we've identified the factors contributing to an outcome, we can use COM-B analysis to choose appropriate intervention functions (such as education, persuasion, Incentivizing, training, enablement, etc.) and evidence-based behavior change techniques ("active ingredients" of the intervention such as goal-setting, providing feedback, etc.) to design an intervention.

When we use customer journey mapping to break down the experience of a product or service that a person goes through in a sequence of phases, steps and events, we are doing gaps and opportunities analysis.

If we limit our analysis to customer journey mapping, we don't see the barriers to behaviors. We see gaps and opportunities arranged in a non-systemic way without an opportunity to identify appropriate intervention functions and evidence-based behavior change techniques to address them.

If we use only COM-B analysis, we see many different behavioral and environmental barriers and facilitators organized in a systemic way, but we don't see the temporal aspect and don't have guidance on when in the experience we should address them.

Combining behavioral analysis with gaps and opportunities analysis in one process and creating one visualization allows us to have a systemic way of representing and analyzing barriers to and facilitators of behavior sequentially. Such a tool can help the team to understand when and how to address these barriers. The alignment of barriers to phases can be used to map the existing customer data to the phases in the customer journey map and measure the effectiveness of individual strategies. Identifying phase-specific barriers allows us to strategize which interventions are likely to produce the most improvement in behavior.

In a practical scenario, when we have limited resources and aim to design in an iterative manner, such a detailed analysis provides an important advantage. It allows us to make evidence-based and data-driven decisions about new product or service development. It can also serve as a working tool for the team, a representation we can return to when we need to understand the impact and effectiveness of a chosen strategy or want to refine an existing product or service. Such an iterative process ensures that the product or service will improve the experience by addressing specific barriers that were identified in the analysis. Employing this representation, barriers can be prioritized and addressed in a sequential way, aligned with the arc of the experience itself.

5 Case study

We illustrate this process below with a simple case study to see how combining the COM-B method with customer journey mapping can improve decision-making and affects the design.

An insurance company offering medical and dental insurance wants to address the high risk of dental complications such as periodontitis among their diabetic membership cohort. They hire an agency to help them design a variety of product and service concepts to help these members. The concepts should support the company's business goal to reduce the number of expensive dental treatments, and thereby reduce total cost of care for members by delivering practical and effective preventative solutions that target these member's unmet needs.

We will illustrate our customer journey map/COM-B analysis method by applying it to this project. Steps 1 and 2 are essential parts of both methodologies. Step 3 is part of the behavioral analysis, while Step 4 is part of customer journey mapping. Step 5 is unique to combining the two methods.

Table 1 Process Steps

Step	Customer Journey Mapping	Behavioral Analysis
1 Literature Review	YES	YES
2 Qualitative & Quantitative Research	YES	YES
3 COM-B Analysis	NO	YES
4 Customer Journey Map	YES	NO
5 Combining the Customer Journey Map and COM-B Analysis	COMBINATION	COMBINATION

6 Methods

6.1 Step 1 Literature review

We begin by focusing on two major themes: (1) the disease and disease complications progressions, and (2) clinical guidelines and recommendations for effective interventions to address teeth-related diabetes complications. In the literature research, we learn that one of the best ways to prevent teeth-related diabetes complications is to have regular preventative dental visits.

6.2 Step 2 Qualitative & Quantitative Research

Even though our literature review identified regular preventive dental visits as a potential target behavior, we still need to learn the context for our target audiences — current and future health insurance members at risk for or having teeth-related diabetes complications — and assess their needs through primary research. In other words, we need to identify whether the potential target

behavior is currently prevalent among the health insurance members at risk, and if not, what are the reasons it is not happening. Qualitative research can help us understand the audience's unmet needs, identify the presence or absence of relevant risk factors, and capture audience-specific behavioral barriers and facilitators. For this case study, we chose to conduct interviews to gain this insight. A well-designed moderator's guide used to facilitate interviews should include questions about capabilities, opportunities, and motivations and prompt people to talk about those factors. Specific questions will include but not be limited to past teeth-related diabetes complications, dental care regimen and diabetes management routine, dental or specialist visits and any prevention or treatment recommendations. The insights from the qualitative research will be then aggregated in the final report with key findings and compared to the insights from the literature review.

We perform quantitative research to validate and prioritize issues to be addressed based on the target audience needs. This provides us with a better understanding of the impact a solution might have on the entire audience.

6.3 Step 3 COM-B analysis

At this stage, we can refer to the COM-B model to do a behavioral analysis of capabilities, opportunities and motivations. The benefit of performing a COM-B analysis with our target audience rather than relying solely on behavioral analysis insights from the literature review is that we can identify the factors most relevant to the audience we are designing for and prioritize designing for addressing those factors first.

We will start by looking at the data from our literature review, qualitative and quantitative research. The majority of insights about barriers and facilitators will come from the interviews with our target audience. Quotes, observations, and key findings from the interviews will be coded and mapped to COM-B factors (e.g. if respondents mention that they don't have a dentist or hygienist, it will be coded under the opportunity barrier as lack of environmental factor). Other insights about barriers and facilitators will come from the literature review and quantitative research. After synthesizing the data from all three sources, we can identify the key behavioral factors related to preventive dental visits that are lacking or missing from our target audience according to our research. So at this point we know what is lacking or missing, but we don't know their temporal sequence until we go through the next step of our process.

Table 2. COM-B analysis

Capability	Psychological capability	Lack of knowledge about the recommended frequency of dental visits for patients with diabetes
	Psychological capability	Lack of awareness of risk and potential timeline for developing teeth-related diabetes complications
	Psychological capability	Lack of knowledge of being at high risk of teeth-related diabetes complications (individual risk communicated by dentist or hygienist)
	Psychological capability	Lack of awareness of insurance benefits covering diabetic condition
	Psychological capability	Lack of awareness that teeth-related diabetes complications are preventable through care
	Psychological capability	Lack of understanding of early symptoms of diabetes and its progression
Opportunity	Social environment	Not having a dentist and/or hygienist
	Social environment	No social norm for regular dental visits among friends who have diabetes

Motivation	Reflective motivation	Lack of belief that teeth-related diabetes complications can be prevented
	Reflective motivation	Perceived insufficient dental insurance coverage
	Reflective motivation	No perceived need for dental visits
	Reflective motivation	Low perceived importance of dental care
	Reflective motivation	Overconfidence/over-reliance on the effectiveness of medication to manage diabetes
	Automatic motivation	Negative emotions associated with dental visits (pain, fear, anxiety)
	Automatic motivation	Fear of having to drill and fill their teeth

6.4 Step 4 Customer Journey Map

We will design services intended to address the barriers categorized in the COM-B analysis. Our qualitative and quantitative research tells us that most of the target audience – people at risk for or diagnosed with teeth-related diabetes complications – does not take advantage of the target behavior identified in the literature review: preventive dental visits. Our hypothesis therefore is, that a service to promote preventive dental visits could lead to better health outcomes. We go back to our qualitative research and analyze the interviews with members to understand how the audience currently relates to preventive dental visits and characterize the future state of the new service. The details are built up with our client during a customer journey mapping workshop to identify and prioritize service solutions. In the map, the phases and steps of the service are represented as a sequence with some cases of branching and loops, unlike the tabular format of the COM-B analysis.

We organize the map into four stages:

- Awareness of the program
- Onboarding to the program
- Attending a first preventive dental visit
- Attending regular preventive dental follow-up visits

We fill this in with the steps a member is likely to experience in each phase, then align a row of touchpoints with each step in the service. We add a row of actors to indicate who will be behind each touchpoint. Now we can see how the member will experience the service through phone calls, printed brochures and physical spaces, as well as who or what will be responsible for each customer interaction.

A customer journey mapping workshop is the opportunity to collaboratively address questions with our client's content-matter experts and develop answers that can drive the design of the new service. We can see where artifacts need to be created, a characterization of the staff needed to support the program, where the member-staff interactions take place, and how information about the members' condition will be captured.

Figure 2: The first phase of the customer journey map (see Appendix A for complete map)

The final result is a future state map (Figure 2) that captures the sequential steps of a new service. The alignment of steps in the member's experience (Patient) and the insurer's service staff (Insurer) with the touchpoints where members interact with the insurer's new service (Touchpoints) and the staffing needed to support the interactions (Actor) gives the team an opportunity to identify gaps in the planned service and opportunities to add member-facing and insurer- or provider-facing value.

6.5 Step 5 Combining the Customer Journey Map and COM-B Analysis

We introduce this step to explicitly integrate the COM-B Analysis with the Customer Journey Mapping process. By aligning the sequence of service features with the COM-B analysis of barriers experienced by our target audience we can visualize what has and has not been accounted for. For example, we align the perception of insufficient dental insurance coverage barrier with the Awareness stage of the customer journey map (Figure 3). The observation that the member does not experience social norming from friends who have diabetes for regular preventive dental visits aligns with the Attend Regular stage. Some barriers may align with more than one stage and one service feature may address more than one barrier. Some barriers will not be addressed at all by the services. For example, there is nothing in the onboarding phase to mitigate the member's fear of having to drill and fill their teeth.

Visualizing the alignment of the services and barriers, either during the workshop process or in the production of the final Customer Journey Map, helps the team refine the way services are designed to address the barriers to accomplish behavior change in the target population. In a systematic development of behavior change intervention, each of the barriers that we identify should be addressed using the appropriate intervention functions, policy categories and behavior change techniques.

Equally important, this visualization highlights the barriers that are not addressed by the proposed service. After the service has been launched and impact data has been gathered, the team can return to the customer journey map/COM-B analysis diagram and determine whether changes should be made to the design of existing service features or if features should be added to address previously-identified but unaddressed barriers. Performing rigorous process and impact evaluations of data collected about member interactions with the service allows us to focus on iterating only those aspects of the intervention that need be improved. The customer journey map/COM-B analysis diagram will have value beyond the initial planning, becomes a problem-solving and

decision-making tool for creating and refining new service offerings as it is updated and re-used to make iterations and refinements of services.

Figure 3: The first phase of the customer journey map combined with COM-B analysis (see Appendix B for complete map)

7 Discussion

We believe that combining customer journey mapping gaps and opportunities analysis with the Behavior Change Wheel framework COM-B analysis creates a valuable tool for both service designers and behavioral scientists.

The objective of this paper is to examine how we can systematically analyze and document the barriers to behavior and subsequently design potential solutions addressing those barriers by combining a COM-B analysis with the customer journey mapping process. While in the paper we focused primarily on presenting a collaborative analysis tool, the work of experience designers and behavioral scientists does not stop there. From this analysis, we need to develop detailed intervention strategies and specifications, covering all aspects of the intervention logic model, content, and delivery. The process that service designers and behavioral scientists follow from this point branches out. See Figure 4 for more details.

After identifying gaps and opportunities using customer journey mapping and mapping the COM-B barriers, service designers prototype the artifacts needed to build out a service, be they a website, mobile application, signage display or printed brochure; test the usability of those artifacts; then use that feedback to refine the service design.

After classifying barriers, behavioral scientists will go back to the BCW framework for a systematic development of behavior change interventions. According to the BCW framework, each of the identified behavioral barriers should be addressed using the appropriate intervention functions, policy categories, and behavior change techniques. The BCW framework currently encompasses 10 intervention functions, 7 policy categories, and 93 behavior change techniques (Michie, Richardson & Johnston, 2013). Specific capabilities, opportunities, and motivations are linked to certain

intervention functions that can be implemented through different features. Behavior change techniques are linked to the relevant chosen intervention functions.

In the future research, we hope to explore how service design teams and behavioral scientists collaborate on behavior change intervention development starting with a customer journey mapping/COM-B analysis diagram followed by application of the theoretically-driven BCW framework.

Figure 4: The alignment of stages/steps/opportunities with COM-B barriers can be used to integrate the Service Design and Behavior Science approaches.

Following the systematic theoretically-driven framework throughout the behavior change intervention development process creates the opportunity to incorporate evidence and insights from the research, design the intervention logic model and strategy that will increase the likelihood of an effective intervention, and generate findings that will contribute to the broader evidence base for behavior change.

8 Conclusions

As the problems that interdisciplinary teams are solving become more complex, our tools must evolve and become more comprehensive. Purposeful complex projects call for iterative design approaches.

In this paper, we present a way to visualize the relationship between two problem-solving methods: behavioral analysis using the COM-B model, and gaps and opportunities analysis using customer journey mapping. Combining journey maps and COM-B analysis in the design process helps to overcome the limitations of each method, while leveraging the advantages of each to create a more powerful behavior change solution. Our case study is a hypothetical example of the many situations where combining customer journey mapping and COM-B analysis can lead to a more thorough understanding of a problem space, and to the design of efficient, cost-effective behavior change interventions. Both methods are aimed at understanding the problem space and designing improved experiences. The differences between the two create a symbiotic relationship, where doing one type of analysis complements to the other, and vice versa.

Having a customer journey mapping/COM-B analysis diagram can be an important competitive advantage. Working on long-term interdisciplinary projects involves multiple hand offs, iterations and external/internal team collaborations. The customer journey mapping/COM-B analysis diagram creates transparency and allows us to see at a glance where the service touches the customer, and how each part of a service aligns with barriers that have and have not been addressed. Therefore, it can serve as a working tool that teams can come back to after testing and evaluation, to understand the impact and

effectiveness of chosen strategies, and evaluate the need to tackle unaddressed barriers. This hybrid tool supports evidence-based and data-driven decision-making and preserves insights frequently lost in the design process due to external business considerations. Presenting information in this temporal visual format helps the team prioritize and sequence the parts of the service.

To sum it all up, creating a systemic way of visually representing and analyzing gaps, opportunities and barriers to behaviors in a sequential way creates a unique tool that can be used by service designers and behavioral scientists to facilitate productive and efficient collaborations on projects that require complex problem solving – mapping out the front-stage and back-stage touchpoints and support systems for a service, and designing for behavior change.

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Appendix A: The First Phase of the Customer Journey Map

Concept Journey **Preventive Diabetic Dental Program (PDDP)**

PHASE	AWARENESS									ONBOARDING		
FUTURE STATE												
Patient	Patient experiences diabetic issues		Outreach from Acme Mutual Dental Program	Telephonic Dental Manager performs Dental Risk Survey.		Introduced to Preventive Diabetic Dental Program (PDDP)		Receive & Review PDDP Brochure	Discuss program details, transportation, and schedule	Enroll in 9 month program		Wait for first PDDP appointment date
Insurer		Acme Mutual notified of member diagnosis			Qualifies for Dental Prevention Programs		Mailer and Coordinator Call request placed				Scheduling confirmation sent to Dental Hygene Service	
Touchpoint	Diagnosis note	Claims screening	Phone	Phone	Risk Survey Results	Phone	Admin System	Brochure	Phone	Phone	Admin System	Home
Actor	Specialist	Claims Department	Telephonic Dental Manager	Telephonic Dental Manager	Telephonic Dental Manager	Telephonic Dental Manager	Telephonic Dental Manager	Mail	PDDP Coordinator	PDDP Coordinator	PDDP Coordinator	
SOLUTIONS included in the future state	Telephonic Dental Manager											
	Dental Risk Assessment											
	Preventive Diabetic Dental Program (PDDP) brochure											
										9-Month PDDP Program		

ATTEND											ATTEND REGULAR	
Receive appointment reminder call	Transported to dental office	Wait for treatment	Receive PDDP Home Kit	Discuss and set program goals		Review home dental treatment	Receive treatment; routine foot exam education, nail trim, wash & lotion		Session notes shared with attending Dental Hygienist		Review goals and progress	Re-enroll in next 9 month program
					Record session notes; goals & appointment dates			Record session notes; condition of gums				
Phone	Car	Waiting space	PDDP Info Kit	Waiting Space	PDDP Appt Journal	Dental Office	Dental Office	PDDP Appt Journal	Dental Office	Dental Office	Waiting Space	Waiting Space
Car Service	Car Service	Dental Hygienist	Dental Hygienist	Dental Hygienist	Dental Hygienist	Dental Hygienist	Dental Hygienist	Dental Hygienist	Dental Hygienist	PDDP attendees	Dental Hygienist	Dental Hygienist
First Meeting Protocol												
Personal Goal Setting Assessment												
PDDP Info Kit												
Appointment Journal												

Appendix B: The First Phase of the Customer Journey Map Combined with COM-B Analysis

Concept Journey **Preventive Diabetic Dental Program (PDDP)**

PHASE: AWARENESS → ONBOARDING

FUTURE STATE

Patient	Patient experiences diabetic issues		Outreach from Acme Mutual Dental Program	Telephonic Dental Manager performs Dental Risk Survey.		Introduced to Preventive Diabetic Dental Program (PDDP)		Receive & Review PDDP Brochure	Discuss program details, transportation, and schedule	Enroll in 9 month program		Wait for first PDDP appointment date
Insurer		Acme Mutual notified of member diagnosis			Qualifies for Dental Prevention Programs		Mailer and Coordinator Call request placed				Scheduling confirmation sent to Dental Hygene Service	
Touchpoint	Diagnosis note	Claims screening	Phone	Phone	Risk Survey Results	Phone	Admin System	Brochure	Phone	Phone	Admin System	Home
Actor	Specialist	Claims Department	Telephonic Dental Manager	Telephonic Dental Manager	Telephonic Dental Manager	Telephonic Dental Manager	Telephonic Dental Manager	Mail	PDDP Coordinator	PDDP Coordinator	PDDP Coordinator	

SOLUTIONS included in the future state

- Telephonic Dental Manager
- Dental Risk Assessment
- Preventive Diabetic Dental Program (PDDP) brochure
- 9-Month PDDP Program

Telephonic Dental Manager

During the telephonic conversation make members aware of the benefit, address concerns around insufficient coverage and make members aware of the importance of the special dental care.

Barriers Addressed

- Lack of awareness of benefit covering diabetic condition
- Lack of awareness that special dental care is important to prevent tooth loss
- Perceived insufficient dental insurance coverage

Dental Risk Assessment

During the telephonic conversation Dental Manager does the assessment to identify the need for Preventive Diabetic Dental Program (PDDP) and address the following barriers:

Barriers Addressed

- Lack of awareness of benefit covering diabetic condition
- Lack of awareness that special dental care is important to prevent tooth loss
- No perceived need for dental visits

Preventive Diabetic Dental Program (PDDP) brochure

Brochure includes description of the PDDP, step-by-step guidance on enrollement and post-enrollement procedures and addresses the following barriers:

Barriers Addressed

- No perceived importance of dental care
- Lack of knowledge about the recommended frequency of dental visits for patients with diabetes
- Overconfidence/over reliance on the effectiveness of medication
- Lack of awareness to risk and potential timeline for developing teeth-related complicatios

9-Month PDDP Program

Present the program of 9 monthly meetings, with up to 3 programs per 36-month period. Set goals to achieve within each 9-month period, along with the subgoals for each monthly meeting. Make it clear that people are encouraged to re-enroll at the end of the first Period to achieve new goals.

Barriers Addressed

- Lack of awareness that diabetes teeth-related complications are preventable through care
- Lack of awareness of benefit covering diabetic condition
- Perceived insufficient dental insurance coverage
- Lack of belief that diabetes teeth-related complications can be prevented

BARRIERS not addressed within solutions

- Fear of having to drill and fill their teeth
- Lack of belief that teeth-related diabetes complications can be prevented
- Lack of understanding of early symptoms of diabetes and its progression

- Lack of knowledge of being at high risk of diabetes teeth-related complications *(individual risk communicated by dentist or hygienist)*
- Not having a dentist and/or hygienist
- No social norm for regular dental visits among friends who have diabetes
- Fear of having to drill and fill their teeth
- Lack of belief that diabetes teeth-related complications can be prevented

Appendix B: The First Phase of the Customer Journey Map Combined with COM-B Analysis (continued)

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Co-designing Behaviour Change in Healthcare

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An emerging challenge in our research is that of understanding mindset and how it directs human behaviour. Literature reviewed of prominent models for the design of health behaviour change has been applied to two collaborative healthcare research projects, conducted in the context of a co-design methodology. The first focuses on the design of remote care for chronic heart and liver disease patients; the second on reducing the rate of hospital-acquired infection through changing hand hygiene behaviours. Issues that are collectively responsible for the deaths of tens of millions of people per year. Empathy studies highlight ingrained social norms, poor attitude, disengagement, low aptitude, disorganised and chaotic environments, and a strong motivational deficiency as drivers of adverse behavioural intention. It is suggested that this is a collectively consistent narrative, exposing a systematic behavioural breakdown between need and desire. Designers should be wary of the complexity and theoretical nature of behavioural intervention while understanding its ability to address interventional design's susceptibility to resistance and misuse. This paper situates these theories through the case studies and discusses how designers can better inform their practice when working within complex healthcare environments.

behaviour, co-design, health, empathy

1 Introduction

Why should behavioural change be a designer's problem? In a more generalised context, behaviour change is a foundational construct to improve the design and implementation of interventions addressing societal issues (Michie, van Stralen & West, 2011). Therefore, if we consider human-centric design, one of our key priorities should be to understand and design for behaviour. This paper will explore design for behaviour change in the context of designing healthcare devices and services. The first half of the paper will focus on establishing various prominent theories for health behaviour change, particularly Albert Bandura's social learning theory. Other theories – including Irwin Rosenstock's Health Belief Model and Ronald Rogers' Protection Motivation Theory – will also be introduced and discussed in the context of two current design research projects relating to healthcare delivery. The paper will discuss collective versus individual design, and the implications on outcomes and desired use. For example, if there is an expected pattern of use to achieve a

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desired result then it needs to be considered that this pattern can vary greatly across populations due to diverse cognitive learning models affecting the drivers and motivators from one individual to another. Design should involve consideration beyond the object or intended function, and how that object or function influences optimal or intended operation. Regardless of any segmentation, the diversity of individuals should be considered to design outcomes that achieve desired use for as large a population as possible. Through two health design research projects, we discovered that many of the issues were deeply ingrained matters of behaviour. This led us to design for health behaviour change, through exploring how we can apply these theories and methods to our ongoing practice in healthcare. The second half of this paper will investigate how two current design research projects – undertaken within the author's healthcare design laboratory – have used the findings from co-design-based empathetic research studies to recognise behavioural problems associated with: (1) compliance in hand hygiene, and (2) remote healthcare for chronic illness. The co-design methodology utilised by this lab applies empathy building as a tool to recognise and pursue systematic problems. The initial findings from these studies have led us to hypothesise that some design interventions misidentify the problem with causation that is symptomatic of a more complex problem. Further, behavioural intervention is discussed as a response to a deeper problem that is thought to influence the efficacy of any intervention. These ongoing projects have both benefited from this shift to an approach informed by behaviour change theory. With this paper detailing these approaches through the literature and these examples from practice, suggests the contribution that these case studies can make to other designers working in the design of healthcare systems, services and products.

Figure 1: hand hygiene co-design workshop including clinicians, nurses, behavioural scientists, designers, engineers, and industry partners.

2 Literature review: design for health behaviour change

Design for health behaviour change is not a new concept, yet our experience reveals that for many designers it is yet to feature prominently in their everyday toolkit. A review of various theories shows the prominence of behavioural intention and how change is strongly influenced by attitude, aptitude, social norms, self-efficacy, environment and motivation. Martin Fishbein and Marco C. Yzer's integrated theoretical model combines aspects from the theory of reasoned action (Fishbein & Ajzen, 1975), and social cognitive theory of self-efficacy (Bandura, 1991) in a more efficient

manner to assess aptitude and intent in behavioural development (Fishbein & Yzer, 2003). Fishbein and Ajzen's theory covers individual intent and estimated behavioural outcomes in relation to oneself, whereas Bandura's theory is a psychocentric approach that looks at how the environment, personal factors and aptitude all influence one another. Comparatively, Fogg's behavioural model is relatively simplistic, focusing heavily on motivation and strategies to minimise ability barriers (Fogg, 2009). While other more modern theories exist, this paper focuses on the application of Bandura's original social learning theory and four-pillar model as a relevant means to measure the ability of a designed outcome to effect desired behavioural change. Each model represents an underpinning of design and cannot guarantee success; therefore an initially speculative, and then iterative, design phase will equally allow for the modification of a behavioural design strategy. This section will review Bandura's social learning theory and discuss the impact of a number of design strategies, including Bandura's four-pillar model and various persuasion tools, on design practice. It should be noted that the following theories and tools are well established in discussion between design and behaviour – for example, in Monique Boekaerts Handbook of Self-Regulation. This paper relates these tools and strategies to examples from our own design practice, while assessing the efficacy of a co-design methodology as a tool to drive design for health behaviour change.

2.1 Bandura's Social Learning Theory and how empathetic research can reveal a different design problem:

Our projects in healthcare design have all employed an empathic co-design methodology, a methodological approach that can be further informed by Bandura's social learning theory. Co-design methodology is strongly interdisciplinary, so as 'to bring the people we serve through design directly into the design process in order to ensure we can meet their needs and dreams for the future' (Sanders & Stappers, 2012, p. 14). Empathy building is an ethnographic research tool that can help designers define problems. A key pillar of empathy building is storytelling through stakeholder interviews and environmental observations, enabling us to draw a rich picture of individual and collective circumstance. Self-immersion into people's lives generates insights, questions, and issues distinct from the elicitations of any quantitative data. We find co-design to be particularly suited to healthcare design since the object of design (a service, experience, product, system or environment of healthcare) is generally unfamiliar to a designer. Designers do not use surgical tools on a daily basis, consult with inpatients and outpatients, nor understand the operational flow of a surgical theatre with any strong authority. Peter Lloyd discusses the limitations of participatory design in the context of need fulfilment and value creation. Lloyd argues that democratisation of groups will result in averages, and therefore the value in 'meeting an average need to a consumer is questionable' (Lloyd, 2004). Lloyd's ideas are strongly premised on the design of consumer objects – such as electronics – and are perhaps less pertinent in this context yet it could be argued that the role of iteration in any methodology should provide a sharp reduction in the average and therefore a higher likelihood of value creation. In this instance, it is through this process that a complex problem emerges that is easily overlooked by other problem-solution methodologies.

Albert Bandura's social learning theory suggests that behaviour is controlled by learning as a cognitive process taking place in a social context (Bandura, 1977). Learning may occur through direct observation, direct instruction, or through vicarious reinforcement – that is, under the guise of consequence as reward or punishment (Grusec, 1992). For example, if behaviour is continually rewarded, it is more likely to continue; whereas if behaviour is persistently punished, it is more likely to cease (Renzetti, Curran, & Maier, 2012). This lends itself to the role of motivation and the drivers that help decide whether any passive or impassive cognitive action is taken. Without motivators, or the drivers of desire to take action, anything expected or intended can be susceptible to failure (Keller, 1987). Yet, as Bandura and Richard Walters conclude, the principles of social learning theory show that learning may still occur without any change in behaviour. Therefore, we might suggest that just because a person identifies with or understands the intention, purpose and aim of a particular design through observed learning, in the short or long-term they may still lack the

behavioural influence to act as intended by that design. For example, our empathy research has shown that despite strong intentions and procedural understanding of the 'five moments of hand hygiene', planned behaviour can fail to translate into reasoned action. In alignment with more recent findings, we hypothesised that an intention to act does not necessarily lead to an act (Sax & Clack, 2015); and suggest that design should focus on motivation and habitual behaviour. The indication is that behaviour is distinct from learning and instead is influenced by reinforcements (Bandura & Walters, 1963). We might add that behaviour is in fact a product of desire and motivation, and if neither of these exist to perform a particular action then occurrence will reduce or cease entirely. Accordingly, if the aim is to improve behaviour over time – particularly addressing negative habits and routines – then the emphasis should revert back to the underlying learning model of the design to help identify what is leading to failure. The empathy study identifies a pool of causal areas – it is these determinants of optimal short and long-term interaction with any product, system or process that need to be understood (Michie, Johnston, Francis, Hardeman & Eccles, 2008). Nevertheless, the ensuing interventional design is unlikely just a learning or behaviour, but rather a product, system or process that is designed in such a way as to affect learning or augment behaviour. Causal learning and behavioural issues should be articulated as a set of 'call-to-actions' that stipulate what is required of the design. Effectively, these can be treated as functional requirements within the design specification.

2.2 The four pillars of observational learning and how to utilise this effectively for design:

If we are to design for behaviour, then we need to recognise the mental processes that control observation as the impetus for change, and understand how these processes are translated into design strategies. As already alluded to, observation is fundamental to learning, and there are numerous mechanisms that dictate whether observation of exhibited behaviour will occur or not. Again, Bandura and Walters identify four key cognitive and behavioural processes that dictate our ability to learn through observation including attention, retention, reproduction and motivation (Bandura & Walters, 1963). The four pillars are co-dependent and rely on other factors such as cognitive ability. For example, pillar two's reliance on memory is possible to the extent of the individual's capacity for, and ability in, memorising information. This model could be embedded within the co-design methodology as a scoring matrix to pre-emptively assess the validity of a design prior to testing and implementation. Weightings may be applied to each criterion depending on the nature and emphasis of the proposed intervention. Although the principles collectively remain the same, it is important to recognise that each individual's needs and desires are different, and, despite granular segmentation, it is often difficult to cluster due to the infinite variance of individual motivation and desire. Therefore, choice and optionality via mass customisation can provide users with more personalised and engaging experiences.

2.2.1 Sensory priming:

More collectively, users must be drawn to interact with a design (attention), and then guided or persuaded to act in the way that is intended (motivation to remember and reproduce). Sensory priming could utilise any of the human senses, but needs to be used in a manner that directs the desired behaviour. 'Psychological priming is the process by which the exposure to certain cues (e.g. words, smells, or images) alters behaviour without the person being aware of the impact of the cue on their behaviour' (Bargh, 1992). This process causes a certain reaction in memory immediately before carrying out a task or action. Two examples of this relate to our hand hygiene research. In one instance, the aim was to artificially mimic the physical auditing process, which we knew from our hospital study, formed feelings of being watched (attention, retention and motivation). King et al. recreated this by placing stickers printed with a set of human eyes on alcohol based hand rub (ABHR) dispensers around the hospital ward as a visual prompt to hand wash. Since there was no auditor present, nor any way to track actual performance, the design relied on the user's vicarious reinforcement system around consequence to elicit compliant action (motivation and reproduction).

This study was extended to test the olfactory system using a citrus smell emanating from ABHR dispensers that can cue association with a feeling of cleanliness. The results showed a 31.9% improvement in use above the baseline compliance rate of 15% (King et al., 2016). The issue with auditing – whether real or artificial – is that it is a form of forced compliance. The design of interventions for hand hygiene and the virtual hospital must gravitate towards unforced action that is driven by understanding and motivating desire, otherwise it can be susceptible to resistance.

2.2.2 Emotional motivation:

Emotional motivation is another approach that aims to elicit a cognitive response via the vicarious reinforcement system. Prominent examples such as QUIT smoking, Worksafe, Drinkwise and the Transport Accident Commission (TAC) road safety campaigns tend to effect social change via shock visual media – a strategy known colloquially as shockvertising. The long-term success of this strategy has been well documented by the TAC's prominent, long-term seat belt safety campaigns (attention and retention through long-term reiteration). Since legislative inception in 1970 to 2014, seat belt use has risen to 98% (TAC, 2014). The TAC slowly changed unsafe behaviour through memorable media, reinforcing the notion that humans are vulnerable and susceptible to mistakes. Some of the hand hygiene interviews identified strong self-interest and an affinity to immediate family rather than the wider population. The opportunity here is to use media in a manner that highlights the potential impact of poor hand hygiene practices on an individual's own interests (self and family). Our virtual hospital research found poor diet to be a major contributor to the perpetuation of disease. Barriers include education, cultural dynamism, and accessibility. We can learn from past examples – such as the Heart Foundation's 'tick of approval' labelling system – to constructively educate and change strongly ingrained habits. The assumption is that any ensuing motivated action could not only reduce the risk to themselves but their family and, in some instances, the wider community.

2.2.3 Behaviour and unintentional outcomes:

Similarly, mindful design, design for healthy behaviour, community or collectivist social marketing, and socially responsible design each utilise more altruistic and collectively-minded persuasion techniques, but can be altered to integrate underlying individual, political and social agendas. Even the unintended effects of a design – those beyond the immediate use and function (Tromp, Hekkert, & Verbeek, 2011) – can, to the general user, be unknowingly deliberate to serve another 'higher purpose'. Langdon Winner's topical paper discussed this phenomenon using the now well-known example of the low hanging overpasses in Long Island, New York, that are thought to deliberately obstruct public transit buses from accessing Jones Beach. The consequence fell on those who relied on public transport – a higher majority from low socio-economic backgrounds. The suggestion is that this was a political manoeuvre to restrict access to Jones Beach to car-owning individuals, who at the time were from predominantly white, middle to upper class neighbourhoods. The darker underlying purpose was to perpetuate inequality (Winner, 1980). To use a less negative example, Bruno Latour describes the varying collective and individualised effect of inscriptions on more unassuming objects in the context of prescriptions (affordances or actions intended by the object) and subscriptions (how users interpret the prescriptions) (Latour, 1994). The 'slow down to be responsible' inscriptions on speed bumps are thought to lead to a collectivist 'slow down to be safe' prescription, and an individualised 'slow down to avoid damaging my car' subscription (Tromp et al., 2011). The park bench is another example that highlights the seemingly innocent object as a source of social contention, in this case around unintended use and the ability of homeless people to utilise the bench as a bed (Rosenberger, 2014). Our own research into hand hygiene compliance auditing showed how a Hawthorne effect can lead to false positives.

2.2.4 Managing collectivism:

The notion of collective versus individual strategies brings to bear the associated consequences of pursuing one over the other. Despite the lack of personalisation – which will not appeal to some – a collectivist approach could have a herding effect. While society is made up of individuals, the

collective power of small individual contributions towards a mutual goal can be a powerful tool for political and societal change. Conformist influence is a persuasive tool that reinforces the behaviour of a larger group via the actions or directions of a higher entity – perhaps a political entity (Simons & Jones, 2011). Therefore, the strategy is to persuade a larger majority to conform to certain behaviour by highlighting the value of small individual successes as part of a larger collective success. This may galvanise interest and desire, aiding longer-term assent to better behaviour (Izuma, 2013). Similar to the findings of a 2010 study, the design of social campaigns, including direct or indirect messaging to promote certain actions and behaviours (Wakefield, Loken & Hornik, 2010), may be pertinent to our hand hygiene and virtual hospital research. Alternatively, this can result in mindless and disassociated imitation that is devoid of learning or motive understanding.

At the very least, a common good approach such as this is consequentialist and still highly subjective. What is positive to some may not be to others, and therefore such a strategy is strongly susceptible to more utilitarian and egoist views of self-interest, and should therefore be expected and addressed. Further, reliance on heuristic and bias-based strategies are weak since it takes only a few influential leaders to change direction and turn their own and others' positive behaviour into negative behaviour. We have seen prominent examples of hierarchical leadership in the hospital environment and susceptibility for one's negative behaviour to influence personnel down the chain. Change needs to be underpinned with learning that enables people to understand the reasons why their behaviour is positive or negative. It is therefore advantageous to utilise herding secondarily as an attention strategy only, and instead focus on changing behaviour individually in a manner that is resistant to pack mentality and less dependent on what others think, say or do. We might leverage the tendencies of some people toward self-interest via the use of persuasion tactics, such as mutual benefit or vicarious reinforcement.

3 Design case studies:

The literature points to the potential of health behaviour change models to contribute to and inform approaches to co-design projects in healthcare. This is investigated through the application of these theories to two healthcare design projects; a project exploring hand hygiene compliance, and another investigating hospital care in the home.

3.1 Hand hygiene project:

3.1.1 Project background:

Evidence indicates the global cost of hospital acquired infection (HAI) is between USD$35.7–45 billion (Scott, 2009), and the World Health Organisation estimates that there are 80,000 deaths per year attributable to HAI in the United States alone (WHO, 2017). In perspective, HAI accounts for 5-10% of admission complications in developed countries and, in contrast, this figure increases between two and twenty times in developing regions, with some countries experiencing an HAI child death rate of 4,000 per day (WHO, 2017). Numerous approaches have sought to address hand hygiene compliance including: education and awareness, monitoring, product and system improvements, environmental initiatives and infrastructure (Pantle, Fitzpatrick, McLaws & Hughes, 2009). Yet the problem shows no signs of abating (Pincock, Bernstein, Warthman & Holst, 2012), and the socio-economic burden of HAI persists.

Figure 2: hand hygiene co-design workshop – developing and testing system and environmental scenarios.

3.1.2 Research and methodology:

Our work on hand hygiene stems from a larger issue surrounding infection control, and how design-led research can identify problems and affect improvements through enhanced user experience, product or service design. Nevertheless, the discovery phase of the project provided greater insight and re-directed the thinking to a foundational problem of behaviour. The research involved a qualitative hospital study to extract stakeholder insights that inform an ensuing design activity. The research team observed and interviewed staff in an intensive care unit (ICU) and several general medicine wards, focusing on traffic flows, clinical and administrative interactions, interface between people and objects, as well as infection control procedures involving clinicians, nurses, cleaners, administrative and management staff (see Figure 3). Auditing was heavily scrutinised since we knew from national compliance data which clinical demographics performed hand hygiene poorly (clinicians were least compliant with an average 72.5% (52,631/72,595 moments performed) (HHA, 2016). However, if you compare people to context the results are different. Compliance in invasive settings is almost flawless, while wards see a comparatively sharp fall. It is suggested in the aforementioned studies conducted by King et al. that due to the Hawthorne effect during the audit process these numbers only capture a small snapshot of compliance. The real compliance rate may be significantly lower. The cognitive effect of being watched is similar to other examples of sensory determinants of behaviour. While these examples can provide an explanation for falling compliance, it may reveal the learning model that can be actioned and integrated for a new design intervention to ameliorate compliance. Sensory determinants are triggered by stimuli in the surrounding environment; but from that point forward there are other mechanisms and drivers that determine whether any action is taken, either positive or negative.

Figure 3: ward round observation – behavioural interaction with objects (i.e. hand wash stations), level of intermittence and associated barriers.

A key insight from the hand hygiene research was one of the first and more consistent barriers relating to the use of mainstay hand hygiene methods including ABHR, and soap and water. While there was also confusion as to why one method was used over the other, an interesting aspect related to the visual determinants of behaviour, and why staff wash their hands regardless of method. The suggestion was that hand washing was dictated by a state of visual or tactile cleanliness. In this instance, the action of washing hands is controlled by a sensory primer – feeling or seeing soiled hands. The drawback is intermittence and failure to recognise the often unseen and unfelt bacteria carried into patient bed areas. Sensory priming is already an issue here, exposing the lack of learning and reasoning for hand washing, and emphasising that behavioural design strategies should be unique to each circumstance. Consequently, we could reactively design for greater visualisation, or challenge the problem of risk recognition. Further analysis of this account indicated a lack of accountability or traceability of infection transmission back to poor hand hygiene practices by specific individuals; leading to a breakdown of direct risk relationship, and making the enforcement of hand hygiene an acute compliance issue. The lack of traceability was a direct result of the invisible nature of bacterial transmission, breaking the visual feedback loop that relates to problem identification. This finding was consistent with Hand Hygiene Australia survey data that identified visual cleanliness as one of the five major barriers to hand hygiene.

A past intervention was revealed during the interviews with administrative staff. A long-standing ward-clerk described a one-time educational experience conducted by the infection control team in 2010. A group of nurses and administrative staff were given a hand washing demonstration and asked to replicate. When complete, they shone a blacklight over each participant's hands to reveal missed areas. Consistent with the Hawthorne effect, many exerted extra cleaning effort due to peer

scrutiny – yet, in almost all cases, the blacklight still revealed suboptimal cleaning. Many participants reported their disgust knowing this result has likely persisted for some time. The behavioural shift was an almost obsessive compulsive desire to hand wash. In this instance, we can hypothesise that visual and experiential shock has created a link between action and consequence driving a change in behaviour. This is an example of the complete embodiment of the four pillars, including attention (shock), retention (visualisation of the bacteria), reproduction (shock and disgust), and motivation (desire to improve safety for themselves and others). This hypothesis is further substantiated in a 2016 study, which tested the long-term change in compliance of individual wards by comparing a grown culture sample from each staff member's hands (collected prior to commencement) to a graphic book of cultured bacterial images (Gregory, Chami, & Pietsch, 2016). Each ward group was exposed to the comparative images over a 10-day period with compliance rates actively audited. At the conclusion of the study the wards showed average improvements between 8.3% and 38.9% (see Figure 4). Yet the most significant finding was the post-test compliance audit, conducted six weeks after the initial 10-day study. Ward 3 initially improved 16.7%, however post-testing revealed sustained improvement, rising by a further 30.9% at the end of the two months. Similar to the blacklight experience, it is likely that the visual imagery has had a memorable impact on habitual learning, by installing a cognitive trigger to hand washing linked to a shock memory. In turn, the shock memory has established bacterial transmission as a higher ranking threat, appealing to the vicarious reinforcement system associated with punishment, and leading to more positive engagement with hand washing procedures. Therefore, the mental model has become more ingrained as a longer-term improvement in hand washing behaviour (Gregory et al., 2016).

Unit	Benchmark Goal	Pre-Intervention Compliance Rate for Last 2 Months of Data	Mid-Way Compliance Rate (8/21/2015)	Completed Compliance Rate
I1	80%	47.4% (June & July)	58.3%	58.3%
F6		50.0% (June & July)	58.3%	68.4%
C6W		33.3% (May & July)*	50%	80.9%
B1		50.0% (April & May)*	88.9%	68.8%

Figure 4 Education and Competencies. Source: Gregory et al., 2016

We can suggest that most people are influenced by visual stimuli that can alter their mental models. Yet the notion of selective perception theorises that 'individuals select, organise and evaluate visual stimuli from their environment to provide meaningful experiences for him or herself' (De Mooij, 2013). This might indicate that conscious visual awareness is subject to individual perception; and by extension what is impactful to one may not be to another. Exploring this further, if you have a universal problem that is not isolated to any person or group, then there are strategies aimed to elicit a collective reaction and, by extension, the opposite is possible for minorities or individuals. The shockvertising method uses violent, repulsive, confronting, lewd, terrifying, controversial, offensive, or politically incorrect images, scenes or videos to illustrate a negative outcome or a worst case scenario brought on by dangerous habits or antisocial behaviour (Parry, Jones, Stern, & Robinson, 2013). The example discussed in Figure 4 – while leading to a positive result – is not a practical means to change behaviour across a collective healthcare environment. The key insight from these examples is not shock imagery but rather the use of certain stimuli to attract attention and influence learning. The next step in the design phase is to experiment with varying stimuli and feedback methods to test behavioural resistance to hand hygiene.

Distinguishing between present (sub-optimal) and future (optimal) patterns of behaviour can affect the method and application of behavioural design. For example, hand hygiene compliance at present may be forced or unforced, and may or may not be performed regularly. We can see multiple issues here, and this can be the case for all design problems. Therefore, strategies for the design for health behaviour change need to be adjusted and applied to the correct problems.

3.2 Virtual hospital project:

3.2.1 Project background:

The Virtual Hospital Project aims to develop remote care for chronic heart and liver disease patients. The current healthcare system is not adequately equipped to digitally manage the needs of rural patients, and therefore the burden on the system and patient is significant. The WHO estimates that as of 2010, heart disease accounted for 17 million deaths per year with an associated annual global healthcare cost of $863 billion (Kelland, 2011). Using compound annual growth rate (CAGR) modelling – this cost is forecast to rise to $1.044 trillion by 2030 (WHO, 2017). To add significance, the sum cost over the next 20 years could exceed $20 trillion. For liver disease, the burden stemming from cirrhosis, hepatitis, and cancer accounted for more than two million deaths in 2010 (Byass, 2014), with some estimates that in Australia alone more than six million people are affected by liver disease, with the direct and indirect costs exceeding $51 billion in 2012 (Economics, 2013). This paper will introduce some key insights from an in-depth empathetic study that reveal unique challenges associated with a confronting illness. Analysis will introduce other concepts, including Ronald Roger's protection motivation theory that will assess the notion of threat appraisal relative to declining health and the barriers to recognition, acceptance and positive control.

3.2.2 Research and methodology:

Similar to the hand hygiene project, our design research into remote healthcare – virtual hospitals – needs to draw on an understanding of behaviour change. The virtual hospital project – in collaboration with a major Australian hospital – is an experiential initiative to identify how to design remote care for chronic disease patients and the scope of this study was limited to chronic liver and heart disease patients. Analysis of the early background and competitive landscape findings helped categorise existing offerings into four segments, ascending in order of complexity and efficacy:

1. virtual information and diagnostic systems (access to online information, data libraries, blogs and forums);
2. online medical consulting services (greater accessibility particularly to rural and low socioeconomic areas);
3. discontinuous virtual monitoring (limited home monitoring supported by a central hospital hub); and
4. autonomous real-time virtual monitoring (full-time at-home virtual monitoring via smart devices that may digitally diagnose or provide real-time feedback on issues as they occur).

This preliminary categorisation helped focus the attention towards finding failures and areas of opportunity in the ensuing empathetic research.
The hospital-based empathy study was a deep dive into the lives of some highly complex patients. The issues extended beyond the directly related causal issues of their disease and include five key areas:

1. lifestyle (exercise and support systems, and diet including medically diagnosed intolerances as well as self-enforced dietary philosophies);
2. culture (varying ethnic and religious backgrounds are strongly interdependent on other problem areas listed here);
3. logistics (geographic circumstance, transportation and the added effect of disability);
4. cognition (capacity and capability – understanding and willingness to embrace one's diagnosis – trust and rapport with medical support networks); and
5. language (varying across ethnic and cultural backgrounds and how this is managed and provided for in current practice versus the implications for remote healthcare).

The immersive experience was both visual and verbal, and provided access to clinic-based interviews within the hospital, as well as selected home visits (see Figure 5). The studies gave a state-of-life snapshot of each patient, giving detailed insight in to their lives as people and patients. The at-home environmental experience was different to the sterile, professional confines of the outpatient clinic

where we had earlier conducted interviews. Their comfort and control at home was evident with evocative storytelling describing their 'new normal' in light of their changing health circumstance. This experience provided the foundational data to identify the drivers behind the four pillars of learning for a diverse group facing the common threat of a potentially life-limiting illness.

Figure 5 virtual hospital empathetic research study – patient at-home interviews and observations producing journey maps and routine based touch point data.

3.2.3 Storytelling and empathy building:

A particularly illuminating opportunity presented itself via the lead clinical champion for this project and the lead clinician for a now deceased patient. The introduction was to the daughter of the deceased who had, during his illness, became his full-time carer. She described her experience in detail, sharing photos and stories. We learnt of the toll that caring for a parent had on her life. She had become an expert in her father's chronic disease, and this had an interesting effect. In one way, she learnt to navigate the often complex and confusing doctor-patient experience that would become routine; in another, it was debilitating being the pseudo-medical translator for her family. Providing answers was an undesirable by-product of devoting herself to full-time care. Upon her father's eventual transition to palliative care, he asked some simple yet poignant questions: 'Why is the experience better when palliative care stepped in? Why do you have to die to have a better experience?' She described the nuances surrounding public versus private care, with particular focus on the mutually frustrating experiences across healthcare. The lack of personalised care and empathy, the exasperation of exhaustingly long hospital visits that increasingly felt reminiscent of a factory. We extracted huge amounts of raw insight from her experiences; particularly what was difficult, trying and unsatisfying. The hospital aims to extend life and yet, in many instances, usurps much of this extra time in unnecessary inefficiencies, leading to frustration and disengagement in the system. At the core of this project is remote care and the ability to provide life-extending medical care with vastly reduced contact. Yet, just because technology exists, doesn't mean people want to use it; rather, they must be willing and educated. If we do not address the willingness, desire, motivation and ability, then the current experience will be much the same as the future experience.

Figure 6: virtual hospital co-design workshop including clinicians (cardiology and gastroenterology), nurses, carers, behavioural scientists, designers, engineers, and industry partners.

3.2.4 Behavioural design analysis:

The relative complexity of this project is strongly multifaceted, including the intricate natures of healthcare, systems and technology, as well as the endless behavioural variance among patients and people connected to healthcare. As discussed, the primary test is not just to identify and design for one individual, but rather designing individualised solutions for the collective. The empathetic research study highlighted numerous cases of ambivalence, disengagement, poor understanding, frustration, loss of trust and rapport, difficulty embracing or accepting diagnosis, and a loss of control and proactivity. There is an excessive reliance on the healthcare practitioner to manage the patient, with some patients reporting a state of detached agreement during consultations despite a complete lack of understanding. Yet, due to the complex circumstance of today's healthcare system, the responsibility is difficult to place. Clinicians (in many of the cases observed) lack the time, drive, tools and ability to communicate on an individual level; while many patients fail to recognise that they must play a role in their own care. It is proposed in this paper that under a consumer-driven model, healthcare from a patient's point of view should be transactional and treated like any other service. Self-regulation may be a helpful strategy to learn, accept and then take control of one's disease management. Boekaerts defines self-regulation 'as a sequence of actions and/or steering processes intended to attain a personal goal' (Boekaerts, Zeidner, & Pintrich, 1999). In other words, the hypothesis posits that self-regulation is the process to control one's behaviour over time and across different contexts to accomplish a set of goals (Boekaerts et al., 1999). This links to a slightly different model of health behaviour to that of Bandura. Rosenstock's health belief model (Rosenstock, 1974) as well as Rogers' protection motivation theory (Rogers, 1975), engages the significance of 'threat appraisal' when deciding to change behaviour. Boekaerts describes threat appraisal as 'a combination of perceived susceptibility to a certain disease (e.g. lung cancer) when continuing the current, unhealthy, behaviour (e.g. smoking) and the perceived severity of that particular disease' (Boekaerts et al., 1999). Yet, as observed during our research, there is a circumstantial breakdown in reception to a diagnosis, leading to delays or barriers to the strategy of self-regulation.

Equally, there are ways to reimagine the doctor-patient relationship to reduce instances of disengagement and negate the loss of patient control. B.J. Fogg discusses persuasion technology as a

means to influence decision-making and engagement with design, and outlines the seven core persuasion tools: reduction, tunnelling, tailoring, suggestion, self-monitoring, surveillance, and conditioning (Behringer & Øhrstrøm, 2013). Increasingly, these persuasion techniques have become digitised and today feature prominently online. For example, Amazon utilises suggestion via their recommendation system to buy more books and other products; CodeWarrior.com uses a reduction strategy to simplify and promote learning how to write code; and various software companies use tunnelling during the user installation process to lead people through a series of stepped actions or events that often integrate advertising (Fogg, 2002). A reductive and tailored approach could be explored to address some of the initial and enduring side-effects of patient-doctor disengagement and misunderstanding that were prominently exposed during the virtual hospital research. These are examples of the broad areas of focus in remote care for chronic illness and how behaviour needs to play a significant role in the design of products, systems and processes.

4 Conclusion

This research, while utilising mainstream design discourse, including co-design, is equally an exploration into behavioural design as an experiential practice of informed trial and error. By shifting the mindset of the designer to consider how observation leads end-users to learn (relative to cognitive ability), and the ensuing drivers and motivators to retain and implement better practices, the intended use of a design may be more successfully followed over the long-term. The correlation between forced action and the relative susceptibility to resistance, and thus the failure of a design, identifies that some people are less receptive to instruction. Therefore, following Bandura's social learning theory, we can look at different ways to design such as persuasion, vicarious reinforcements, or the constructs of another theory for health behaviour change. Applying end-user empathy building as the data source is a provocation for change, through the exposure of shortcomings and the ambivalence and failure of existing solutions. The inclusive nature of end-user immersion leads to stakeholder engagement and relationship forming that can reduce siloing, and provide an opportunity to take people on a journey through the co-design framework. It is reassuring as an end-user to know that a fellow end-user was involved and given a voice in the design process, which – as suggested by several interviewees in our hospital studies – is a peculiar proposition to front-line staff in historically hierarchy-led organisations. Therefore, there is a strong argument that a co-design framework should form the overarching approach for experiential design to enable a robust behavioural investigation to take place. We speculate that using co-design methodology can more easily identify and distinguish problem from causation and, using key behavioural design methodologies, design solutions that fulfil a pre-determined and desirable outcome. This co-design approach can be meaningfully enhanced by understanding the fundamental behaviour change literature, to create a more robust approach for the design of behaviour change in healthcare.

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Designing for Lifelong Sports Experience

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In recent years, design for behaviour change by means of design and technology has been the focus of a large body of research. Advancements in personal informatics systems and applications of these in research have testified to the potential of design for behaviour change strategies in the context of sports and exercise. However, these efforts have been mainly focused at people who are new to sports and not so much at people who are already active. With the success of design for behaviour change studies, this group of more active users (i.e., *active exercisers)* with an interest in personal informatics has grown. The needs of this group of users are different from those who are unable or unwilling to change their activity behaviour. While the latter might lack knowledge and motivation to change behaviour, active exercisers are already motivated and are willing to stay physically active. Thus, this paper draws out the need and importance of a shift in the focus of designing for physical activity tracking, and discusses the significance of designing for lifelong sports experience.

active exercisers; behaviour change; design for sports experience

1 Introduction

There are many different reasons for people to be physically active. These relate, but are not limited to, emotional beneifts of exercising (e.g., feeling immersed or absorbed in the physical activity), social benefits (e.g., getting social support or praise from others), benefits of interacting with nature (e.g., seeking out suitable or motivating places to go for exercise), and health related benefits (Silvestri, 1997). In addition to these sources, people may also become motivated to start exercising as a resultant of new technologies entering the market such as smart watches, apps and dedicated health devices. Such personal informatics can serve as persuasive or supportive tools, aimed at helping people to "self-track, collect and reflect on personal information" (Li, Dey, & Forlizzi, 2010). Activity trackers are a type of personal informatics that either assist people to keep track of the number of steps they take (for example, by nudging them when they fail to take 10K steps a day), or help people to keep track of and reflect on their physical activity at more advanced levels. In the last decade, designing activity trackers to create awareness on the importance of physical activity (and increase physical exercise accordingly) has been a topic of considerable interest to (design)

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researchers (Li, 2009; Lin, Mamykina, Lindtner, Delojoux, & Strub, 2006; Rooksby, Rost, Morrison, & Chalmers, 2014).

Taking the Transtheoretical Model of Behaviour Change (TTM) (Prochaska, Redding, & Evers, 2008; Prochaska & Velicer, 1997) as starting point, physical activity behaviour change studies are directed mostly at changing behaviour of people who are at the early stages (mostly contemplation and preparation) of TTM. According to TTM, people pass through 5 stages of change. People start out from a pre-contemplation stage at which they do not even think of changing their behaviour. Next, they move through contemplation and preparation stages at which they gradually start thinking of changing their behaviour. If they pass through these stages and decide to change their behaviour, they take action (action stage), sustain the desired behaviour (maintenance stage), and finally come to a durable behaviour change.
Adoption and maintenance of physical activity has noteworthy life-long health benefits (Marcus et al., 2000). Thus, making people aware of their own behaviour, by giving personal information (i.e., about their physical activity level) and motivating them to adopt a healthier lifestyle (i.e, to become more active and move to action stage) is of great importance. However, although many potential exercisers seem to adopt new products and technologies in their lifes, there is limited evidence that adoption also leads to sustained behaviour change (Hermsen, Frost, Renes, & Kerkhof, 2016). Physical activity becomes a more planned and structured endeavour for those people with an aim to improve and maintain their physical fitness. They became more willing to join sports competitions, even though they do not have a chance to win (Araújo & Scharhag, 2016). However, regardless of their strong desire for durable change, this group of people is prone to relapse (Marcus & Simkin, 1994). The question thus becomes how to support this group of *active exercisers* through technology and design. This growing group of users is the one that we focus on in this paper.

2 Research Question and Aims

Although the one of the aims of activity trackers is to change people's behaviour, when people move to the action and maintenance stages of behaviour change process, these products become less useful to them. The main reason behind this shift is that when people start to be more active, the motivational needs of these people change as well (see Ludden & Hekkert, 2014). Data-based needs of these people differ from the people at the early stages of behaviour change, and they may need or want more information about their exercise behaviour than the number of steps taken. As a result, active exercisers seek for more advanced products to help them improve their performance and show their improvement (Kuru, 2016). Therefore, the technology should also shift the focus from merely informing the user about the collected data, to analysing it and turning these data into valuable knowledge for the users.

In sports science and psychology, there is a large body of knowledge on training and athlete behaviour. Generally, this knowledge has been applied to consumer products and applications. Designing for the last two stages of change is relatively new compared to physical activity motivation studies. This research area is open to contribution of designers who can specifically target challenges faced by active exercisers. These include external challenges such as weather conditions and work load, and internal challenges such as injuries and pregnancy. However, many of the activity trackers that are now available on the market do not respond adequately to changes that people might undergo after becoming more active. This paper draws attention to the changing needs of active exercisers by discussing the challenges of designing for active exercisers, and analysing how current knowledge in sports science and design for experience might contribute to designing for this particular group. Based on our analysis, we will propose research directions for designers to empower active exercisers to engage in lifelong training. Following up on these research directions, this paper takes the first step towards the development of design requirements to engage active exercisers with both the physical activity itself and product use to sustain flow experiences in both activity and product use.

3 Challenges of Designing for Active Exercisers

It is apparent that activity trackers are motivational tools for a majority of the users (Sullivan & Lachman, 2016). However, several researchers have shown that these devices are often abandoned after relatively short periods of use (Lazar, Koehler, Tanenbaum, & Nguyen, 2015; Shih, Han, Poole, Rosson, & Carroll, 2015; Sullivan & Lachman, 2016). Most of the less active people abandon these products after a couple of months, as they are discouraged by the feedback given by those trackers (Meyer et al., 2016). This is mostly because feedback does not address challenges faced by people who are starting to integrate sports in their lives (e.g., how to integrate activity with work or social life, or how to stay motivated even during times when progress is not apparent) (Kuru, 2016) .

There is a complex interplay between the changing user needs of active excercisers and evolution (or the lack thereof) in the the field of activity trackers (Clawson, Pater, Miller, Mynatt, & Mamykina, 2015). Most notably, whereas active exercisers constantly evolve to higher levels of performance (Suh & Hsieh, 2016), most devices are static in so far they only target a specific type of action (e.g. number of steps taken). In other words, such trackers are prone to abandonment not so much because active exercisers fail in keeping up with the desired change, but also as a result of a mismatch between (positively changing) user needs and technology. The reason behind their changing needs is that people are open to finding ways for further self-development and seek for more advanced products.

For instance, in a recent study on how running and the experience of supportive technology by amateur runners changes over time, it was revealed that data-based needs of runners evolve over time and once runners start to become more mastered at running, they require more running dynamics data (Kuru, 2016). With respect to the user requirements, the reason why people use running apps or sports watches varies. For instance, it has been shown that, when people become more experienced in running, they tend to use sports watches, while less involved runners keep using apps (Janssen, Scheerder, Thibaut, Brombacher, & Vos, 2017; Kuru, 2016).

Currently, there is a wide variety of wearable activity trackers on the market (see Figure 3). The product category as a whole ranges from pedometers that only count the number of steps taken to advanced sports trackers that measure several parameters of the exercise such as heart rate and vertical oscilation during running. Wearable sports trackers are the most advanced ones that give real-time feedback which active exercisers utilize during exercise (Daiber & Kosmalla, 2017). Recent research proves the abilities of the sensor technologies and wearables in measuring the wearer's key vital signals unobstrusively. One of the very recent examples is the closed loop smart athleisure fashion which measures the heart rate and breath of the wearer (eg: http://www.by-wire.net/clsaf/). Arguably, systems designed specifically for sport experience should support the development of knowledge and user skills (Mueller et al., 2011). That is, these systems should empower users with knowledge about their body, and facilitate improving skills through training and practice (Doherty, Lemieux, & Canally, 2014). To address this, the systems should facilitate listening to the "inside" of their body and should give reasonable feedback rather than simply forcing the users to push their limits (Mueller & Young, 2017).

As stated, current physical activity trackers only inform the user about the number of steps taken, while people have a lot to learn about physical activity dynamics. Advanced sports watches have a lot of multi-sport abilities. For instance, cyclists use smart watches for self-monitoring, and they are mostly used by "competitive cyclists" rather than commuters, in order to improve their cycling performance (Piwek, Joinson, & Morvan, 2015). Another example from the context of swimming relates to watches which can track and understand stroke type and give feedback about the efficiency of the strokes accordingly (i.e. Garmin multisport watches). However, it fails to identify errors in swimming technique, something which is extremely important in order to progress to more advanced levels of exercise (Morais, Marques, Marinho, Silva, & Barbosa, 2014). Even though these watches do more than just tracking number of steps, they still do not succeed in providing the valuable information that people need in order to improve themselves.

Figure 1. Examples of Current Activity Trackers

While performance becomes incrementally important for active exercisers, injuries can be frustrating for them as those can withhold people from long-term training. There are several causes of injuries in different sports. By focusing on technique, distribution of energy, and force during the course of a sports session, supportive technology could also prevent injuries. For instance, wrong running technique can result into injuries and knee problems (Novacheck, 1998) while knee, shoulder and overuse injuries are the most common types of injuries among swimmers (Kerr et al., 2015; Morais, Marques, Marinho, Silva, & Barbosa, 2014). Thus, while challenging the users for performance and supporting positive experience, the design of activity supporting technology should also prevent injuries and negative experiences. Therefore, the aim of design for sports experience should be sustaining activity while supporting life-long engagement with sports through products, systems and services.

4 Engaging Active Exercisers through Design

Engaging active exercisers through design can facilitate maintenance of the physical activity and ongoing product use over timeTherefore, engaging active exercisers through design has a twofold goal: engagement in physical activity and in product use.

4.1 Engagement in Physical Activity

In sports science, engagement with the physical activity has been connected to the experience of *flow* (Jackson, Ford, Kimiecik, & Marsh, 1998; Swann, 2016), as people are more motivated to engage in certain activities when they experience flow (Landhäußer & Keller, 2012). From a broad perspective, Flow Theory (Mihaly Csikszentmihalyi, 1988, 1990) addresses people's experience when they are highly involved in certain activities. When people are in a state of flow, "*the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it. (pg 4).* Importantly, people will be in a "flow state" if they have the time and opportunity to focus on the activity. The skills of the individual and the challenges of the activity define the level of flow: if these two are balanced (i.e., when user skills match the exercise challenge), flow will arise. Reversely, people may experience anxiety if the level of challenge is (too) high relative to their skills, and boredom if the challenge is too 'easy'. Furthermore, levels of flow increase when the user has control over the activity (Mihaly Csikszentmihalyi, 1988, 1990). In general, flow situations contribute to the personal development and thus life satisfaction of people in the long run (Mihaly Csikszentmihalyi, 1990; Landhäußer & Keller, 2012).

On a more specific level, flow makes people loose their sense of time in the activity and makes them forget about potential negative consequences of the sports activity (Engeser & Rheinberg, 2008). For instance, athletes highly desire flow experiences, as it may boost peak performances (Landhäußer & Keller, 2012). During flow, people do not worry about failure, which is why it is important to design for flow experiences. After all, when feeling 'good' (i.e., flow is associated with positive affect) and

worries recede into the background, active exercisers are likely to stay motivated and eager to keep improving their performance (Swann, 2016).
Importantly, however, flow experience and (related) loss of sense of time may also bring high risks as it may increase the likelihood of injuries resulting from over-exercising and fatigue (Schüler, 2012). In sports science, *periodization in training* has been used as a strategic method to prevent such consequences and optimize peak performance (Issurin, 2010). Basically, the idea of periodization is to split the training program into micro-cycles (such as days or weeks) within the (monthly or yearly) macro cycles, and plan each training session with a specific goal (such as improving performance, endurance or building strength) (Bompa & Buzzichelli, 2015; Mattocks et al., 2016). With these, both the effects of overtraining and the risks of injuries are minimized (Figure 2 shows this periodization of training). In short, the design challenge here is to both help active exercisers focus on their performance in the present moment, whereas at the same time it is important to help them take a long-term perspective with overarching goals as more experienced exercisers do.
We consider both perspectives on training and performance (focusing on the present moment and flow, *and* adopting a long-term perspective) as essential starting points which should inform the design of supportive technology for active exercisers. Hence, the design of such technology should be targeted at informing, challenging, and 'managing the exercise session' at both the the micro levels (specific race-based trainings) and macro levels (e.g., comprising weekly or monthly exercise plans). While doing so, available knowledge from sports science can also inform how the technology should react to prevent fatigues and long term effects of these fatigues. One promising avenue for doing so relates to the practice of mindfulness (Kabat-Zinn, 1994).

4.2 Engagement in Physical Activity through Flow and Mindfulness

Mindfulness practice aims at a non-judgmental present-moment awareness of internal events (i.e., thoughts and feelings) and/or external events (i.e., the environment). It is this complete focus on the task or environment in the present moment that underlies both mindfulness and flow. But whereas, flow has been recognized as important to sports experience, mindfulness practice has been relatively underexplored in sports, although it has been suggested that awareness and acceptance of the present moment may allow athletes to focus less on negative or distracting thoughts, but rather spend more energy and focus for on the task at hand (Pineau, Glass, & Kaufman, 2014). In line with such notions, some have pointed out mindfulness as a critical component of peak sport performance (Mihalyi Csikszentmihalyi & Jackson, 1999; Ravizza, 2002) and some research suggests that mindfulness exercises can indeed generate "flow", (Aherne, Moran, & Lonsdale, 2011; Kee & Wang, 2008). Furthermore, it has been shown that mindfulness training may decrease (stress-related) pre-competition salivary cortisol (John, Verma, & Khanna, 2011), decrease resting heart rate (Hewett, Ransdell, Gao, Petlichkoff, & Lukas, 20011), and decrease pain sensitivity (Kingston, Chadwick, Meron, & Skinner, 2007; Zeidan, Johnson, Diamond, David, & Goolkasian, 2010). Hence, cultivating mindfulness via design may also decrease risk of injury and burnout.
Apart from being mindful of their own (intrinsic) thoughts and feelings, mindful athletes may also benefit from being mindful of the (extrinsic) environment. For instance, in addition to helping exercisers focus (i.e, becoming mindful) of their breathing, heartbeat or the sound of their feet on the ground, design may also direct attention to specific features of the (natural) environment such as multi-sensory properties (smell, the wind blowing) and spatial properties which have been shown to stimulate positive affect, creativity and inspiration (Fredrickson & Anderson, 1999; van Rompay & Jol, 2016).

Figure 2. Aim of Periodization and Relations with Sports Engagement

In short, design and technology could generate flow both at the macro level (e.g., life-long flow experience in sports) and at the micro level, in relation to which mindfulness practice offers a particularily interesting starting point. Likewise, the design should inform the user about the benefits of micro plans such as improving endurance and performance in the longrun. But as outlined, design could also promote flow experiences at the micro level and accurate. Apart from generating flow through mindfulness, design research also points at the product and the way it interacts with the user as a source of flow.

4.3 Engagement in Product Use

Taking user experience as a starting point, flow experience can be reconciled with user engagement as it is strongly connected to how a product can attract and sustain user interaction. Early research by Overbeeke et al. (2004) state that products should engage users through their "physicality"; products should be fun to use, and thus, be engaging. Therefore, the goal of the designer should be ensuring pleasure or fun during product use. Overbeeke et al (2004) defined five aspects that are essential for understanding the nature of 'engaging experiences', which include "functional possibilities and performance of the product; user's desires, needs, interests and skills; the general context of use of the product; richness with respect to all the senses; possibility to create one's own story and ritual". A much-cited example in this context talks about Apple's ipod which stood out from (at the time current) music players by providing intuitive, smooth interaction (connecting and drawing on users' motor skills), connecting to user needs for easthetics and meaning (e., through its minimal design), and by allowing for personalization (e.g., by creating profiles, playlists and the like). As for sports, Apple's iWatch was designed based on these same principles, intending to provide flow and pleasure during product interaction. Engaging experience relates to users' skills of "knowing, doing and feeling" (Overbeeke et al., 2004). The experience of technological products also covers dimensions in each level, such as aesthetics, interactivity, pleasure, functionality and social issues. In this sense, the process of engaging experience is based on and related to "cognitions, motor skills and emotions" of users.

In product use, engagement is an evolving process, which covers engagement, non-engagement-disengagement and reengagement of the product (O'Brien & Toms, 2008). Overall *engagement* is defined as the actual experience of a product. When the novelty effect passes, users may *disengage* with the product. If, after a while, the user desires the experience and starts using the product again,

reengagement occurs. Understanding the overall engagement process will take time, thus engagement can be defined as a longitudinal process in which people's reactions towards the product can evolve over time.
We argue that the flow state can be considered both for the product usage and the physical activity and design can aim for sustaining "life-long flow". Design for sports experience of active exercisers can benefit from both sports science and psychology. Thus, we suggest that, design can (1) challenge performance and facilitate positive experience including flow at the micro level; (2) prevent injuries and impede negative experience and (3) sustain physical activity and thus life-long flow for active exercisers. We already have extensive knowledge on how to challenge people through technology, which can inform designers to design for micro training. However, facilitating macro plans through micro goals of training through design, and hence engagaging users with life-long training while overcoming challenges and pitfalls which are bound to arise as users progress through long-term training programs are not supported by the current knowledge about using technology to motivate people to be physically active. To fill this gap in knowledge, we need more insights in how activity-based needs of active exercisers change over time. At this point, there are several topics that need to be explored first. These include the current experience of exercisers with both activity and products and how dynamic their experience is. Therefore, in the following section, we offer several research directions to facilitate the design for sports experience process.

5 Research Directions and Conclusions

We have outlined how current products and applications aimed at motivating physical activity do not match the needs of lifelong training for active exercisers. This topic lies at the interplay of design, sports science and psychology. Thus, we can partly inform design by drawing on insights from the fields of sports science and sport psychology. However, studies from these fields usually do not consider the experience of (and engagement with) products when providing, for instance, user support and generating engagement and flow during the activity itself. We therefore suggest that designing for sports experience requires specific attention.

We propose that the focus of future research should be on designing for sustainable life-long training by preventing injuries and helping them physically active throughout their lives. Here, the role of the designer is very strategic. The aim of the designer should comprise a) clearly defining the needs of "the user" and "the active exerciser", and b) designing products, services or systems which incorporate sports experience knowledge into meaningful training plans and use experience." To achieve this, the micro plans (can be race-specific or activity specific) could be utilized to help active exercisers to improve their performance and give them insight in how current exercise influences performance in both the short and the long run (Bompa & Buzzichelli, 2015). The outcomes of the research should lead to guidelines to design supportive technology that empowers people to take care of and make the right decisions for themselves to be physically active throughout their lives.

We suggest three main areas of research that together inform the design of supporting technology for active exercisers throughout life.

1. **Activity-based training:** The focus of this area is helping active exercisers to formulate their own daily or weekly plans. In order to achieve this, we need more insights in how to design training plans which can prevent short term-fatigue and motivate people to follow through the training program. Through research, we should first explore both the activity and the technology experience of active exercisers; then the possibilities and strategies for engaging them with the activity (i.e., flow in the present moment and supporting mindfulness) and performance.
2. **Performance-specific training**: The focus of this area is helping active exercisers to formulate their own long-term performance and injury-preventive training plans. Thus, this second area of research focuses more on knowledge building (with respect to sports performance and dynamics over time) of active exercisers. To achieve this, it is important to do more longitudinal research on activity trackers and to study how more dynamic supporting technology could motivate and

engage users with both the activity and the product (used to track the activity). Furthermore, we should also develop strategies for preventing long-term effects of fatigues while improving people's endurance and performance.

3. **Life-Long training**: We know that when people get older, their muscle strenght decreases and people get more prone to injuries. However, in order to sustain the life-long engagement in the physical activity, we need more knowledge on providing directions to overcome the effects of aging on people's performance. In the long run, the aim is to prevent injuries and sustain life-long training. It is natural that, people disengage with sports when confronted with expected (such as pregnancy) or unexpected events or short-term disabilities (such as injuries or illnesses). Arguably, it is particularily important during these times to keep people motivated by, for instance, pointing out what they still *can* do. Therefore, this line of research should study the effects of short-term disabilities and strategies for keeping people's motivation and helping them to recover healthily. This also can lead to understanding what types of personalized data active exercisers would benefit from, and thus exploring the possibilities and strategies for engaging them with their data.

In conclusion, this paper has mostly focused on the potential of knowledge within sports science, psychology and design for experience to inform future development of activity supporting technology. We would like to emphasize that developments in related areas such as information and sensor technology can also largely (positively) influence future developments in this field. Developments in wearable technology, for example, have already identified sports clothing as an interesting field of application. Such developments could also include more advanced use of sensors and activity tracking systems that are better able to learn from and adapt to people's behavior. Such developments could be included in the three research areas that we have now defined. Together, these areas have the potential to inform the design of more personalized, engaging and motivating products and systems that could support people to be physically active throughout their lives.

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The Beauty of Making Hot Chocolate – an inquiry on designing for everyday rituals

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The everyday is often mentioned in design, yet hardly inquired. The everyday is about what is banal, *infraordinary*, not memorable, as well as about the force that makes things habitual, *endotic*. In the research encompassing this paper, we question the everyday and explore opportunities to enchant it by design. This paper focuses more specifically on the design of everyday rituals, and aims to propose a descriptive framework to 'read' and compose such rituals. The elaboration of the framework is done based on a case study: the making of a hot chocolate in the morning. Through an autoethnographical approach, the main dimensions of the framework are determined (place and time, essentiality, and strength) and discussed. Throughout this inquiry, the value of a first-person perspective while designing for the everyday is discussed, as well as its relationship with the third-person perspective. This framework proposed points out the importance of quick iterations and of the consideration of consequences of design decision at all levels of the everyday ritual (structural, temporal, aesthetical, ethical…).

everyday; everyday ritual; descriptive framework; hot chocolate

1 Introduction

Although we would have enjoyed speaking extensively about the making of a good hot chocolate, in this paper we focus on the design of everyday rituals. Previous works (Lévy, 2015) have shown the importance of everyday rituals as they are importantly constituting one's life experience, and ethically pervasive: the values appreciated in everyday rituals have consequences on the way the everyday is experienced and lived outside the time of the ritual as well. Designing everyday rituals is therefore not only beneficial for the quality of the experience of the ritual itself, but also how the everyday is experienced as a whole.

In this paper, we aim to make a more practical step to design of everyday rituals, that is to propose a descriptive framework to 'read' and support composing such rituals. This framework intends to provide means to characterise the elements of a ritual from the perspective of the experience of the

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participant(s), in a way that would serve the design of this ritual. To start the study, it is first important to clarify what is heard by the terms 'everyday' and 'rituals', which are often used yet hardly discussed.

2 The everyday

The term *everyday* is highly utilized in the design literature (e.g., (Hallnäs & Redström, 2002; Norman, 2013; Saito, 2007; Wakkary & Maestri, 2007). But very little is said about the notion itself. And as we look closer to this notion, it is not as trivial as it may seem in the first place. An explanation on the *everyday*, probably arguable yet intendedly constructive, is proposed here to point the non-triviality of this notion and the focus of this research.

We suggest here that the everyday is the reality in which we act and perceive through unremarkable experiences. It is about going to sleep, waking up, cleaning, eating, dressing and undressing, reading, drinking tea or coffee… Dewolf (Dewolf, 2008) tells that "the spirit of the everyday life is in the closest facts, the least significant and perceptive ones". It is therefore in the flow of the *infraordinary* (Perec, 1989), away of the *extraordinary* and of the memorable. What the everyday is therefore less a matter of activity value than a matter of 'specific mode of manifestation'. Dewolf continues adding that "the quotidian is what is manifested in the habitual things as well as in the implementation force that makes them habitual, force that could be called *quotidianisation*". The everyday is therefore the result of a continuous process making things around us *quotidianised* or domesticated (Paavilainen, 2013), of the reality that is made banal, liveable with quietness.

However, describing the everyday only as space of habits is too limited. It is also framed by its limit, that is an *irregularity* (Yanagi, 1989), a moment of the unexpected which provides a space of imagination, creation, and transformation. The everyday, as an endless process of *quotidianisation*, is therefore composed of the transformation of things and activities towards quietly liveable habits, as well as of irregularities creating space for changes through creativity.

The first design challenge related to the everyday mainly lies in its obviousness. It is that obvious that calling it into question is already non-trivial. How to start? How to reflect and to question the apparently obvious? Designing for the everyday seeks for matter to (re)explore, to (re)question, to (re)shape the everyday. The second challenge for design is the disdain of the everyday by the consumer market, and often by people themselves. Georges Perec magnificently pictures this (translated by the authors):

> *In our haste to measure the historic, the significant and the revealing, let's not leave aside the essential: the truly intolerable, the truly inadmissible. What is scandalous is not the pit explosion, it is the work in coalmines. 'Social problems' are not 'a matter of concern' when there's a strike, they are intolerable twenty-four hours a day, three hundred and sixty-five days a year. […]*
>
> *What is really going on, what we are living, the rest, all the rest, where is it? How to consider, question, describe what happens every day and repeats every day: the banal, the quotidian, the obvious, the common, the ordinary, the infra-ordinary, the background noise, the habitual?*
>
> *To question the habitual. But precisely, we are adjusted to it. We do not question it, it does not question us, it does not seem to pose any problem, we live it without thinking about it, as if it was carrying neither any question nor answer, as if it was not the bearer of any information. This is no longer even conditioning, it is amnesia. We sleep through our lives in a dreamless sleep. But where is our life? Where is our body? Where is our space?*

How are we to speak of these 'common things', how to track them down faster, how to flush them out, wrench them away of the gangue in which they stay bogged in, how to give them a meaning, a language: for them to finally speak of what is, of what we are.

What is needed perhaps is finally to found our own anthropology: one that will speak about us, will look in ourselves for what for so long we have been plundered from others. Not the exotic anymore, but the endotic. […]. (Perec, 1989)

3 Designing for the everyday

To question and to design for the everyday, i.e., the banal and the infraordinary, a two-step approach is currently being established throughout a larger research programme called *enchanting the everyday*, encompassing the project presented in this paper. A brief description of the draft of this approach is provided in this section as it will help later to clarify the position of the current project in the larger research. Both steps presented here highly involve reflection in and on action (Reymen, 2003).

The first step (on the left of Figure 1, in blue) aims at creating through design – it is therefore based on a constructive design approach (Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2012) – enough insight for design to be able to transform the addressed, and possibly reshape design space. It is therefore a step of exploration and sensemaking at the lower level possible of experience in the everyday. Considering that the everyday experience may often appear irrational from a third-person perspective, but most often rational from a first-person perspective (Coyne & Mathers, 2011), this step is done at the first-person perspective (Tomico, Winthagen, & van Heist, 2012). By experimenting through design on the everyday, we can determine the values at stake in the design space, how they emerge in and impact the experience of the everyday, and how they can be addressed through design. In other words, through this step, we point out the values embedded in an everyday experience and its way of *quatidianisation*. This eventually leads to two outcomes: first a descriptive framework to comprehend how various elements (which can be artefacts, gestures, interactions, signs…) constituting the experience of the everyday may influence this experience, and second a refined (and sometimes redefined) design draft to address more accurately the key value(s) greatly impacting the everyday experience.

The second step (on the right of Figure 1, in green) aims at using the insight and the descriptive framework created in the first step to transform the everyday. Keeping in mind the rational-making issue at the third-person perspective (Coyne & Mathers, 2011), this step is actually a dialogue between designing at the first-person perspective and at the third-person perspective. The earlier is used as a means to keep the rational clear and the experience accessible to the designer. The latter is used to validate the proposition made by the first-person perspective and to eventually produce a valuable design for the targeted user group.

Figure 1 Process on designing for the everyday (v.3)

4 Designing everyday rituals

The research project presented in this paper focuses on everyday rituals and intends to give a base for the first step of the everyday design approach specifically for everyday rituals.

In everyday life, we perform many regular practices, apparently established and repetitive yet always in progress, i.e., relatively more *framed* in comparison to other everyday activities, through which a certain ethics is expressed and experienced (Petrelli & Light, 2014). We call such regular practices everyday rituals. Multiple definitions of the notion of *ritual* exist in numerous disciplines (e.g., anthropology (Firth, 2012; Levi-Strauss, 1963), cultural studies (Petrelli & Light, 2014), economics (McCauley & Lawson, 2002), ethnology (Bell, 1992; Cullen, 1966), psychology (Erikson, 1966; Schelling, 1980), or sociology (Chwe, 2013).

Yet, to specify more precisely what an everyday ritual is from the perspective of this design research, we distinguish it from the routine and the ceremony, especially considering the way values are put into the activity. However, it is to be noted that these comparisons consider the extremes to ease the clarity of the comparison, and that any observed habits may lie in the in-between these extremes. All are habits, regular activities with a seemingly stable structure, and meaningful (possibly from an aesthetics, functional, social, ethical, or religious perspective). However, the difference between rituals and routines lies into the individual focus, and the difference between rituals and ceremonies lies into the explicit formalisation of the activity.
Whereas routines quasi-exclusively pay attention to the result, rituals pay attention as well to the experience of the journey to reach the result. The efficiency, described here as the ratio between the quality of the result and the effort put into reaching the result, is of paramount in routines. The engagement, described as the level of involvement in a certain experience, may be seen as of greater importance for rituals. Rituals invite for a higher appreciation of the process to reach the result, of the possible choices and the required skills, of the creative potential of irregularities on the way of the making.

The difference between ceremonies and rituals lies into the formalism of the process. Whereas a ceremony is structured by a set of formalised rules, known and accepted by an entire community of practice, the ritual is structured by a set of implicit rules, often individually elaborated or at least nuanced. Moreover, as ritual rules are implicit rituals are often more flexible and evolved with the skills and the level of engagement of the individual performing the ritual.

What characterises the ritual are the expression of cultural and ethical values, their affect on participants, the engagement of participants (Rozendaal, Keyson, & Ridder, 2008), and the context in which the ritual takes place. Although rituals are part of the everyday, they are not necessarily completely banal (Petrelli & Light, 2014). This is implied by the notion that the rules of the rituals do not matter so much, but rather the lived experience through the fulfilment of the ritual.

The design of everyday rituals focuses therefore on two points: the beauty of the process that leads to the result, and the result itself, obviously considering that these two points are in a complex interrelation in the way they can be appreciated. Previous researches (Lévy & Wakabayashi, 2008; Rozendaal et al., 2008) show that the involvement of senses and of skills, the possibility of choices, and the social dimension impacts, as well as the qualities of the result of the artefacts impacts the experienced quality of the ritual.

In this research, the design of everyday rituals is a case in the design for the everyday, addressing the design space of the everyday and its values, away of the extraordinary. Our intention is to focus on what is here and now, too often ignored or forgotten (Perec speaks about amnesia) in our lives and in design. Focusing on the design of everyday rituals is still about the banal and the endotic, to find there what is or what can become beautiful.

> *What is to be questioned is the brick, the concrete, the glass, our table manners, our utensils, our tools, our use of time, our rhythms. Questioning what seems to have ceased forever to astonish us. We live, for sure, we breathe, for sure; we walk, we open doors, we go down stairs, we sit at a table to eat, we lie down on a bed to sleep. How? Where? When? Why?*

Describe your street. Describe another one. Compare.
Make an inventory of your pockets, of your bag. Wonder about the origin, the use, the future of each of the objects you take out.
Question your tea spoons.[…]
It matters little to me that these questions are fragmentary, barely indicative of a method, at most of a project. It matters a lot to me that they seem trivial and futile: that's precisely what makes them as essential, if not more so, as so many others by which we have vainly tried to capture our truth. (Perec, 1989)

Perec points out again here what design is challenged by while focusing on the everyday and on the infra-ordinary. It questions life as it is, its many details as they are, not as they are dreamed. It demands to consider life as it is lived and not as it is imagined. We clearly distinguish here the way life is, and the way imagination and imaginary are experienced in the everyday life. The latter is to be considered by design for the everyday, and especially in designing rituals.

5 A descriptive framework for everyday rituals

The first step of the research is to determine a descriptive framework to 'read' rituals in order both to comprehend and to support their composition. To explain our approach, we base our description on the main everyday ritual that has supported the elaboration of this framework itself: making a hot chocolate in the morning.

5.1 The hot chocolate ritual

Making a hot chocolate is a simple everyday ritual that may take place in the morning, nested with other activities that may also appear to be (or not) everyday rituals. In this case, such activities were preparing other elements of the breakfast, partly for other family members, taking shower and getting dress, preparing things to go to work. The overall could be described as a complex nested structure of activities.

The ritual starts entering the kitchen (which is actually a trigger of the ritual). Then the first actions consist in picking a cup and putting it on the kitchen counter, and to do the same with a spoon. Then I take a big jar of glass with cocoa powder in it from the top of a higher shelf, and put next to the cup. I open the jar and plunge the spoon in order to take some cocoa powder that I put then directly in the cup. This action is repeated another time, making sure that there is enough as well as not too much cocoa in the cup. Then I hit the spoon on the edge of the cup, before leaving the spoon in the cup and closing the jar to put it back to its original place. Then I mix the cocoa powder with the spoon to make the powder loosen. Then I pick the milk from the fridge. I put then an insufficient quantity of milk and start to mix for a little. I add more milk and mix again (left picture of Figure 2), repeatedly until starting to obtain a dense paste, that requires more mixing to obtain a dense yet smooth and uniform chocolate paste, paying attention to remove lumps. This mixing can take enough time to be able to enjoy looking at the street outside the window where a bakery is preparing to open (right picture of Figure 2). Then I pour more milk in small quantities around three times while continuously mixing the content of the cup with the spoon, in order to obtain the desired quantity and consistency of hot chocolate, again paying attention to remove any remaining lumps. The texture at the surface of the mix shows the quality of the mix and of the ratio between cocoa powder and milk. To warm the chocolate, I use a microwave for 1:20s. I place the cup slightly on the left side of the tray, the handled oriented towards the diagonal left-back. The cup is then positioned such as after the warming up, it is in a position which makes me feel that the microwave is serving me the cup as I reach for it. The colour and the little bubbles on the surface of the hot chocolate are pre-gustatory signs attesting the success of the making.

Figure 2 Everyday ritual of the hot chocolate (left), the view and its bakery in white (right)

5.2 Explorative experiments

To reach and to comprehend the elements of this ritual, many explorations have been done. It is unfortunately not possible to expose them all here, yet providing a few of them here helps to understand the approach.

The microwave – The use of the microwave was a logistic necessity considering the other events taking place in the morning. However, finding the right time for warming the chocolate and the right place for the cup required many tests. Variables are numerous and of different nature. Among others, the temperature the hot chocolate rises depending on the cup, the warming duration, and on the place where the cup stands in the microwave. The place was itself explored to provide this feeling of being properly served by the microwave, which also depends on the shape of the cup (e.g., the presence of a handle gives the cup a 'direction', which is not the case with a completely cylindrical cup). Finding a proper balance is therefore a matter of exploration and refinement, while any change (e.g., of the cup) might demand for a readjustment.

Figure 3 The cup while put in the micro-wave oven (left) and before taken out (right)

The jar – The glass jar containing the cocoa powder was selected after on exploration with different jars of various volumes and materials. The transparency of the material was appreciated as it enables the visual attention for the cocoa powder to be engaged early in the ritual. The size of the jar provides the possibility to insert the hand in the jar to collect some cocoa powder, action that requires a movement of the entire arm and of the upper part of the body. An appreciable body expressive movement that enhances the engagement. However, this is possible only if the jar is not full of powder. In the case of a full jar, even the spoon does not really enter the jar. Therefore, the jar needs to be big enough and not full so that the expressive movement is possible. The quantity of cocoa powder in the jar influences as well the quality in the interaction with the jar.

Figure 4 jars (left), taking cocoa powder in half-full jar (centre), full jar (right)

The cup – The cup is used as a container to mix the cocoa powder and the milk, and then to contain the hot chocolate. Different forms, as well as bowls, have been experienced. In the case of this ritual (and we will see later that this may vary with other rituals), the cup itself was interchangeable, yet with a specific structural constraint: the inside bottom of the cup needs to be round, narrow enough and its side vertical enough so the spoon would be able to *properly* and *smoothly* mix the cocoa powder with the milk at the bottom of the cup without accidentally sliding up. Here again, the balance is determined by the structure of the cup and the movement of the spoon inside.

Figure 5 Various cups used for the experiments

These three exemplary experiments show both the richness and the complexity of exploring and comprehending rituals. Choices in the rituals are numerous and interdependent, and their appreciation can be functional (the spoon moving well at the bottom of the cup), emotional (felt as the entire body contributes to the hand movement entering the jar), and ethical (the microwave oven serves properly the hot chocolate). Moreover, the aesthetics does not concern only the structural and visual qualities of the artefacts used in the ritual, it also concerns the beauty in interaction, i.e., the aesthetics of the movements and how various movements come together. All these are elements that requires to be characterised in order to create a descriptive framework supporting the 'reading' and then the composition of the ritual in a design manner.

5.3 Elements of the descriptive framework

Place and time – It is first to be noticed that this ritual takes place at home in the morning. It is not done anywhere else in the morning, without the feeling of missing it. When home, it is emotionally missed if it is not done in the morning. The coincidence of space and time triggers the attention for the ritual, while entering the kitchen triggers the ritual itself. This coincidence is seen in other rituals (e.g., "At home, I cook dinner; at friends' place I let others do") and deserves a greater attention in design to understand its impact on ritual and possibly how to trigger them.

Essential elements, contingent elements – In this everyday ritual, one can observe essential elements: the cocoa, the milk, the cup (as a container), and the spoon. They are necessary for the ritual to happen and to be experienced as expected. In order to look for essential elements, other ones were tried and then tentatively put away. For example, sugar and almonds were tried, and orange was suggested. But none of them stayed as essential elements of the rituals, as their absence did not significantly distort the ritual. They are contingent elements.
However, the notion of essential element is more complex than the list of tools required for the process of the ritual. For example, the cup as a container can appear as an essential element, while the used cup would be a contingent element, as it could be replaced by any other cup (as long as it respects the aforementioned structural constraints at its bottom, cf. strong elements). But this is not the case for all rituals. In another ritual exploration on making coffee after lunch [reference to this ritual are removed for the anonymity of the paper, and will be added after review], a specific cup appeared to be essential. It happened once that the cup broke, and the person performing the ritual needed to wait the weekend to return to her parents and to find an emotionally acceptable cup to replace the broken one in the ritual. The ritual was impossible with any other cup, emotional requirement determined the type of cup and made each of these two cup relatively essential elements. In conclusion the essentiality of an element in the ritual is determined by its necessity for the proper conduct of the ritual.

Strong elements, weak elements – As previously explained, the cup itself is not an essential element of the hot chocolate ritual, but its structure contributes to the quality of the way the ritual can be performed and experienced. The shape of the bottom of the cup and its material are strong elements of the ritual as they enable to experience quality in the ritual. The quantity of cocoa powder in the jar is also a strong element of the ritual: it needs to be enough yet not too much, so the body can expressively participate to dig into the jar to collect cocoa powder. In contrast, the overall quantity of milk put in the cup during the ritual is a weak element: a reasonable change of quantity of milk does not seem to influence the experience of the ritual. In conclusion, the strength of an element in the ritual is determined by its impact on the perceived quality in the experience of the ritual.

5.4 Reflection on the descriptive framework

This descriptive framework, although simple, helps to determine the necessity (essentiality of an element) and the variability (strength) of the qualities constituting the value of the everyday ritual, regarding the qualities of the artefacts, of the gestures, of the symbols, of the relations… The designer can then better estimate what can be modified, removed or added, and then discuss the consequences of any change. Essential elements are necessary for the ritual to be experienced as such. Strong elements elevate the quality in the experience of the ritual. This is the main objective of this framework for the designer: providing a means to constructively consider the way qualities are structured in the everyday ritual, considering their interdependency, their essentiality and their strength.

6 Consequences for design

Determining the essential elements of the ritual, seen as constructive constraints in the design process, and searching for strong and weak elements, seen as design opportunities, are the main quest of the designer for the design of everyday rituals, and a fortiori for the design for the everyday taking the process of quotidianisation into account. However, we still need to understand the process of quotidianisation, and how the descriptive framework can help the designer not only to foresee the key aspects that require attention as they may have a major impact on the quality of the habitus, as well as the aspects to take into consideration for effective irregularities.

Being able to approach the design process from the first person make this quest very effective as it enables the designer (1) to explore valuable experiences for design in an implicit and intimate way that the third-person perspective cannot offer, (2) to pay attention to details that the third-person perspective may not capture, and (3) to build and follow a rational that the third-person perspective may not comprehend. The everyday, as well as everyday rituals, demand for this first-person perspective explorative and constructive approach, while not neglecting that eventually a shift is required to the third-person perspective for the resulting design proposition to be meaningful from a design practice perspective.

An autoethnographical-like approach in the first step of the design approach for the everyday is therefore obvious. Yet this approach is not strictly autoethnographical as the outcomes are not reflective description of an experience, but a means to tinker and to point out opportunities to initiate designing. It allows for dealing with complexity, for reaching details and understanding at different levels (functional, emotional, ethical) the consequences of making changes in the ritual. Whereas a third-person perspective would make this design rapidly tedious, even impossible because of its complexity, a first-person perspective enables quick iterations and trials to promptly consequences of any change both for the experience and for the flow of the ritual. We call this design step an 'exploration by consequences': every modification may have an impact on the perception and the appreciation of the targeted activity as a whole, or on any of its elements (may it be structural, temporal, aesthetical, ethical…). And details matter for the experience of the ritual. The designer needs to experience and comprehend the consequences of a modification, and to determine implications for the next iterative trials. Eventually, the designer will be able to designate

the strong elements of the ritual and to design for them, in order to enrich the experience of the practice of the everyday ritual.

7 Conclusion

This inquiry proposes a descriptive framework for the everyday ritual, supporting the determination of essential and contingent elements, strong and weak ones, as well as their interdependencies. It constitutes an important step in the design process of everyday rituals, starting on the consideration of a design space expected to evolve throughout the process. This framework is then used to compose or transform the ritual through experiential trials, and to regularly question design decisions and their consequences.

It enables then to question the *infraodinary* in an *endotic* experience, and leads towards a design for the everyday.

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Persona Development in the Public Domain? Challenges to tackle

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How to create personas to improve designs for behaviour change strategies in the public domain? Three recent cases illustrate lessons learnt and challenges encountered during persona development in the public domain. Personas were helpful to gain insight into diversity within a target group, to create empathy for its members, and to have a shared understanding when communicating about them. The main challenges encountered were 1) capturing complex behaviour with personas, as the behaviours involved were variable over time, the (legislative) environment in motion, and the target groups diverse; 2) finding the right balance between intuitive vs. evidence-based decision-making, a process we coined "taking a responsible leap of faith"; and 3) transferring personas to third parties, as free sharing of insights and tools is common in the public domain. Validation plays an important role in personas' transferability. We call for all involved researchers to share experiences with using the persona methodology in the public domain, in order to tackle the challenges, and to create a more standardised way of developing personas.

personas; public domain; behaviour change; methodology

1 Introduction

Designers have known for a long time that products and services should match users' perceptions, motivations, and circumstances to increase satisfaction and effectiveness. One particular tool used by designers for this purpose are personas (Cooper, 1999). Personas are fictitious archetypes of users, each reflecting a distinct pattern in goals, attitudes and behaviours, based on empirical research among potential users. According to Goodwin (2009), personas can help in the design of almost anything that is used or experienced by humans. They can be used for multiple goals, for example in designing products, in communicating with stakeholders, and in marketing products. Personas help build empathy and user focus in situations where the user's context is complex, and

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where service providers have some distance to the end user, for reasons of organisational complexity or hierarchy.

However, despite its widespread use and potential value, the method of personas has also received firm criticism from design researchers. A major point of critique is the lack of possibilities to check personas' validity (Chapman & Milham, 2006), reason for several researchers to publish their efforts to validate personas (Subrahmahiyan, Higginbotham & Bisantz, 2017; Vincent & Blandford, 2014). Although these studies are valuable additions to literature, we are nowhere near a gold standard how to validate personas. Another point of critique is articulated by Matthews and colleagues (2012), who warn not to replace actual contact with the target group by personas alone. Moreover, they urge not to include too many personifying details to personas, as this can be misleading or distracting (Matthews, Judge & Whittaker, 2012). Clearly, personas are not mature yet in terms of methodological rigour.

Exactly this rigour in methodology is important when working in the public domain (including areas as health promotion and health care, sustainability, and safety). As strategies aimed at behaviour change in the public domain are often financed through taxes, all expenses need to be justified, and scientific evidence is a common and accepted way to do this. So, the immaturity of personas in terms of rigour seems to stand in the way of applying them in the public domain; both researchers and budget owners prefer more thoroughly validated tools to arrive at project results. At the same time, there is an urgent need in the public domain to better target strategies aimed at behaviour change to specific groups, to which personas may contribute.

The disappointing effects of traditional one-size-fits-all strategies on behavioural change in the public domain have led to a call to make strategies fit in with users' actual experiences, or in other words, to tailor them to the receiver (Noar, 2006). Tailoring refers to the development of a strategy intended to reach one specific person, based on characteristics of that person that are related to the target behaviour (Kreuter & Skinner, 2000). Whereas tailoring is focused on reaching one person specifically, targeting is focused on reaching a defined subgroup (Kreuter & Skinner, 2000). Taking into account the unique characteristics of people in the target group greatly increases relevance, and thereby effectiveness, of strategies aimed at behaviour change (Noar, Benac & Harris, 2007; Whatnall, Patterson, Ashton & Hutchesson, 2018). So far, efforts to target behaviour change strategies have often been limited to stratification on sociodemographic factors like gender and age. Differences in meaningful behavioural determinants like motivation are usually not accounted for.

Can personas be helpful in identifying the relevant distinguishing characteristics of the target group? Recently, Vosbergen and colleagues (2015) explored the use of personas to tailor education messages for coronary heart disease patients. Although the results were cautiously positive, the researchers conclude that the distinctiveness of their personas was too low, and that the amount of information needed to describe their personas was too burdensome for respondents. Moreover, to have personas fully integrated into actual patient education strategies, they would need to be scientifically valid.

Despite these difficulties in applying personas in behaviour change strategies in the public domain, we believe there is a promising match between the two. Designers often express a desire to boost innovation in the public domain[1]. Professionals in the public domain, at the same time, are eager to increase the effectiveness of their behaviour change strategies, and are stimulated to achieve this through multidisciplinary approaches. Therefore, the research question this paper aims to answer is: how can personas add to designs for behaviour change strategies in the public domain? We explored this in three recent cases, in which a multidisciplinary team developed personas aimed to eventually guide behaviour change strategies.

[1] E.g., see CLICK NL; the Dutch national Research Agenda for the Creative Industry.

2 Cases

2.1 Case 1: Preventing smartphone use by young adolescents during bike riding ('SMARTPHONE CASE')

Project team: Communication researchers from an applied university in cooperation with commercial service designers.

Commissioned by: A Dutch regional government organisation.

Project goal: To investigate potential strategies to prevent young adolescents from using their smartphones while riding a bike.

Problem description: Phone use during bike riding increases the risk of an accident (Goldenbeld, Houtenbos & Ehlers, 2010). In this project, we investigated strategies to prevent this risky behaviour targeting children in the last year of primary school (aged 11-12y). What can we do in order to prevent smartphone use while riding a bike among these young adolescents?

Purpose of personas: The purpose of the personas was to aid prioritising different intervention strategy options with a shared picture of the users in mind. The personas were solely meant to inspire strategy development within the project team. They were not intended for use outside the project team.

Data collection: The data collection involved two activities: 1) literature study, and 2) field research. Data were collected med-2016. From literature, we gained insight into smartphone use (in general as well as during bicycling), and cognitive development of children in the target group. The main aim of the fieldwork was to put ourselves in the shoes of the target group. Literature study and field work took place simultaneously to enable them to inspire each other and help to determine focus. The field work started with an open exploration among the target group by observing and questioning young adolescents who passed by in the street on their bikes (n=18). Next, both a primary and a secondary school class were visited to immerse ourselves in the (social) environment of the target group. Finally, 8 children were interviewed at their own kitchen table together with at least one of their parents, to deepen our insights into the role of the smartphone in children's lives, and the consequences this has for their behaviour on the bicycle. Topics in the interview were: social environment, smartphone use (both in general and during bike riding), house rules related to smartphone use, perceived bicycle skills, and the transition from primary to secondary school. Before the interviews, all children and parents individually filled in a sensitizer (i.e. a visually attractive assignment, aimed to provoke and facilitate respondent reactions) (see Figure 1). The interviews were audio recorded and transcribed verbatim.

Persona development: Data were coded by grouping similar quotes in order to capture reoccurring themes. These themes were used to determine scales on which members of the target group could vary (e.g. frequency of smartphone use while bicycling, risk perception, (house) rules related to smartphone use). These scales formed the basis for the personas. In a working session with all project members, we mapped different personas on these scales. The team decided on the number and characteristics of personas based on both the empirical data and intuition. After creating five personas, all extremes of the scales appeared to be covered. Then, citations from all transcribed interviews were assigned to the different personas in order to check whether the five created personas covered these citations. This was indeed the case, which led us to definitely decide on the five personas. In the final step, we expanded the personas with more details and illustrations.

Persona validation: As the personas will only be used for inspirational purposes within the project team, validation is considered irrelevant.

Outcomes: Five personas (Bukman et al., 2016) that helped to guide further decision making in the project. First, by jointly selecting one of the personas to prioritise further actions, or in other words, collectively agree on which part of the target group to focus on first. Second, by helping to imagine

how different behaviour change strategies would influence each of the five identified parts of the target group. In a follow-up project, the aim is to further design intervention strategies, building on the personas.

Reflection on persona development process: The number of respondents, particularly the number of interviewees, was small, which may have led to a disproportionate dependence on intuition, as compared to actual data. In a relatively short time, five detailed personas were developed. The target group is highly dynamic, that is, they are subject to drastic social and personal changes due to puberty. As the personas are static and the risky behaviour is (mostly) in the future, current personas might give limited clues for developing strategies for preventive purposes. We therefore feel the need for 'dynamic personas'.

Figure 1 A page from the sensitizer booklet used in the smartphone case. The illustration shows the child's perception of a bad ('een slechte fietser') and a good cyclist ('een goede fietser'). Source: Case 1.

2.2 Case 2: Targeting young adults' use of alcohol and drugs ('SUBSTANCE USE CASE')

Project team: Researchers from a Dutch institute specialised in mental health and addiction in cooperation with communication researchers from both a university and an applied university.

Commissioned by: The Dutch national government.

Project goal: To define distinct subgroups of users and non-users of alcohol and drugs, and develop personas that can assist in (re)designing targeted prevention strategies. The project focused on young adults (aged 18-25y).

Problem description: Intervention strategies aimed at the prevention of alcohol and drug use generally distinguish two groups: users and non-users. However, within these groups large differences exist in e.g. motivation, lifestyle, social environment and experiences with drugs. Insight into the different subgroups is necessary to target prevention strategies more specifically. Which subgroups can be distinguished, and how can they be captured by personas?

Purpose of personas: The personas were developed to guide professionals in designing targeted intervention strategies for and communication with young people considering drug use. Therefore, the personas developed in this project needed to be suitable to be transferred outside the project team to professionals designing or implementing intervention strategies.

Data collection: This project followed two stages: 1) literature study, and 2) interviews. The literature study took place in 2016; the interviews were conducted early 2017. The literature study focused on previously identified subgroups, and the determinants responsible for distinguishing these subgroups. The identified subgroups were used as a basis to recruit participants for the second stage: the interviews. In the interviews (n=43), we dug deeper into young (18-25y) people's perceptions and experiences regarding alcohol and drug use. The interviews were conducted at public places (e.g. their school or a bar) and followed a semi-structured interview protocol, based on determinants of behaviour (Fishbein et al., 2001) and topics identified during the literature study. Participants were asked about their drug use and their favourite drug. The interview concentrated on both participants' favourite drug and their most often used drug. When a participant had not used alcohol and/or drugs in the past 12 months, the interview focused on determinants of not using alcohol and/or drugs. The following topics were discussed: personal and sociodemographic characteristics, current behaviour (alcohol and drug use, lifestyle, nightlife), first experience with substance use, determinants of current substance use, and determinants of and intentions for quitting or reducing substance use. The interviews were audio recorded and transcribed verbatim.

Persona development: Transcribed data were coded with the specialised coding software MAXQDA. The topics from the interview guide were used as themes for coding. For developing personas from the data, the steps of Goodwin (2009) were followed: (1) Identify behavioural and demographic variables for each role; (2) Map interviews to variables; (3) Identify and explain potential patterns; (4) Capture patterns and define goals; (5) Clarify distinctions and add detail.

Persona validation: The personas will be validated by qualitative research among professionals working with the target group. Additionally, quantitative research among the target group will be done to determine to what extent the different personas represent the target group.

Outcomes: Fourteen draft personas. The next step is to validate the personas.

Reflection on persona development process: The large amount of data made the persona development a timely process, but provided a very solid empirical basis for the personas. In line with their evidence-based way of working, the researchers were hesitant to make intuition-based decisions. The persona development process in this case was further complicated by the diversity of the population of interest. All young people aged 18-25y were targeted, for use of any type of drug. Consequently, a large number of interviews were carried out to capture the diversity and a large amount of data was collected.

2.3 Case 3: Supporting nature conservation ('NATURE CASE')

Project team: Commercial service designers in cooperation with representatives of the commissioner, and commercial quantitative researchers.

Commissioned by: A Dutch nature conservation society (NCS).

Project goal: To provide the NCS with insights in the drivers of people's behaviour related to enjoying, experiencing and protecting nature, so that the NCS can develop value propositions (i.e. sets of core customer benefits) for target group segments based on these drivers.

Problem description: It is the NCS' mission to protect Dutch nature. The NCS needs a substantial body of members and supporters backing their activities. Therefore, the NCS has to continuously reach new people with meaningful value propositions, to persuade people to become active (paying) members rather than 'passive' consumers of nature. What are the main drivers of different subgroups to actively support NCS?

Purpose of personas: The purpose of the NCS personas was threefold: 1) to create a shared understanding between internal stakeholders; 2) to create a clear picture of how the NCS target group is segmented in terms of behavioural drivers; and 3) to better design value propositions that persuade these segments to become active members of the society.

Data collection: This project's data collection encompassed two stages, carried out early 2017: 1) desk research, and 2) field research. In stage 1, previous research related to the (potential) target groups of the NCS was collected and summarised, including other segmentation studies (based on socio-demographic), customer satisfaction studies, and brand positioning studies. A shared understanding of existing knowledge on the topic is essential to provide solid ground to work from, to prevent double work, and, particularly in this case, to acknowledge previous efforts done by stakeholders. In the field research of stage 2, we conducted 16 contextual home interviews preceded by a sensitizer (Sleeswijk Visser, 2009) in the form of a self-documenting diary (Gaver, Dunne & Pacenti, 1999). In addition, 24 ad hoc street interviews were conducted in several NCS nature areas. All interviews were audio recorded, and key quotes were captured during the interview through time stamping (to help relocate them in the audio recording).

Persona development: The qualitative data was analysed and organised according to theme. The themes were selected both top-down (based on the researchers' previous experience) and bottom-up (emerged from the data). Then these themes were organised into clusters on the basis of motivations such as: what are people hoping to find in nature, what do people expect from NCS in their relationship with nature, and what type of role would people like to play in protecting nature. By looking at how people differed on these motivations 6 motivational clusters were distinguished, which were then enriched on the basis of both desk and field research. These enriched clusters resulted in detailed personas, based on motivations describing a persona's relation to nature, behaviour in nature, and expectations of NCS.

Persona validation: The persona profiles were validated quantitatively by the commercial research agency participating in the project. In a representative sample of the target group (n=1,200), the agency assessed the extent to which respondents related to each of the attributes that underlied the personas (e.g. "I am an adventurer"; "I am annoyed when people show disrespect towards nature"). Responses were subjected to a statistical cluster analysis. The resulting clusters were then compared to the personas. Results showed that the six personas were statistically congruent with the clusters identified through quantitative analysis of the representative sample data ('real people'). The six clusters together represented 99% of the sample, which indicates that the personas indeed covered the target group well. In addition, the quantitative study included other attributes as well, such as media usage, channel preferences, and socio-demographic variables. Although the researchers found a poor correlation between the personas and the socio-demographic variables age, gender, and geographic region, the other variables (related to actual behaviour and preferences) helped the project team to further enrich the personas with these variables. For example, the persona that was more adventurous tended to be more active on social media while the persona that was more interested in nature preservation was less active on social media.

Outcomes: Six quantitatively validated personas that enabled the consecutive co-creation of different value propositions to target marketing activation and persuasive design, to eventually increase member acquisition and retention. Currently NCS is in the process of piloting these value propositions and assessing which ones lead to the highest activation of the potential target group.

Reflection on persona development process: The personas received great support amongst NCS staff; they were found inspiring to work with, seen as realistic and relevant, and supportive in decision making process. Some issues we encountered were that the target behaviour appeared to consist of multiple, poorly correlated drivers for behaviours: those related to nature and those related to actively supporting charities. This made it difficult to capture both behaviours in a limited number of coherent personas. Designing suitable value propositions for all six personas would create a too large portfolio and too much organisational complexity. Therefore, NCS is currently considering a clustering of personas for practical purposes. Lastly, the personas did not correlate statistically significant with age, gender, and geographic region, which means that new ways have to be sought to reach these people.

3 Lessons learnt

The cases have in common that the personas served their purpose of providing the project team and stakeholders with a vivid image of the different people in their target groups. In all cases, the development of personas revealed important challenges that could hinder the use and acceptability of personas by designers and health professionals in the public domain. The cases differed considerably in the way personas were developed, the level of uncertainty that the project team was willing to accept in translating data into personas, the amount of data that was collected, and the purpose of the personas (only internal vs. also external use). The different methodologies applied in the three different cases raise questions about whether there is a 'right' way to develop personas in this domain, and how to determine the best way. The experienced challenges are discussed next.

3.1 Challenge 1: capturing complex behaviour

It is challenging to grasp behaviour with personas when…

… there are multiple behaviours or diverse populations involved.

In the public domain, it is important to target each and every subgroup, as public organisations often have a responsibility to contribute to an inclusive society. Stakeholders in the public domain might therefore be hesitant to focus on a specific part of the population. That was also the situation in our substance use case. The aim was to include all subpopulations related to alcohol and drug use, including both users and non-users, and users of alcohol and/or any kind of drug. The result was a tremendous amount of data, and many different personas. Similarly, the nature case experienced difficulties caused by the need to capture multiple, even poorly correlated behaviours (those related to experiencing nature and those related to supporting charity). Also, in the latter case, the identification of six distinct personas asks for the design of six differentiated value propositions, which is deemed unfeasible.

… the target group will change in the near future.

In our smartphone case, most respondents in the target group did not perform the risky behaviour of using their smartphones while riding a bike, yet. In fact, most respondents in the target group appeared to be quite positive about the target behaviour of not using it in traffic. The problem analysis showed that this behaviour would increase in the year ahead of them. From literature, we knew that the young adolescents were about to change considerably, e.g. showing more risk-seeking behaviour (like using their phone while cycling), and being more sensitive to peer influence. Therefore, both the target behaviour and its determinants were expected to change in the next years. How to capture the expected dynamics in the personas? One solution could be to collect longitudinal data to continuously update the original personas.

… there are changes in rules and regulations.

In our smartphone case, the persona project was just on a roll when the public debate opened up around the prohibition of this risky behaviour by law. So far, prohibition is not in force, but if it will, the determinants of the behaviour will likely change, as will our personas. This instable regulatory context applies to many behaviours in the public domain.

3.2 Challenge 2: Taking a responsible leap of faith

In each of the three cases, the personas could not be created by only statistically analysing or restructuring the data. Personas emerge from the research data through a process of collaborative, creative reasoning, sometimes referred to as abduction. Persona development requires an act of interpretation, or sense-making of the data: a wilful filtering and enriching of the data that turns them into useful personas that will help design better solutions. Internally, we call this interpretative phase the 'leap of faith', because it requires the project team to agree on a certain level of uncertainty, which in turn requires trust among the team members. They have to agree on a set of personas with a set of

attributes that is not either right or wrong, but rather a contextual and educated best guess. Or as Pruitt and Grudin (2003) phrased it: “Persona use does require decision making. It isn't a science.”

Behavioural scientists have difficulties with taking the leap of faith. As Goodwin (2009) already described, “The step of assigning characteristics with no regard for the data, is a difficult step for researchers.” Especially in the public domain, where evidence-based working has high priority, it is difficult to draw conclusions about the personas that cannot be retrieved directly from the empirical data. One way to fill these blanks is to do thorough desk research preceding the field work; a step that was taken in all three cases in this paper, but that is sometimes neglected in persona development. Another way to fill these blanks could be to exploit practice-based experiences.

3.3 Challenge 3: Transferring personas

Sharing insights is common in the public domain. By sharing knowledge we can help each other to better tackle societal challenges. But is it feasible to transfer personas?

In all three cases the personas were shared with the problem owner. Sharing the personas certainly helped bringing the target group alive to the problem owner. Because the problem owners were closely involved with the project’s progress through frequent meetings, the problem owners were well able to interpret personas correctly. However, what happens when personas leave the project team to be used by third parties who were not involved in the development of the personas, is less certain.

Sharing the personas with third parties was exactly the purpose in two of our cases. In both the substance use and nature case, the purpose of the personas was to inform and inspire professionals working with the target group, i.e. other parties than the research team. The project team who developed the personas had a detailed understanding of the personas, and how they mutually differed. It is the question whether other parties are able to distinguish the personas correctly. The naming of personas, the pictures representing them, or non-essential socio-demographic details could unintentionally distract from the essence of the personas. Misinterpretation of the personas by third parties lies in wait, meaning some form of guidance by the creators is necessary when the personas are to be transferred to others.

If personas are used for inspirational purposes within the project team only, like in the smartphone case, transferability is less of an issue. However, it is an important issue when the personas will be used outside the project team. One way to enhance the transferability of personas is to validate them, either among experts, users, or both. A validation will be part of the intended follow-up study in the substance use case. This will help in checking whether the personas are interpreted correctly by third parties. In the nature case, a quantitative validation was carried out with users. Although useful, this validation in a large-size sample was time-consuming and expensive. This type of validation requires expertise in quantitative research, but also, it sets extra requirements to the personas. That is, the personas need to be of sufficient resolution. They have to be composed of attributes that are suitable for use in a quantitative survey. Respondents of the survey need to be able to self-assess how they relate to the attributes. The more ‘factual’ the attribute (e.g. education level), the easier it is to self-assess the extent to which it applies to you, whereas the more ‘latent’ the attribute (e.g. intrinsic motivation), the more difficult this is. However, for achieving behaviour change, it is more important to have insight in these latent attributes than in the factual, more superficial attributes. So the paradox here is that validation favours more factual personas, whereas effective behaviour change strategies favour in-depth, motivational personas. Further research should explore the optimum level of validation for different situations of persona usage.

4 Conclusion

The three cases illustrated the potential use of personas in the public domain. Although each of the cases covered entirely different target behaviours and target groups, they revealed similar lessons and challenges. Personas appeared helpful to gain insight into diversity within a target group, to create empathy for the members of the target group, and to have a shared understanding when

communicating about the target group with stakeholders. All this can assist in creating targeted intervention strategies in the public domain. However, the cases also exposed specific challenges related to the use of personas in the public domain.

First, we struggled with capturing the complex behaviours in the public domain with personas. The behaviours involved were variable over time, the (legislative) environment was in motion, and the target groups were highly diverse. In one of the cases, our attempt to fairly capture this complexity led to the development of as much as 14 personas. One of the conclusions of Vosbergen et al. (2015) in their persona study was, that the cognitive load for respondents to understand all the persona information was too high. Considering that they had five personas, this presents us with a real challenge. Second, we identified the tension between the necessary leap of faith and the evidence-based world of intervention strategies to change behaviour in the public domain. Multidisciplinary experiences are necessary to mitigate this tension and to search for accepted ways to make the leap of faith from data to personas as small as possible. Third, we discussed the question of the transferability of personas to third parties. If personas are purely meant to inspire the problem owner to guide further actions aimed at the target group, the need for transferability is quite low, which leaves some more elbow room. However, personas that will be used as a stand-alone tool by third parties ask for additional requirements. For example, too many personifying details may hinder correct interpretation of personas by third parties. This is especially relevant in the public domain, where free sharing of insights and tools is common. Validation of the personas seems to be a promising avenue for handling this challenge. However, as validation always comes with a price, the optimum level of validation needs to be established for each specific context.

Despite the promising match between personas and designing for behavioural interventions in the public domain, it can be challenging to bring together the worlds of designers and behavioural scientists. Differences between designers and scientists in approach, methodology, and view on what constitutes truth, may hinder the exchange of research tools. Whereas designers and design researchers generally take a holistic perspective on a person's experience and acts, scientists' approach to research projects is usually reductionist in nature, attempting to establish the influence of single factors in controlled circumstances (Hermsen, Van der Lugt, Mulder & Renes, 2016).

Behavioural scientists who are usually involved in intervention strategies in the public domain may not accept personas as a serious research tool, because the development of personas is an inherently creative process. Although good personas are grounded in research data, there is always a point in their creation where a leap of faith has to be taken that cannot be completely underpinned by the data alone. The contrast is possibly too sharp with the evidence-based way of working that is both common and required in interventions in the public domain. Specifying, or perhaps even standardising, the methodology to develop and validate personas might help the tool to gain acceptance by professionals in this domain. Another solution might be to not frame personas as a research tool per se, but as a tool bridging reductionist research activities and holistic design activities.

If done properly, the development of personas is an intensive process, both in time and budget. Especially the latter is often scarce and strictly regulated in the public domain. Future research should point out whether the benefits of creating personas do outweigh the costs (in time and money). Moreover, we call for designers and (design) researchers to share experiences with using the persona methodology in the public domain, in order to tackle the experienced challenges and to create a more widely accepted way of developing personas.

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Heuristics for selecting and using behavioural design methods

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Design for behaviour change is a young and developing practice grounded in the belief that using insights from the behavioural sciences leads to more effective interventions for behaviour change. Although a wide range of tools, techniques and methods exist to support this, few are well introduced in terms of their underlying values or paradigm for understanding behaviour. As a result, designers are often limitedly aware of why and how methods fit their personal beliefs and way of working. This not only obstructs professional development; it decreases the effectiveness and efficiency of behavioural design. In this paper we present an initial set of heuristics for designers to anticipate the appropriateness of a method, given the task at hand and their preferred way of working. These heuristics have been developed through an analysis and comparison of nine behavioural design methods. We conclude with discussing their potential in framing and staging behavioural design methods and studying method usage.

design for behaviour change, method usage, heuristics

1 Introduction

The notion that we can affect behaviour through the design of an intervention has spurred the development of new professionals and institutes. Around the world we witness a growing number of design agencies and consultancies focusing on behaviour change, and several countries adopted the UK model of a behavioural insights team to advice governments in policy making and execution. To support this new practice of what we can call 'behavioural design', the large and growing body of knowledge around behaviour change is being transformed into methodological support. This has led to an abundance of strategies, principles, models, frameworks and methods directed at design for behaviour change (e.g., Niedderer, Clune, & Ludden, 2017).

Although methods, tools and techniques are popular amongst designers, and an often anticipated result of (design) research (Blessing & Chakrabarti 2009) , there is generally little knowledge of their

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usage (Daalhuizen, 2014). But when one wishes to use a method, this often leads to a number of questions: How should the plethora of methods be navigated? What method fits the task best? What method fits me as a designer best? Once selected, how should a method be adapted to a specific context and applied? And how should a method be communicated to team members and stakeholders so that they buy into it and are involved? Although methods typically promise specific results, they often do not communicate well how they do so, nor why this is a good way. Productive use of a method typically requires a 'method mindset' (Andreasen 2003, Daalhuizen 2014) that is appropriate for the specific method or type of method. That is, to choose an appropriate method in a given situation, and to use the method productively, one needs to understand for example the mechanisms that underlie the method, have know-how about the application of the method, and be able to judge (intermediate) results. Yet many methods do not include information that allows practitioners to make such judgements to a sufficient extent. As a result, designers are often little aware of possible mismatches between their way of working and the prescribed way of working advocated by the method. For example, a behavioural design method that prescribes qualitative field work to gather empirical data about people's behaviours and attitudes might not explicitly mention that the user of the method needs competences to perform qualitative research. But it requires skill to perform semi-structured interviews or observation techniques, as well as to analyse qualitative data and translate it to inspiring insights for innovation. If such a method is chosen by a team who typically work with quantitative research, it is likely that the use of the method leads to poor results and frustration in the team. Just like professional tennis players select their gear adjusted to their personal ergonomics, playing style and the type of court they will play at to optimize their performance, so too should designers (or method users in general) be better aware of what methods and techniques will actually improve design performance for them.

The contribution of the paper is twofold. First, it is to propose an initial set of heuristics to help practitioners navigate the body of methods that are available in the field of design for behavioural change. This set has emerged from analysing a small, yet varied sample of methods and therefore explicitly serves as a starting point for more work in this area. Second, the paper intends to spark a debate within the behavioural design community as to how methods ought to be presented, evaluated and compared in order to best serve the community of practitioners and researchers.

The remainder of the paper is structured as follows: first, we discuss the role of methods in design in general, after which we introduce the value of heuristics in supporting method selection for behavioural design. Next, we introduce a study to understand how differently a set of behavioural design methods support the shift from analysing the behavioural issue to synthesizing a solution. This results in an overview of nine methods, their fundamental characteristics, and how differently they support various stages in this design process. Based on this study, we propose two process-heuristics and four method-heuristics that can aid the designer in selecting and applying a behavioural design method given the task at hand and their preferred way of working. We end with discussing the limitations of this study, the preliminary stage of the heuristics, and avenues for future research.

1.1 The role of methods

In general, methods are developed to mediate the learning of procedural knowledge, defined as knowledge exercised in performing a task. This means that methods are 'intermediates' that support people to learn how to do certain things, either based on the experience or insight of others or based on theory (Daalhuizen 2014). Although the core function of methods is to transfer knowledge about how to reach a specific goal, they often include declarative knowledge about this goal as well (particularly in the field of behavioural design). For example, the Persuasive Systems Design method prescribes five main steps to get from starting point of a project to design of a system (procedural knowledge), yet it also includes a set of principles that contain declarative knowledge about behaviour (Oinas-Kukkonen & Harjumaa, 2009). One example of such a principle is 'social comparison', which states that people are more likely to be motivated to perform a target

behaviour, when they can compare their own performance with that of others. Thus, declarative knowledge refers to for example theoretical explanations of specific phenomena, in this case behaviour. Whereas procedural knowledge refers to knowledge about how to perform a task, possibly including statements on how and when to use specific declarative knowledge in the process. In fact, many behavioural design methods are grounded in specific models of behaviour or behavioural change.

Methods in design have long been conceptualized as systematic instructions for good design: they need to be followed to reach optimal design outcomes (Jensen & Andreasen 2010). Underlying this conceptualization is a model of human beings as rational actors – a point illustrated by Bousbaci in the context of design (2008), who are willing and able to follow instructions as they are spelled out in a method. However, the way methods are being conceptualized is changing (Dorst 2008, Andreasen 2011), with implications for their use. Whereas the 'traditional' view of methods as 'instructions to be followed' implies a passive – one could say obedient - role for the user of methods, a view of methods as 'mental tools' puts the method user in a pivotal position. In the latter conceptualization of methods, the method user is the one who actively selects and uses methods to enhance or learn new capabilities and to perform at a higher and more consistent level. It also acknowledges that the use of a new method requires learning and motivation before it can be used beneficially (Andreasen 2003). Perhaps more importantly, it acknowledges that human beings are mostly non-rational actors, and that their motivation and ability to actually use a new method cannot be presumed by method makers.

1.2 Models of the user

When developing interventions to change behaviour, models of the human being are inherently embedded in the eventual design. Beliefs or assumptions about what interventions will be effective explain how people are being modelled in the targeted context by designers. Are people motivated to change? Are they willing to absorb information? Do they have the capacity to oversee consequences? Although such assumptions may not always be explicitly addressed during a design for behaviour change project, the resulted intervention does model people on such dimensions. Lockton and colleagues performed a study to investigate how exactly designers see the anticipated users of their design (Lockton, Harrison, & Stanton, 2012). Based on a set of twenty-five clusters of statements, labelled from 'users are stupid' to 'users want a choice', the authors propose a 'pinball-shortcut-thoughtful' spectrum in modelling users. In their explanation, the metaphor of a pinball frames the user as someone "who only reacts simply to inputs, doing the same thing each time the same stimulus is applied, and does not think about any decisions" (p.9). On the opposite side of the spectrum, designers can frame people as thoughtful human beings "who think about what they are doing, and why, analytically – they are able to set and modify their own goals" (p.10). As an intermediate category, they argue how the user can be framed as taking short-cuts, as someone "who is boundedly rational, who makes choices to minimise energy or cognitive expenditure" (p.10). What Lockton and colleagues argue is that a variety in models is probably best to design for, since all forms of human systems in driving behaviour exist. Nobody can be said to be just one of these three 'models'. On the contrary, we all embody these models to a greater or lesser extent and depending on the context.

Alongside the fact that awareness of such modelling helps designers in targeting behaviour more effectively, we argue designers should equally consider their choice from a moral viewpoint. Which contexts allow for more steering interventions based on the pinball model (e.g., when they concern safety), and when do you wish to compromise on effectiveness just for the sake of providing people with a learning opportunity? In this regard, Tiemeijer and Anderson (2014) talk about 'untamed' and 'domesticated' issues. When issues are still untamed and people have a large variety of in disposition to the matter, like for instance the case of organ donation, implicit guidance of actions and choices are considered immoral. Yet when an issues is uncontested, like in case of the obliged use of seatbelts, implicit influence is considered acceptable. Given similar characteristics of

employed strategies, Tromp, Hekkert and Verbeek (2011) argue that designers should estimate the relationship between individual and collective concerns in the matter. They suggest this relationship (do they align or collide?) defines the type of influence that is appropriate given its salience and force. In similar fashion, Zachrisson, Storrø and Boks (2011) introduce guidelines to consider the level of control interventions may impose on people's behaviour. For instance, they propose that interventions should not violate with user values and norms to increase the level of acceptance, or strategies are allowed to be obtrusive when the issue is urgent or important. Deciding on the level of control and the level of implicitness of interventions when changing people's behaviour are considered ethical decisions. Yet to what extent such aspects of behavioural design are considered in practice is not only informed by one's moral stances in life, but heavily depends on one's model of the user. Regarding people as lazy and in search for efficiency in life would probably frame an implicit intervention as rather helpful, whereas the same intervention would be considered highly unethical when one regards people as thoughtful and deliberative actors.

In sum, behavioural design methods generally exist to make the development of a behavioural interventions more effective and efficient. Yet how a method does so, can vary greatly. This implies that success of the method in doing so (will it indeed improve performance?), depends on the interaction between a variety of variables. Figure 1 explains a few of these variables. It explains how performance depends on the match between, amongst others, the values, beliefs, and working style of the designer/method user, the type of task at hand, and whether it involves for instance a tamed/domesticated and clear-cut/messy issue, and the characteristics of the method, its underlying values, how it models people, and what working principles it embodies.

Figure 1 Relationship between method user, design task and method. The image explains how a variety of interacting variables affect whether method use will indeed improve performance.

1.3 Why heuristics?

When developing a way to support designers, both students and practitioners, to navigate a body of methods and tools, it is tempting to follow some logic to come to a structured system. That is, it is tempting to 'make the choice' for those designers by offering them a set of parameters they can set, resulting in an automatically generated choice for a method by the system. However, we argue that - rather than making the choice for them through some algorithm - it is better to provide designers with a set of heuristics for selecting and using methods for behavioural design. First, because such an approach will empower them to make such choices more consciously, connecting their choice of methods to the complex set of factors they find themselves in for any given project. Such conscious decisions will also help them to take responsibility for their choices, and learn to make better decisions as they gain experience. Second, this approach is more future-proof as it still valid when new methods for behavioural design are introduced and become part of the choice set.

Heuristics are defined as means of support that aim to guide cognitive processes of their users by providing prompts for information processing that can assist in learning, decision making, problem solving and reflection (Daalhuizen, 2014). Heuristics are characterized by their aim to support their users to achieve satisfactory results using minimal information, as opposed to achieving optimal results using complete information, which is characteristic for systematic methods. This definition of heuristics builds on Gigerenzer and Brighton's definition of heuristics: "efficient cognitive processes that ignore information" (2009, p. 107).

Heuristics are particularly useful in two types of situation. First, in situations where complete information is not available or when processing complete information would be too time- or resource consuming. And second, when optimal results are not needed or cannot be expected to be achieved (e.g. due to the inherently bounded cognitive ability of the decision maker). Arguably, the activity of choosing an appropriate method in real-life projects typically fulfils both the abovementioned criteria.

2 Study

The reason for this study was a question of the Behavioural Insights Team that is part of the ministry of Infrastructure and Environment in The Netherlands (BIT-IM). This team is developing a method for policy makers to include behaviour into the equation when working on policy development and new interventions for policy implementation. In doing so, they wish to work as evidence based as possible, while equally supporting policy makers to think as creatively as possible. In working with their method to support this, they experienced difficulties in moving from analysis to synthesis: how to 'think creatively' about the issue without losing the scientific rigour embedded in the analysis? They asked us to investigate how different methods support this shift in the process, and argue how insights from this investigation could be used to improve their way-of-working and ultimately their method.

For this, we analysed and compared nine methods that deal to a greater or lesser extent with behaviour change. The three authors collaborated on this relatively small project, which took about sixty hours in total during roughly one month. Since time and budget were both limited, the setup of the research was done as pragmatic as possible. This meant for instance, that many of the methods included in the analysis were selected because one of the authors had experience with or knowledge of the method. Additionally, methods were selected based on an assumption that it would expand or complement the thinking of the members of BIT I&M. Regarding Figure 1, we made sure that we included methods that deal well with *clear-cut problems* and methods that are more suitable for *messy problems*. For instance, Design with Intent (Lockton, Harrison, & Stanton, 2010; 2016) focuses on redesigning existing products or services to change the behaviour that occurs in interaction. This immediately sets the stage for developing solutions. Whereas Frame Creation (Dorst, 2015; Dorst et al., 2016) focuses on reframing the (behavioural) issue at hand, which means large part of the design effort is spent on developing a new frame to understand the issue first, before any solution can be developed. Additionally, we ensured variety in *the model of the user* that is embedded within the method. For instance, Practice-Oriented Design (Shove, Watson, Hand, & Ingram, 2007; Kuijer, 2014) models people as part of and shapers of practices. It explains how people's actions are historically shaped over time due to interactions between cultural developments, the adaptation of the physical environment, and the development of human capabilities. Such a model, informed by sociological theory, explains a contextualized and detailed view of human beings. Whereas Brains, Behavior and Design focuses on fundamental theory about human decision making by distinguishing emotional, social and psychological factors that affect it. This method is heavily rooted in behavioural economics and models people as having bounded rationality. Finally, we ensured methods dealt differently with the shift from analysing the problem to generating solutions, since this was key for BIT I&M. We assumed policy makers would deal with this shift differently than designers do. Hence, we included the policy development method MINDSPACE (Dolan et al., 2010; 2012) next to our more

familiar design methods. Also, we included a very structured approach to solution generation, i.e., Systematic Inventive Thinking (Goldenberg, Horowitz, Levav, & Mazursky, 2003), since this would balance the more intuitive design approaches. An overview of the nine methods can be found in Table 1.

2.1 Approach

To study and compare the nine methods, we first developed method sheets for each method in which each method is described according to a predefined framework.

The framework defines 4 levels of abstraction on which a method can be described. The first, most abstract level was that of 'values and principles behind the method'. On this level, we described the values behind the way of working a method prescribes. For example, the persuasive systems design method emphasizes the value of 'transparency' in the way a solution aims to change peoples' behaviour from an ethical perspective. Similarly, the same method emphasizes the principle of 'working systematically' in making sure that the results from behavioural analysis inform the design of interventions.

The second level describes 'phases and steps', i.e. the process level. On this level, we described the main phases that were prescribed by the method, typically delineated by an intermediate deliverable, and the individual steps that ought to lead to those deliverables. For example, the Social Implication Design method prescribed four phases: 'debriefing', 'anticipating the future', 'goal setting' and 'developing the intervention', each with their own deliverable. Then, for each phase, a number of steps prescribe how to achieve those results.

The third level is that of 'tools, templates and models', i.e. the methodology level. On this level, we describe the tools, templates and models that are suggested to support the steps described in the previous level. For example, the Persuasive by Design model offers five behavioural lenses that can be used to support the organization of the insights from research into the target group's behaviour and to inspire idea generation later on in the process.

The fourth level is 'staging', i.e. the practical level of applying the method. On this level, we describe practical tips & tricks on how to apply the method in a real-life context and/or what to be aware of when applying the method. For example, the Social Implication Design method requires quite a high level of abstract thinking from its users, and thus the staging level included the tip to assess whether a team that is going to use the method is able and willing to do so.

For an overview of all the methods and their fundamental characteristics, see Table 1. For an example of a method sheet that describes one method in more detail, see Figure 2.

Table 2. Characterization of the set of methods used in the analysis

	Method	**Synopsis** (of the method):	**Paradigm underlying model of the user** (embedded in the method):	**Key values/working principles** (underlying the method):
1.	**MINDSPACE** (Dolan et al., 2010; 2012)	Mindspace is a framework that describes 9 ways in which policymakers can influence behaviour. The framework is embedded in a structured process for policy development, and is intended to emphasize behavioural components in existing policy development processes.	Rooted in behavioural economics	• Evidence-based Innovation • Iterate • Practice what you preach • Be context-sensitive
2.	**Persuasive by Design** (Hermsen, Renes, & Frost, 2014; Hermsen, Mulder, Renes, & Van der Lugt, 2015)	The method offers a set of 'behavioral lenses' that help to clarify behavior of a target audience. It does so by asking questions during the design process and by offering ideas for intervention strategies in a design. The behavioral lenses help to define how to approach a project, and with making informed decisions, contributing to a project's decisional accountability.	Rooted in cognitive/social psychology	• Cross-disciplinary collaboration • Define behaviour • Evidence-based
3.	**Brains, Behaviour and Design** (Pfarr & Gregory, 2010)	The Brains, Behaviour & Design toolkit offers methodological tools to understand and change decision processes. The toolkit offers a behavioural economics perspective on decision processes and behaviour and helps to come to testable solutions based on existing theory.	Rooted in behavioural economics	• Cross-disciplinary collaboration • Science-based design
4.	**Practice-oriented Design** (Shove et al., 2007; Kuijer, 2014)	The practice-oriented design method prescribes an analysis of individual behaviour as part of a social practice that is time- and context-dependent. Through the analysis, one sees behaviour as a performance constituting of meaning, skills and materials. The method suggests taking a wide scope for understanding behaviour and in doing so offers new opportunities to change behaviour.	Rooted in sociology	• Respect the complexity of behaviour • Accept small steps • Involve the end-user

5.	**Social Implication Design** (Tromp & Hekkert, 2018)	The Society-Centred Design Method is based on a tested method (Vision in Design) and distinguishes between a societal and individual user perspective, emphasizing that the core problem of much undesired behaviour is rooted in a conflict between individual and societal interests. The method focuses on achieving behavioural change through resolving such conflicts from a future-oriented perspective. The method requires the design team to take an explicit stance regarding the future perspective they take.	Rooted in science, yet informed by the context/Depending on method user	• Effect-driven (independent of the design manifestation) • Anticipate the future • Take responsibility
6.	**Frame Creation** (Dorst, 2015; Dorst et al., 2016)	Frame Creation is a method that helps to tackle today's open, complex, dynamic and networked problems in organizations. It applies 'design thinking to generate new approaches to understand - and frame - the problem situation itself.	Depending on method user	• Study the context • Postpone judgement • Embrace complexity • Zoom-out, expand and concentrate on themes • Seek patterns • Detail themes • Clarify frames • Be prepared (the process takes time and effort)
7.	**Design with Intent** (Lockton, Harrison, & Stanton, 2010; 2016)	The Design with Intent toolkit helps to understand environments, products, services and systems to guide behaviour and to consciously design interventions. The toolkit contains a card set, worksheets and 8 lenses that can be used to view design for behavioural change. Each lens helps to recognize different patterns of behaviour, with a total of 101 patterns.	Variety of models	• Be aware of your model of the user • Use your influence responsibly
8.	**Persuasive System Design** (Oinas-Kukkonen & Harjumaa, 2009)	Persuasive system design integrates theories and principles of persuasion. The method offers a way to develop interactive technology (called Persuasive Technology). The work is focused on how technology can be used to change behaviour, yet offers a	Rooted in social psychology	• Be transparent • Be true to human principles (interventions cannot be too intruding, unusable, or useless)

		way to systematically develop interventions in other domains as well.		• Be precise • Work systematically
9.	**Systematic Inventive Thinking** (Goldenberg et al., 2003)	The Systematic Inventive Thinking method helps to come to come to new ideas in a systematic manner and with available means (inside the box). The method supports the manipulation of existing products or services using 3 starting points, 5 thinking patterns, along 6 steps.	Depending on method user	• Closed-world principle • The innovation sweet-spot (balancing newness and acceptability) • Function follows form

Figure 2 The Persuasive by Design model (Hermsen, Renes, & Frost, 2014).

The improved understanding of the nine methods allowed for more systematic comparison between methods. Since BIT-IM was especially focused on methodological support for moving from analysis to synthesis, we compared methods for each of the first three stages in de double-diamond model: discover, define and develop (see Figure 3).

For the discovery stage, the leading question was: what type of approach to information gathering does the method promote? For the define stage, leading question was: how is the designer supported in making decisions? For the develop stage leading question was: how does the method structure ideation? In comparing the different ways in which the methods supported each staged, i.e., the discover, define or develop stage, we recognized distinct differences. For instance, in the

discovery stage some methods help to better understand the behavioural problem at hand, while others support a broader investigation of opportunities for behavioural change.
Answers to these questions were generated by the first and last author, and discussed and refined through an iterative process with the second author. For each of the three stages, we eventually identified two dimensions that helped to describe how this stage could be supported by a method in different ways. Finally, these dimensions have been discussed and evaluated with BIT I&M. In the next section, we will present the results.

Figure 3 The figure shows which stages of the Double-Diamond model are supported by each of the nine methods.

2.2 Results

For each stage, we identified two dimensions that helped to describe the different ways in which methods support discover, define and develop-related activities. These two dimensions can be depicted as two axes, resulting in a graph in which each of the method can be plotted. As such, it visually presents commonalities and differences between methods. Next, we will explain these graphs for each of the stages. But before doing so, we wish to stress that placement of the methods are indicative, and should foremost be seen as a starting point for discussion rather than an uncontested truth. Our main goal is to highlight the dimensions of the graphs, and their potential value in generating heuristics for selecting and using methods for behaviour change.

2.2.1 Discover-stage

For the stage of discovery, at the start of the project, we saw variety in the approach to discovery each method supported, along two lines: the way each method defined or expanded the scope of the research, and what type of design research it supported or stimulated.

The scope refers to a problem-focused scope on the one hand, and an opportunity-driven scope on the other (see Figure 4). What we see is that methods that are grounded in behavioural sciences and then transformed to design methods generally focus the research around the problematic situation. They help to better understand and actually deconstruct the context in which the problematic behaviour arises. On the other hand, methods that are originally design methods that allow or even stimulate knowledge from the behavioural sciences to enter the process, support opportunity-driven research in the discovery stage. In such an approach, not only the context of the behavioural problem is relevant, but even more so the broader context that may reveal levers for change. In such an approach, information may serve inspiration rather than explanation, and as such, information is not necessarily relevant, but *potentially* relevant.
The type of research that is encouraged through the method can vary from being driven by empirical data to being driven by theory. Some methods encourage empirical research within the context of use and with people whose behaviour is targeted for change, embracing the complexity of reality. Other methods rely strongly on theory from the behavioural sciences and emphasize the value of generalizable principles. However, it follows logically that there must also exist behavioural design methods that explicitly call for both, stressing the importance of linking theory to the context of application.

Figure 4 Organisation of the behavioural methods along two dimensions that describe relevant ways of working during the discover phase: work problem-focused versus opportunity-driven, and focusing on theory versus engaging in empirical research for behavioural insights.

2.2.2 Define-stage

For the stage of defining the focus or goal of the design project, we first of all observed that very few methods explicitly support this stage in design for behaviour change (i.e., only four of the nine methods, see Figure 5). Most of the methods consider the outcome of the discovery stage the start of the development stage, where the design team should be able to define focus without any support. However, in moving from analysis to synthesis, the bridging step of 'defining' may actually be quite crucial. In comparing the four methods that do explicitly support this stage, we see variation in how the design team is supported in defining the goal. On the one hand we see methods that allow for decisions to be guided by the designer's intuition. However, especially the methods grounded in the behavioural sciences promote a rational and nearly deductive form of reasoning to define the design goal. Yet, this deductive reasoning may actually conflict with the reasoning form that underlies design reasoning, which is called 'design abduction' and which is needed to generate original and appropriate solutions (Dorst, 2011; Roozenburg, 1993). On the other hand, we see a difference in the role of values in taking this decision. Some methods consider design decisions

informed by science as value-neutral decisions, while others explicitly support designers to let values enter the design process and guide decision making.

Figure 5 Organisation of the behavioural methods along two dimensions that describe relevant dispositions in the stage of define: be driven by ratio versus intuition, and be value-neutral or value-driven.

2.2.3 Develop-stage

For the development stage, we see mainly a difference in guidance in two ways: in their directive style, and in how they structure this stage (see Figure 6). Some methods are letting the designer free, supporting a divergent way of generating design ideas based on processes of association: opening up as many possible routes to solving the problem as possible. Such methods aim to help generate a high number of ideas across the solution space. Other methods are actually limiting the designer, supporting a more convergent process of ideation. In this case, the designer is guided by stimulating strictness in coherence with previous stages. For instance, the development of ideas is guided by a vision of its interaction with people, a selected analogy that fits with this vision, or the underlying frame or working principle. While both can have a clear behavioural goal to start from, convergent processes narrow down and actually 'limit' the number of ideas by becoming more specific in defining how the goal should be achieved.

Additionally, methods can support a step-by-step way of working, building a clear rationale for accepting or rejecting proposed ideas. Or they are more open-ended, and trigger a reflective attitude with designers. The latter methods allow for a process in which design ideas may be proposed 'out of the blue', and where a rationale for selecting or rejecting the idea emerges from the ideation activity.

Figure 6 Organisation of the behavioural methods along two dimensions that describe relevant forms of generating ideas: systematic generation versus emergence, and free association versus working vision-driven.

2.3 Conclusion

The axes presented in figure 4-6 help to understand what way of working can be supported through a method for each of the three stages. As such, we imagine they can serve as heuristics for designers and other method users in deciding which method to choose. That is, they will help anticipate which method will fit one's personal way of working and the design task at hand. In ordering these heuristics, and exploring how they might guide method selection in practice, we distinguish two types of heuristics: process heuristics, and method heuristics. Process heuristics refer to dimensions about the general process to follow that are quite dominantly shaping one's approach. The method heuristics describe variations of taking steps within the process. We therefore anticipate it will be most beneficial to first work with the process heuristics to define a sub-set of suitable methods, followed by the more detailed method heuristics to define specific ways of working within that process (see Figure 7).

2.3.1 Process heuristics

The first step in choosing behavioural design methods, is to determine what kind of underlying process is desired or required. We defined two heuristics that support practitioners with this choice. The first heuristic helps to determine the nature of the first stage of a behavioural design process, covering the 'discover' and 'define' phases (see Figure 7). The second heuristic helps to determine the nature of the second stage of a behavioural design process, covering the 'develop' phase.

Heuristic 1: Problem-focused versus opportunity-driven scoping (Do you wish to work analytical and design more like an engineer, or are you more a design thinker and wish to allow for reframing the brief?)

Heuristic 2: Free association-driven versus vision-driven development (Do you like to brainstorm and allow for anything during ideation, or do you wish to work more vision-driven?)

2.3.2 Method heuristics

The second step in choosing behavioural design methods, after the underlying process has been determined, is to choose the specific methods that can support practitioners to perform the chosen process.

Heuristic a: Empiricism versus theory (Do you wish to do empirical research or are you more a theory-minded person, and what does the design brief require?)

Heuristic b: Intuition-driven versus ratio-driven definition of the goal (Do you prefer to take decisions rationally, or do you rather work more intuitively?)

Heuristic c: Value-neutral versus value-driven decisions (Does the brief require moral positioning, or do you wish to make values explicit, or not?)
Heuristic d: Systematic generation of ideas versus emergence (Do you wish to structure ideation, or are you more chaotic yet reflective?)

Figure 7 The Double Diamond model and how each of the two process heuristics shapes it. Additionally, the four method heuristics describe the various ways of working within the discover-, define- and develop-stage.

3 Discussion

The study in this paper should be seen as an attempt to advance methodological knowledge in design for behaviour change. Even when the rigour and internal validity of some of the behavioural design methods are well developed, their use in practice reveals issues academics have not yet found the answers to. The study presented in this paper dealt with one of these issues: the difficult shift from analysis, informed by behavioural science, to synthesis, driven by design thinking and the ways in which this is supported by a set of methods. In this section, we discuss the results of this study. We discuss the potential implications of these heuristics for the field of behavioural design, address the limitations of the study, and explore some avenues for future research.

3.1 Implications for research and practice

First and foremost, the heuristics proposed in this paper are intended to increase the understanding of students and professionals of the value of various methods and how they may differ. This understanding should support better selection and application of methods in design based on what way of working they support. A better awareness of and reflection on method usage is expected to benefit both the professional development of designers and behavioural design practice. However, we have not yet evaluated these heuristics, nor do we consider these heuristics conclusive. But since BIT-IM has expressed their appreciation for the delivered work, our colleagues have responded

positively to the work, and since we often refer to the heuristics in teaching design students, we wish to put forward the work for academic discussion.

Besides practical value, we hope to inspire design methodologists or academics in the field of design for behaviour change to consider the staging of their behavioural design methods. A better introduction of the methods we develop does not only improve the selection and use of methods in practice, it also helps to better assess and ultimately develop them. We can become more focused and targeted in both research and design when we explicate more specifically the paradigms, values and principles that have guided the development of the method.

3.2 Limitations and future research

It goes nearly without saying that this study is a limited study. As such, we do not claim we are conclusive, nor that the presented heuristics have shown to be valid. In fact, we very much intend to study them further and invite feedback and criticism. In fact, based on our reflection upon this study, we recognize two important avenues for future study.

First of all, the type of integration deserves closer study. Behavioural design integrates the behavioural sciences and design practice (including the design of policy), but there is still little knowledge on how this integration exactly happens or should happen to optimize performance. How to integrate deductive insights in design abduction? Through this study, we have witnessed great differences. Methods that are grounded within the behavioural sciences often support application of insights to design, whereas methods grounded in design thinking rather seem to support incorporation of behavioural insights within the design process. This is a big difference. It deserves further study to describe these differences in detail, find out what other forms of integration could be developed, and study how this affects behavioural design performance for whom, for what tasks and in what context.

Second, we see methods that rely on a single paradigm for behaviour change, systematically bridging this one viewpoint to design. Although such methods are often structured well and are internally consistent, they seem to run opposite to the fact that design is transdisciplinary by nature. Design teams generally incorporate insights from multiple disciplines to get grip on the issue at hand. In fact, the notion that behavioural design support should allow for multiple theories to adhere to as designer, and therefore allow for various models of people to design for, is often expressed (e.g., Bartholomew Eldrigde, Markham, Ruiter, & Parcel, 2016; Cash, Hartlev, & Durazo, 2017; Lockton et al., 2012). Limitation to only one behavioural viewpoint to the matter, whether it is a behavioural economic point of view, or a practice theoretical point of view, will obstruct natural behaviour of designers in creative resolution. We consider it crucial to better study how a science-driven paradigm of behavioural design can evolve without negotiating some of the key characteristics of design.

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Rational Overrides: Influence Behaviour Beyond Nudging

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Service designers and organizations are struggling to understand and change customer behaviour since it is complex, dynamic, multidimensional and very often not considered to be rational. Knowledge from behavioural sciences can provide service designers with the ability to more fundamentally understand, predict and guide customer behaviour. A combination of qualitative and exploratory methodologies was used in order to develop a design approach that supports service designers to create behavioural interventions across customer journeys. While service designers increasingly leverage the insights of behavioural science for designing nudging interventions, we propose that different efforts are needed to increase the chances of having a durable impact on behavioural change. We propose the inclusion of rational overrides in service design as an additional approach for influencing behaviour. Rational overrides introduce micro moments of friction in the customer journey, which can be used to disrupt mindless automatic interactions, prompt moments of reflection and more conscious decision making. This research resulted into a design toolkit to support service designers, clients and stakeholders to understand and design behavioural interventions by combining nudges and rational overrides.

service design; rational override; behavioural design; nudging

1 Introduction

Service design is a holistic, multidisciplinary and integrated design approach in which new services are created or existing ones are improved. The core value of service design is using customer insights - their needs, expectations, beliefs and behaviours - to design useful and desirable services that are effective as well as efficient for organizations (Moritz, 2005; Sleeswijk Visser, 2013). In essence, the effectiveness and value of a service relies, to a large extent, on the decisions and behaviours of the people that interact with the different touchpoints (Fullerton, 2009; Payne et all, 2008). All the different interactions between the customer and a service create the overall customer experience (Poline et al, 2013). The customer experience is based on peoples' personality, internal state and prior experiences. While service designers cannot design the actual customer experience, they can

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design the environment around it. In order to create the best possible conditions for a positive customer experience it is key to understand customer needs and behaviours. Service design methods and tools, such as customer journey mapping, customer shadowing and service safaris, are currently used to generate insights about what people do and want. However, these methods do not offer a fundamental explanation on why people behave the way they do. Knowledge from behavioural sciences can provide service designers with the ability to more fundamentally understand, predict and guide customer behaviour (Naumof, 2014).

1.1 Using nudging interventions to influence behaviour

Customer behaviour can be explained and influenced if we understand the underlying decision-making processes that determine if, and how, people will act (or not). Behavioural economics, a discipline that bridges economics and psychology, is focused on these individual, cognitive driven behaviours and decision-making processes. Making good decisions requires large amounts of brain capacity since we need to weight the pros and cons, possible alternatives and our own motivations and needs. Therefore, people tend to rely on their instinctive subconscious mindset when making decisions (Kahneman, 2011; Zaltman, 2003). Within this mindset people are guided by mental shortcuts and therefore use limited cognitive capacity. These mental shortcuts are universal, based on core capacities of the brain and strongly influenced by the context (Gigerenzer & Gaissmaier, 2011). By understanding the mental shortcuts that take place in a particular service environment, service designers have the ability to create behavioural interventions that help and guide customers in predictable ways to make 'more optimal' decisions and create better experiences.

In an attempt to influence customer behaviour, service designers have increasingly experimented with nudging interventions. Nudges are interventions that stimulate individuals' specific cognitive boundaries, biases, routines and habits, to influence people's judgement, choice and behaviour in a predictable way (Hansen, 2016). Nudges help to reduce choice overload, redesign confusing interfaces and remove unnecessary steps from the process to create frictionless customer experiences. These simple interventions make information or a particular behaviour really easy, attractive or social. Nudges can support service organizations and service designers to, among others, quickly resolve adoption problems, smooth channel migration and streamline operations.

1.2 Disadvantages of nudging in a service environment

Although nudges have been proven to be very effective, they are not always scalable, sustainable or suitable to apply in a service context. First of all, nudges only work in the present moment and in a stable context as they are designed to effect immediate behaviour (Dholakia, 2016; Strassheim, 2016). Nudging customers to a desired direction is only effective within a specific touchpoint and will not likely stretch beyond it (Bisset & Lockton, 2010; Stutzer, 2011; Hansen & Jespersen, 2013). Since nudges facilitate automatic and subconscious thinking it can only change behaviour in the environment in which the nudge is present. Services are inherently dynamic; customer move from one touchpoint to another. In order to change customer behaviour in a service context, multiple nudges would need to be present across different touchpoints. As customers move through a service in a nonlinear manner across channels, touchpoints and over different periods of time it is far less predictable and thus difficult to effectively integrate nudging interventions.

A second disadvantage is that nudges can make customers lazy and inactive. Using nudges to create frictionless experiences will result in customers that use less and less cognitive capacity to perform certain tasks. These frictionless interactions make that the decisions a customer takes go unseen, unnoticed and unprocessed. If customers are exposed to an overflow of nudges it can result in 'excessive convenience' that makes them lazy and disengaged (Bovens, 2009; Schubert, 2015). Moreover, since nudges stimulate decisions through inaction they are less likely to result into the committed follow-up that is often useful for implementing new behaviours or habits (Keller, 2011; Fowlie, 2017). However, most service organisations want to stimulate an active and engaged customer base that frequently interacts with the service.

Thirdly, nudges do not require customer input and are primarily created according to a one-size-fits-all approach. Nudges are completely provider let (service organisations determine the desired behaviour) and do not require or request active customer input. Changing customer behaviour by nudging can be effective when a single unified outcome is the optimal course of action (Botti & Iyengar, 2004; Dholakia, 2016). However, as most organizations serve customers with different characteristics and needs they require more than a one-size fits all approach. In some situations, nudges can hinder people from making a conscious decision that fits their personal situation best.

Finally, nudges do not increase the customer experience. Nudges facilitate automatic subconscious thinking and they make that the decisions a customer takes can go unseen, unnoticed and unprocessed. Nudges will thus not increase a decision maker's satisfaction and experience (Botti & McGill, 2006; Keller, 2011). A service is an interactive exchange between the provider and user over time in which value is co-created (Payne et all, 2008; Reckwitz, 2002). However, nudges do not require customers to be aware, let alone be involved in, the value creation process. Therefore, nudging customers into desired directions might not increase the perceived value and customer experience of a service.

1.3 A service design approach towards creating behavioural interventions

If service organizations objectify to create an endured behaviour change it requires customers to get out of the status quo, make an active or individual decision it is essential to get the customer in the right mindset at the right time. The objective of service design should thus not be to facilitate automatic and fast thinking alone but to also include behavioural interventions that can stimulate people to switch to more deliberate and conscious thinking when necessary. See figure 1.

Figure 1. Behavioural interventions can influence behaviour in two ways. Nudging interventions stimulate the activation of specific mental shortcuts in the unconscious, automatic mindset and guides customers to a single predictive outcome. Rational override interventions use micro moments of friction to disrupt users' mindless automatic interactions and stimulate conscious individual decisions making.

Based on the results of this research we propose an alternative design approach towards creating effective behavioural interventions in services. In this approach two types of behavioural interventions (nudges and rational overrides) are combined across a customer journey to either speed up or slow down the user's momentum. The interventions in this design approach do not only facilitate automatic and fast thinking but can, when necessary, switch customers to the conscious state. People can be prompted to switch to the conscious state by implementing micro moments of deliberate friction in the customer journey. We refer to these micro moments of friction as rational override interventions. They can be used to disrupt mindless automatic interactions, prompt moments of reflection and stimulate conscious decision making. These type of 'mindful' interventions have been reported, and are known in the behavioural literature, as debiasing interventions (Jolls and Sunstein, 2004), mindful nudges (Ly, 2013), system 2 nudges (Sunstein, 2015) and inclusion nudges (Nielsen, 2016). Additional literature research showed that in the UX and design discipline interventions like these are referred to as frictional feedback (Laschke, Diefenbah &

Hassenzahl, 2015) and micro boundaries (Cox & Gould, 2016). In comparison to nudging there has been limited attention for behavioural interventions that opt to make people consciously aware of their behaviour. However, different scholars have highlighted the potential of these mindful interventions, but indicate that more research is needed (Sunstein, 2015; Strassheim, 2016).

This paper describes our efforts to integrate these two types of behavioural interventions in the service design process. To achieve our goal, we used a combination of qualitative, exploratory methodologies that resulted into a toolkit consisting of five templates, two card sets and two databases to support service designers, clients and stakeholders to understand and design behavioural interventions by combining nudges and rational overrides. The toolkit enables designers to create tailor-made solutions that fits both the customer, business and organization. The proposed approach and toolkit is the first step towards systematically applying two different types of behavioural interventions across customer journeys to influence (and eventually change) behaviour, and should be interpreted as such.

2 Methodology

In order to understand how service designers can integrate behavioural knowledge into the design process to influence customer behaviour, an exploratory research design was performed (Yin, 2013). The research included a multi-case study at a service design consultancy to review the current design process, activities and tools used to include behavioural theory in the design of services. An additional goal was to identify how service designers can be best supported to design behavioural interventions. The case studies have been executed at one of the first service design consultancies and has offices in London, Oslo and Rotterdam. The company is dealing with both private and public-sector projects, which generate a wide range of design briefs. A purposeful sampling technique was used since there were limited cases at the case company in which behavioural science has been intentionally applied and to be sure to get information-rich cases (Patton, 2002). Seven cases were selected on the condition that these were completed cases, varied across sectors, performed by different designers and include both explicitly and implicitly uses behavioural economic principles.

These case studies were complemented by a series of semi-structured interviews with experts in applying behavioural knowledge to create behavioural interventions. Three experienced practitioners with different backgrounds and from different sectors were interviewed to generate insights into the development and implementation of behavioural interventions.

2.1 Data collection and procedure

2.1.1 Multi Case study analysis

The data in the case study analysis have been collected by means of desk research and semi-structured generative interviews with designers and clients. Triangulation was used in order to minimize bias and strengthen the findings of the research (Yin, 2013). Triangulation was achieved through the use of multiple data sources: designers as well as clients were interviewed to capture multiple perspectives on the phenomena. The desk research was used to create an initial understanding of the projects and create focus for the subsequent interviews. The desk research included a review of the information that was used and created during the projects; including presentations, workshop assignments, designs, brainstorms, user interviews, reports and summaries of knowledge about behavioral sciences. The findings from the desk research were used to create a thematic guide for the interviews in order to make sure important topics were included (Patton, 2002).

Subsequently, designers and clients were interviewed in order to understand the design process, success factors, challenges and ways on how to best support them in behavioural projects. Rich and anecdotal information is required in order to provide a throughout understanding of the current projects and design process (Eisenhardt, 1989). Therefore, a generative research approach, called context mapping, was used to acquire deep understanding of user needs. Context mapping can help

to capture emotional responses and deeper levels of knowledge from participants by letting them create designerly artifacts such as collages and drawings (Sanders & Stappers, 2008; Sleeswijk Visser et al., 2005).

Six designers were interviewed about seven different cases, as one of the designer was involved in two cases. Prior to the interview, designers received a sensitizing booklet with 4 small assignment to help them to reflect on the project and express their experiences. The subsequent interviews were semi-structured and involved two generative assignments that build upon on the assignment in the sensitizing booklet. All interviews were voice recorded and notes were taking during the interview. As sensitizing was not possible, the clients were only involved in one our generative interviews. The assignments and questions were similar to that of the designers. From two of the seven cases, it was not possible to interview the client. Thus, these cases were only used as additional verification of findings in the cross-case analysis. Again, voice recordings and notes were taking during the interviews.

2.1.2 Expert interviews

Next to the case studies, three experts were interviewed about the different applications of behavioural economics, development of interventions, ethical considerations and opportunities and challenges in the field of behavioural economics. While the three interviewees represent a small sample, care was taken to include different perspectives. Two interviewees, one with a social psychology background and one with a management background, are active in the private sector. One member of the Dutch 'behavioural insights team' was interviewed to include insights from the public sector. A thematic guide for the semi-structured interviews was created based on a literature study. The interviews were exploratory in nature and were voice recorded.

2.2 Data analysis

From the audio recordings statement cards were created and used for an analysis 'on the wall' (Sanders & Stappers, 2013). To become familiar with the individual cases and find patterns in each case a with-in case study was done. This first analysis was done by clustering the statement cards in themes and finding relationships between the themes. The themes are part of the findings as they were not based on a predetermined theoretical framework but come directly from the participants. This within-case analysis accelerated the cross-case comparisons. The themes and relationships of the individual cases were compared to allow for general patterns to emerge. The themes were based on (dis)similarities and quantity of insights that were gathered. The insights from the case study and expert interviews were synthesized into a systematic design process and guidelines for a behavioural design toolkit.

2.3 Toolkit development

The results of the exploratory research revealed that service designers and clients have a strong need for a systematic design process and practical tools in different parts of the design process. Up till now, projects have been of an experimental nature. In order to apply the behavioural theory, different approaches, methods and tools are used by service designers. Due to the increased interest in behavioural science in the field of design dozens of models, short-lists and tools have been emerging. These behavioural based tools are generally focussed on either behavioural theory (like the behavioural model of B.J. Fogg), a behavioural design process (like the Design for behavioural change from Stephen Wendel) or execution (like the EAST cards from the behavioural insights unit in the UK). While these different behavioural tools have shown significant opportunities in different domains there is yet not an approach focused on the design of interventions in a service context in which the organizational, business and customers experience perspective is taken into account. The insights from the case study were used to visualise a process overview, that includes the general steps and phases a service designer has to go through in order to create behavioural interventions. Although none of the processes described in the research were exactly the same, but the

approaches and steps showed large similarities. The activities, supporting resources and needs of designers and clients were plotted on the process overview.

The process overview was subsequently translated into four clear design requirements for the toolkit. These guidelines were used as a starting point for the development of the toolkit through a series of brainstorm and validation workshops with design students and design professionals. The first workshop included an exploration into the possible activities, visualizations, structures and forms design tools can have. Different behavioural models, the dual system theory, nudge cards and cognitive biases were evaluated on usability, effectiveness and possible opportunities for integration. The resulting toolkit prototypes have been progressively improved through validation sessions and design iterations with designers, clients and experts. The outcome is a toolkit consisting of five templates, two card sets and two databases to support service designers, clients and stakeholders to understand and design behavioural interventions by combining nudges and rational overrides. In the next paragraphs, we will focus on the part of the toolkit where the rational overrides are introduced and combines with the nudging interventions for the design of successful services.

3 Behavioural Intervention Design

This research integrates nudging interventions and rational overrides in a service design toolkit that enables service designers to fundamentally understand behaviour and design interventions that can influence, and eventually, change behaviour. The behavioural intervention design process consists of six phases, which are related, and complementary, to current phases in a service design process. The toolkit, consisting of five templates, two card sets and two databases, can be used by designers to create a strategy, conduct a behavioural analysis and generate ideas for behavioural interventions.

3.1 Guidelines for a service design toolkit

The insights from the exploratory research were translated to clear design guidelines for the toolkit. In order for the toolkit to effectively support service designers in creating rational overrides and nudges it should fit the following criteria.

- *The toolkit should facilitate co-creation*, as behavioural projects require a high level of client and stakeholder involvement. Co-creation workshops can stimulate clients to generate a feeling of ownership and engagement, which will increase the chances of successful implementation.
- *The tools need to be practical and flexible in use*. As the tools will be used by different people and in different types of projects, the tools in the kit should be modular, adaptable and easy to explain.
- *The toolkit should be supporting people with different levels of behavioural knowledge*. The tools must be accessible for people with no knowledge of behavioural theory but also need to support experience designers to get more in-depth insights when necessary. Thus, the tools should balance abstract theory, in-depth insights, with actionable steps and practical examples.
- *The tools should enable designers to think on abstract as well as more detailed levels*. While the design of behavioural interventions requires a micro perspective, it is important to integrate the more holistic insights of organizational challenges and effects on the overall customer experience.

3.2 Behavioural Intervention Toolkit

In order to create effective behavioural interventions, it is important to first understand behaviour and the underlying mental mechanisms. Applying behavioural principles should

not simply be about intuition or trial and error, but requires a systematic design approach. Therefore, we have created a design process consisting of six phases – from strategy development, behavioural analysis, synthesis, idea generation, creation and validation. The phases are deliberately linked to existing phases in a service design process in order to align the activities and increase the changes of adoption. In general, all service design projects resemble the four main stages of the double diamond model (Moritz, 2005). Therefore, similar divergent and convergent stages are included in the behavioural intervention process. Table 1 shortly describes the different phases and elements of the supporting toolkit. No specific tools were developed for the create, validate and implement phase since the activities in these phases vary greatly and are strongly depended on the running time and budget of a project.

Table 1. The Behavioural Intervention Design process consist of six phases. For the first four phases, behavioural intervention tools are developed to support service designers. The behavioural toolkit consists of 5 templates, 2 card sets and 2 additional databases. The activities, behavioural tools, additional tools and outcome are presented per phase.

Phase	Activities	Tools from toolkit	Additional tools and materials	Outcome
Phase 1: Determine scope & strategy	Based on business objectives and organizational challenges of a client a clear scope, target behaviour and customer segment can be identified.	▶ Behavioural Intervention Canvas ▶ Behavioural Strategy Tool ▶ Customer Segment Template	Use an existing customer journey's to explore multiple unwanted behaviours and customer segments.	A target behavioural statement for one (or multiple) customer journeys for a specific customer segment.
Phase 2: Behavioural analysis	Analyse the unwanted behaviour to understand the underlying mental mechanisms. The influencing factors of the behaviour can be used to create direction for subsequent user- and context research.	▶ Behavioural Factor Template ▶ Behavioural Factor cards ▶ Cognitive Biases database	Based on the influencing factors, qualitative context and user research methods can be used.	Key behavioural factors that influence the unwanted behaviour and qualitative user insights.
Phase 3: Insights integration	Integrate insights from the behavioural analysis, user- and context analysis on a journey map to find key moments to influence the behaviour.	▶ Behavioural Journey Map	Use customer journey mapping activities to create a complete overview of the customer journey.	Key moments to influence behaviour across the customer journey.
Phase 4: Idea generation	Generate ideas for behavioural interventions for the key moments in the customer journey.	▶ Behavioural Intervention Strategy Cards ▶ Behavioural Intervention Strategy Database	Use ideation methods and tools support the idea generation process.	Ideas for nudging and or rational override interventions.
Phase 5: Create and test intervention	Select promising ideas and create multiple variations of the interventions.		Use quick prototypes to test the effects with real users. Focus on qualitative insights and results.	Multiple variations of interventions and qualitative insights that fuel iterations.
Phase 6: Validate and implement	Combine interventions across a journey to test for quantitative results.		Randomized control trials and before-after measurements.	Quantitative results on effect of interventions.

The behavioural intervention toolkit can be used in multiple ways; ranging from applying the templates or card sets individually during some of the phases in a service design project, to using all the tools consecutively throughout a whole project. The tools are modular and can be seen as

‘building blocks’ to support designers in different phases of a project. Depending on the client, case and resources, the toolkit can either be used in project or workshop mode. The tool activities are largely the same, but the amount of time, research and iteration can be adjusted to match the clients or project needs. It is suggested to use the tools over longer periods of time and in separate co-creation workshops. This enables designers to make iterations and acquire more in-depth (scientific) knowledge on the subject. The majority of the tools in the toolkit are developed to support designer, clients and stakeholders in co-creation workshops. However, it is recommended to have internal moments of refection, integration and iteration with designers alone.

Figure 2. (parts of the) Behavioural Intervention Toolkit in use by design students in a co-creation workshop.

The behavioural Intervention design canvas, behavioural strategy tool, customer segment template and behavioural journey map are relatively simple templates that support designers to structure the process, integrate insights and communicate the process and results to the client. The templates enable designers to explore and select the scope, target behaviour and key moments in the customer journey by providing guiding questions.

The behavioural factor template and accompanying behavioural factor card set supports designers to analyse the current unwanted behaviour of customers. The tool integrates insights from behavioural economics, consumer behaviour and social psychology in 20 influencing factors of behaviour, divided in three main categories. The well-established Motivation-Ability-Opportunity model (MacInnis et al., 1999; Ölander and Thøgersen, 1995) and Dual-system theory (Kahneman, 2011) were used as a foundation for this analysis tool as these models are rather simple, applicable to almost any type of behaviour and encompass both individual-level and environmental influences on behaviour. The behavioural factor template and cards can be used in a co-creation workshop to explore the unwanted behaviour and select the most important factors that influence it. If designers require additional knowledge they can consult the cognitive biases database, which includes over 200 cognitive biases categorized in 20 influencing factors of behaviour. The behavioural factor analysis can be used to create direction for subsequent user- and context research.

In the ideation stage, designers and clients work together to generate ideas on appropriate interventions to lead customers towards desired behaviour. Our findings indicate that, in order to change behaviour effectively, nudging is not sufficient and should be combined with rational overrides that inject moments of self-awareness and conscious decision making during the customer journey. To reach this goal we developed a card set to support designers in the ideation stage. The

card set includes 9 rational override strategies and 17 nudge strategies categorized on the three main behavioural factors that are corresponding to behavioural analysis. Different nudging tools, existing categorisations, a variety of nudge examples and the results from the exploratory research were evaluated to select relevant strategies for service design. The cards are colour coded, include an easy to understand visual, provide specific strategies for interventions and illustrate a real-wold example on the back. Figure 3 shows an example of a card for a rational override. Additionally, a database was created in which over 140 categorized examples of nudges and rational overrides are described.

Figure 3. The Behavioural Intervention Strategy Card Set includes 9 rational override and 17 nudge strategies, categorized in the 3 main behavioural factors; environment, motivation and ability. The front and back of one rational override strategy is shown in detail.

4 Rational overrides

The interpretations and applications of rational overrides vary greatly. From top-down debiasing skills, tricks and training (such as prompting people to think about alternatives by providing information or educating people about biases) to more bottom-up approaches like situated, frictional feedback embedded in products (Laschke et al, 2015). We propose the following working definition of a rational override, which includes elements of different existing definitions:

> *A rational override is a small moment of intentional friction that attempts to influence people's behaviour or decision-making by intervening automatic thinking and activating reflective conscious thinking.*

The interventions from our case studies, an additional literature study on deliberate friction and desk research into examples of behavioural interventions that stimulate conscious decision making resulted in a collection of 45 rational override examples. We clustered and rearranged the examples several times, until a set of nine rational override strategies was created. See figure 4. Some of the strategies originate from nudging tools, such as the EAST card set of the Behavioural Insights Team in the UK. Although they are currently categorized as nudges, additional literature research into these

strategies revealed that the underlying mental mechanisms fit better with rational overrides. The basis for all nine intervention strategies stems from academic literature and are all reflected in real-world service examples.

1. Extra decision points
By adding extra decision points at the right time people have the possibility to become aware, take a step back and re-evaluate the decision or behaviour at hand. It helps to establish boundaries that can minimize the risk of making a mistake or undesired decision (Cox & Gould, 2016).

2. Functional friction
Include small additional steps in the process to disrupt mindless automatic interactions. People are asked to put in a little bit extra effort to get to their goal (Cox & Gould, 2016; Laschke, Diefenbah & Hassenzahl, 2014).

3. Create commitments *
Let people create a specific commitment to achieve a certain behaviour before they have to perform it. Make the commitment detailed and action oriented (Hansen &Jespersen, 2013).

4. Relative ranking
Provide customers with personalized data, including their rank, in comparison to the performance of similar others. A relative rank can increase the personal relevance of information and thus stimulate conscious thinking. (Hansen & Jespersen, 2013; Frey & Rogers, 2014)

5. Enhanced active choice

Stimulate people to make an active choice in a desired direction by highlighting losses incumbent in the non-preferred alternative (Keller, 2011).

6. Checklists *

Simplify how information is presented in order to make it easy for people to remember and use. Simple checklists for important multistep procedures are effective reminders and useful in preventing errors (Hales & Pronovost, 2006)

7. Personalized feedback *

Personalized feedback prompts people to reflect on their behaviour since it this type of data is highly relevant to them and they perceive it to be of increased value, as it has taken some effort to produce (Frysak, J., Bernroider, E. & Maier, 2016).

8. Real-time feedback

Real-time feedback makes people consciously aware about what is going on. It can show the consequences of current actions and encourages to adjust and improve behaviour (Hansen &Jespersen, 2013; Wendel, 2013)

9. Alerts
Alerts and reminders can be used to make people aware, help them to remember important actions or persuade people to perform desired behaviour. Alerts and reminders work as feedforwards and could be implemented as sounds, visuals, push notifications or objects in the environment that stand out (Jung & Mellers, 2016).

*Figure 4. Nine rational override strategies emerged from the case study analysis and additional literature on functional friction. * These strategies are currently used in tools as nudging interventions, such as the EAST cards, IIT institute of design cards, Artefact strategy cards and Design with Intend toolkit.*

Friction is generally thought off as a barrier to perform the desired behaviour. For instance; due to confusing interfaces, unnecessary steps and choice overload. It is common practice to remove these points of friction and opt for a seamless experience. However, not all interactions require the speed and usability of frictionless experiences. Some situations require users to slow down, focus on the decision at hand and understand the options that they have. In these situations, friction is not bad, it is necessary. The surge pricing model of Uber is a good example of how a frictionless experience can turn into a negative customer experience. Although, Uber did tell users that prices were higher because of increased demands people ignored, or not even consciously processed, the information. This resulted in dissatisfied customers since they were negatively surprised by higher fares. The experience turned out to be too smooth. To avoid this, Uber introduced a micro moment of friction; the app forces users to type the correct surge price to confirm that they are aware of and consciously accept the increase (as seen in figure 5). This patented method of 'forcing' users to manually agree to the higher fare drastically reduced customer complaints.

Figure 5. Example of 'extra decision points strategy'. App screenshots from Uber's patented method to force users to type the multiplying number during surge pricing. Image from https://medium.com/adventures-in-consumer-technology/surge-pricing-can-save-hundreds-of-people-e2f3c0f6517e

4.1 When to apply which type of intervention

Rational override interventions have high potential to change behaviours in a service context. However, it should not be the objective to prompt users in more reflective and conscious thinking in every situation. Although it might seem that rational thinking would enable people to make better choices it is recognized that automatic thinking can, in some situation, result in better outcomes (Gigerenzer, 2011). Moreover, people do not have the cognitive capacity to use their conscious reflective mindset all the time. To create successful behavioural change through service design it is important to use the right type of intervention in the right situation. Thus, the tools in the toolkit support designers to discern when to use the rational overrides and when not. The most important factor to consider in the decisions between a nudge or rational override is the intended outcome. Since nudges stimulate a predictive unified outcome is likely to be effective in situations in which there is a single optimal course of action, that most people do not take (Keller, 2011). Rational overrides are suitable for situations in which the optimal outcome is largely depending on an individual situation. People are prompted to actively decide what is best for them. Since 45% of everyday behaviour is habitual, most behavioural challenges are concerned with changing habits

(Verplanken and Wood, 2006). Both type of interventions can change habits. Nudges can be used to change routines by automatically cueing desired behaviour. In order for the new routine to become a habit it needs to be repeated frequently and therefore the nudges needs to be present every time. Nudges can thus only be used to change routines in stable contexts (Frey & Rogers, 2014). Habit formation takes time, varying by person and situation from a few weeks to many months (Lally et al. 2010). It is therefore important to consider if and when a behaviour persist when the nudge is discontinued. Rational override strategies are more effective to change routines that take place in different environments, at different times and or require a change in people's beliefs, attitudes, or interpretations (Frey & Rogers, 2014). To consciously change a habit, people need to establish a new routine and extensively practice it so it can eventually move down into subconscious thinking (Strassheim, 2016).

5 Evaluation of the rational override and toolkit

To evaluate the applicability, usefulness and value of the toolkit and rational override strategies, evaluation sessions with design students, service design professionals, behavioural experts and a service organisation were held. To evaluate the toolkit design students were asked to use the tools in a workshop. Students were instructed to work on a design brief using various tools and describe their experience. During the workshop, the researcher was present to observe and ask questions. Video recordings were made and a group discussion at the end of the session provided detailed insights into the use of the tools and possible improvements. Additionally, separate feedback sessions were held with service design professionals, behavioural experts and members of a service organisation. During the sessions participants were introduced to the rational override, the nine strategies and the toolkit.

The evaluation workshop with design students mainly resulted in general improvements to the instructions, wording and templates in the toolkit to make them more clear and accessible. Generally, the tools were perceived as useful. The divergent and convergent elements in all the tools were highly valued by the designers since it enables them to quickly come to conclusions and valuable results. Service design professionals expressed that the toolkit adds value to their existing practices and would predominantly help them to structure the process and design activities. Finally, behavioural experts recognized that the proposed toolkit combines the strengths from behavioural economics, consumer behaviour and some aspects of psychology in a novel way. It is stressed by some of the experts that the integration of interventions that trigger both mindsets is valuable and that this is the direction in which the field of behavioural economics is going to develop.

Experts mentioned that the biggest opportunities and application possibilities for rational overrides are with lifestyle decisions, long-term decisions and financial decisions. This type of decisions are generally hard to influence with nudging, do not have a one size fits all outcome and happen across touchpoints and time. Members of the service organization recognized that rational overrides have the ability to increase customer loyalty, profitability, positive referrals and create bigger market shares. However, behavioural experts mentioned that the rational override, and getting people aware and conscious, is only the first step. If we can be effective in making people conscious we should also think about (and design for) the follow-up behaviour or decision. Where nudging leads to an immediate predictive action or behaviour, this is relatively unsure with rational overrides. Conscious customers might decide to do nothing, or choice the non-desired alternative (e.g. switch to another service provider). This insight shows the difference between nudging and rational overrides in terms of quantity and quality. Nudging can affect a relatively larger group of customers. With rational overrides the number of people that choose the desired outcome might be smaller but the ones that do decide in favour of the desired behaviour are more engaged and can provide more value.

6 Conclusive remarks

The purpose of this paper was to understand how service designers can improve the way in which they use behavioural knowledge to influence (and eventually change) customer behaviour. An alternative design approach, Behavioural Intervention Design, was developed to support service designers in the development of behavioural interventions across customer journeys. This approach goes beyond the theory and current applicability of behavioural economics and nudging. Key principles from behavioural economics, consumer behaviour, psychology and service design were integrated and synthesized towards a new design approach and toolkit. Behavioural Intervention Design is focused on influencing behaviour by getting the customer in the right mindset at the right time. The design approach integrates two types of behavioural interventions that not only stimulate desired behaviour by facilitating automatic and unconscious thinking, but can help customers to switch to a conscious interaction during critical points in the customer journey. By integrating micro moments of deliberate friction, also referred to as rational overrides, we can disrupt mindless automatic interactions and create active, conscious and engaged customers. Rational override interventions can change customer behaviour, not because they make things really easy, but because they put customers in control of their actions and they help raise their awareness. In this paper, we presented a service design toolkit that includes nine rational override strategies and seventeen selected nudge strategies. This toolkit can be seen as a first step towards systematically applying two different types of behavioural interventions across customer journeys to influence behaviour, and should be interpreted as such. The goal of the introduction of the rational override was modest: to provide an initial list of strategies that can be used to create rational override interventions. The strategies are all supported by empirical evidence but more research is needed in order to validate the effects and specifics of these type of interventions. However, the initial evaluation of the toolkit shows the potential use for service designers, clients and stakeholders to create service environments in which customers can make more optimal decisions.

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Section 19.

The Role of Design in Open Innovation

DRS 2018 Design Research Society 2018 Catalyst

University of Limerick
25th–28th June 2018

Editorial: The Role of Design in Open Innovation

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Chesbrough coined the term open innovation in 2003, and after a decade of research he redefined it as "a distributed innovation process, based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms, in line with the organization's business model" (Chesbrough and Bogers, 2014). Understanding open innovation helps to realize how sharing knowledge with internal and external stakeholders can promote innovation. The essence of such knowledge sharing by internal and external stakeholders build relationships that are based on common interests and goals.

Although open innovation has been a hot topic within business, design and innovation management, it is still ill defined and companies struggle with smooth implementation of open innovation practices into their daily operations. Different perspectives exist on the need for openness, antecedents of open innovation, different typologies of practices, how to determine which one fits each company and challenge, the processes for implementation and the roles that design and designers can play in these processes. The main aim of this conference track is to debate some of these emerging issues and position designers within this context. Therefore, within this track, the role of design, the designer and design management are considered and potential drivers for implementation of open innovation within organisations discussed.

The themed track features three submissions from 5 authors, who share interesting insights, knowledge and research outputs relevant for this track topic. We thank our authors for the diversity of research presented in this section and the great insights they brought us.

In "Exploring the Pop-up Shop for Co-design Research" paper one by Anja Overdiek takes a first exploration into the employment of physical pop-up shops for user and stakeholder engagement. The author first develop an operational definition of the pop-up shop by analyzing literature from marketing and human geography that leads her to identify successful properties for pop-up shop as a temporary and highly experiential physical space. This paper will further develop this definition from the perspective of experience prototyping and user engagement and place the resulting research approach into the landscape of co-design (Sanders and Stappers, 2014). From this perspective, the author illustrates this approach with three cases developed in 2016 by The Hague University in the frame of a national open innovation network initiated by the Dutch Ministry for

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Economy responding to the significant disruption of the retail sector caused by the move to online and changing consumer values and purchasing behavior.

This research intervention consisting of an iteration of pop-up shops that were conceived as experiential engagement platforms around different themes, working together with Industrial Design and Communications students. At the last part of the article, opportunities and challenges of pop-up shop research for co-design are discussed and the need for further exploration of pop-up shop experience prototyping as a process tool for multiple stakeholder co-design in open innovation projects is proposed.

Paper 2, titled "The design and social enterprise ecosystem: How can design be applied to a developing social enterprise ecosystem? by Hyejin Kwona; Youngok Choia and Busayawan Lamb, explores how encouraging the strategic use of design can address the growth and sustainability of social enterprises, from the multiple stakeholders' perspectives in the social enterprise ecosystem. This paper draws the outputs from the exploration phase of a research project that consist on the investigation of the UK's existing social enterprise ecosystem, identifying the status of design knowledge and use of design among key stakeholders. The study employed a combination of qualitative and quantitative methods, including both primary and secondary research tools. The conclusions of this paper first illustrate that social enterprises remain poorly understood in the public and private sectors, with gaps between key stakeholders and social enterprises. Secondly, the authors state that most stakeholders in the UK's social enterprise ecosystem have little understanding of design and are largely unaware of the influence of design. However, the excellent case study of the Good Finance project demonstrated how design could be applied in solving problems for the social enterprise ecosystem, especially in finance and investment among the fundamental elements of social enterprise ecosystem. Finally, further research opportunities are opened such as a comparative analysis of case studies of South Korea and the UK's social enterprise ecosystems.

Kim Kyuleea in the paper titled "A Case Study to Explore Applicability of Creating Shared Value (CSV) into Design Practice" reports preliminary research on roles of design to leverage creating shared values (CSV). CSV is a nascent, but widely accepted, business concept that attempts align strategically social goals and business goals together in one value for a company's competitive and sustainable growth (Porter and Kramer, 2011). The author work is based on a selected case of collaborative new product development (NPD) project that involves three independent parties that include a design consultancy, a MNC, and a social business. This case is one of the rare projects where practitioners' motivations and contributions were clear and the project had been attempting to create shared value since the planning stage. This paper arrives at the conclusion that two challenges of CSV's applicability into design practice are recognised through case study. One challenge lies in the lack of explanation on non-economic and non-social design goals. Another lies in the undefined role of CSV in the realm of design.

The diversity of contributions of this track enrich the discussion about the role of design in Open Innovation and more widely in stakeholder engagement for interdisciplinary innovation activities. We also realize through these contributions how social goals are gaining relevance in innovation practices and that even in the era of social networks, virtual reality and on-line business, physical interaction still remain key on engaging stakeholders. Finally, according to DRS2018 conference theme, these contributions highlight the role of design as a catalyst of change based on open innovation and as an agent for social change. On behalf of the track editors, we thank the authors for commitment to the discipline. We wish the authors success and trust that the readers will find value of the articles within this track.

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A Case Study to Explore Applicability of Creating Shared Value (CSV) into Design Practice

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This paper reports preliminary research prior to a larger investigation on roles of design to leverage creating shared values (CSV) as a new popular method for design innovation management. CSV is a nascent but widely accepted business concept that attempts to strategically align social goals and business goals together in one value for a company's competitive and sustainable growth. However, this popular business theory has not been fully explored in design practice; therefore, a design project, which aspired to create shared value, was chosen for understanding and implementing the theory through the lens of design practice. This applied research aims to identify project goals to match theoretical goals of CSV and explore gaps between CSV as the business theory and a design practice to identify the gaps in future research. Two challenges of CSV's applicability into design practice are recognised through case study. One challenge lies in the lack of explanation on non-economic and non-social design goals. Another lies in the undefined role of CSV in the realm of design.

creating shared value (CSV), new product development (NPD), and case study.

1 Introduction

Living in economically and socially transitional times, designers play key roles (Irwin, Kossoff, Tonkinwise, & Scupelli, 2015) in assisting, mediating, and facilitating businesses and societies' subsequent changes, which are appropriate to time and trends. As a way to understand the roles of design in this transitional period, this study aims to explore one recently-introduced business theory, 'creating shared value' (CSV), which acts as an amended capitalist business model for this unprecedented era that is explained by fast-paced changes so-called, "transformation economy" (Brand & Rocchi, 2011; Gardien, Djajadiningrat, Hummels, & Brombacher, 2014). This transition even appears distinctive after the global financial crisis, when Porter and Kramer coined the new business model as a modified version of capitalism (Szmigin & Rutherford, 2013; Pirson, 2012). On the other hand, design scholars identified a paradigm shift, in which consumers' demand for meaningful experience and impact as opposed to the typical industrial goal that concentrated on profit through

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high-quality design (den Ouden, 2012; Gardien et al., 2014). While CSV is known not only as a popular business strategy for brands and businesses to become smarter (Moon, Parc, Yim, & Park, 2011), but also as a reinvented capitalist model for this transition period, this paper adopts and introduces this business theory to describe a design practice.

Creating shared value (CSV) is a business concept that was first introduced by Michael Porter and Mark Kramer in the *Harvard Business Review* (HBR) in 2011. The objective of Porter and Kramer's research is to increase awareness of CSV's effectiveness and sustainability as a competitive business strategy that is a win-win for society and business (Porter and Kramer, 2011). Since its debut in 2011, CSV has garnered the attention from business practitioners' for its capability to be innovative by creating sustainable, competitive, cost-efficient, and high quality products (Porter & Kramer, 2011) by applying a holistic yet strategic perspective on corporates' relationships with society (Porter & Kramer, 2014). Numerous academic papers have employed this theory across various disciplines (Dembek et al., 2016, p.233); however, CSV is still surprisingly untouched in design academia.

While much of business literature focuses on interpreting and enhancing the theory, and empirical studies have focused on the applicability in business practice, hardly any study in design has reviewed practical design cases that were organized after the article was published or used the business concept as a key reference. For this article, academic design papers that have adopted CSV as a key concept were searched. Referring to Gemser et al. (2011), six widely noticed design journals, such as *Design Studies*, *Design Issues*, *International Journal of Design*, and *The Design Journal* were reviewed. Despites its popularity in other academic fields, CSV in scholarly design work is scarce, and only three of the reviewed papers refer to the concept. Furthermore, they refer to it only to support other neighboring concepts such as social innovation (Yang & Sung, 2016), socially responsible design (Koo, 2016; Koo & Cooper, 2016) and corporate social responsibility (CSR) (Koo & Cooper, 2016).

This paper depicts a pilot study that is conducted for further investigation on how to leverage this business model via design. Prior to this ultimate goal, a set of case study is conducted to adopt and evaluate the popular business frameworks in the field of design. There are three main phases of this study. This study, first, seeks to understand key concepts of CSV as a theory. Literature review is conducted to understand the definitions, goals and advantages of CSV. The second task is to identify and understand project goals in design practice in creating shared values by investigating how design helps to achieve expressed project goals. Finally, identified goals are compared with CSV's goals. Through this comparison, gaps between CSV as a business theory and design practice are analyzed. These three tasks aims to explore the applicability of creating shared value, a business theory, in a design project.

Previous to selecting a case, many products as well as service designs for social innovation or for sustainable business were reviewed, and a new product development (NPD) project was chosen for a case investigation to explore CSV's applicability in design practice. The case is a collaborative new product development project that involved three independent organizations; they are, an automobile manufacturing multi-national corporation (MNC), a start-up shoe-manufacturing social business, and a design consultancy firm. The project was initially brought up by the MNC as a smaller part of a new future-oriented business strategy; it built a *brand experience space*, where the newly developed product could be displayed and sold. For the MNC's new product development, a design consultancy suggested collaborating with the shoe-producing social business to create shared value. Four in-depth interviews with project managers of different collaboration teams were arranged to obtain a diverse perspective of the process. Because the nature of the research aims to understand multiple aspects and complex procedures of a project, data collection and analysis were done qualitatively.

This paper comprises three main sections. The first part portrays research methods. The second provides an overview of the core concept, CSV, from business literature. The third section delivers

three sets of analysis of the case study. The analysis section compares the findings of the case study and literature-based knowledge; this generates a conceptual framework for future studies that identify prospective knowledge gaps and limitations to applying existing CSV to design practice.

2 Research Method

The study aims to understand CSV as a theory and explore its applicability in design practice. There are three research questions to this objective:

1. How do Porter and Kramer describe goals of CSV as a business theory?
2. What kind of project goals does a design practice had in order to create shared value?
3. What gaps appear by comparing the theoretical goals and practical goals?

Reviewing Porter and Kramer's original article in 2011 and other scholarly work on CSV will help understand the first question. This investigation highlights key goals of CSV through its definition, significances, methods, criteria, and process. The second research question is explored by a conducting case study on a design practice and identifying its project goals. Understanding how design impacts the project and deliveres the result reveals the major project goals. Finally, the third question is examined by matching theoretical goals of CSV and practical design goals that are achieved through CSV. Through this comparison, gaps between CSV as a business theory and a design practice can be identified. These three tasks aim to explore the applicability of creating shared value, a business theory, into a design practice.

After the first section of comprehensive literature review, a case is selected as a unique project (Yin, 2003, p. 41) attempting to achieve shared value from an early stage. It is a new product development (NPD) project that involves three independent organizations, a multi-national corporation (MNC), social business, and design consultancy firm. A case study was conducted after the project was finalized in the summer, 2017, and the newly designed product is still on display at the MNC's brand shop. Narrative data was collected through four semi-structured, in-depth interviews of 35-75 minutes each with four project managers from three organizations for insightful views on the project. These participants not only well represented the three organizations involved in the project but also provided adequate saturated data (Minichiello, 1995, p.168; Strauss & Corbin, 1990). Most of the data are descriptive; however, some of the content are supported with images. Because the goal of the qualitative research is to systematically display the findings or extract comprehensible theory (Miles & Huberman, 1994) from complex sets of data, all obtained interview data were transcribed, codified, and analyzed. Analysis followed Ritchie and Spencer's (2002) five steps for creating a framework: familiarizing, identifying themes, indexing, charting, and interpreting (p.310).

3 Literature Review

3.1 Definition and Significance of CSV

This research is based on the business concept *creating shared value* (CSV), coined by Porter and Kramer in 2011. This section provides an understanding of the definitions, purposes, and significance of creating shared value according to Porter and Kramer (2011) and other scholarly reviews.

CSV is also called *shared value*, a *sharing value initiative* (SVI) (Maltz & Schein, 2012), a *shared value model* (SVM) (Aakhus et al., 2012), or *shared value creation* (SVC) (Dembek et al., 2016). Although the concept is nascent (Porter et al., 2012; Maltz & Schein, 2012), many scholars admit that CSV has gained popularity and become a "buzzword" in the business world (Beschorner & Hajduk, 2017, p.27), as well as a new foundation (Aakhus et al., 2012, p. 235). It has already achieved a desirable influence on business practitioners (Crane et al., 2014, p.132; Kettner, 2017, p. 153). One reason for this reputation is that many scholars agree with Porter and Kramer that there is an immediate need to reshape (2011, p. 64) or reinvent (Aakhus et al., 2012, p. 232) existing capitalist models, especially

after witnessing the global financial crisis (Szmigin & Rutherford, 2013, p.171; Pirson, 2012, p.31). Porter and Kramer argue that it is necessary to expand and customize Adam Smith's concept of the invisible hand (2011) so that capitalist enactors tend to be more socially and ethically responsible in free markets. Szmigin and Rutherford endorse CSV as a way to enhance ethical approaches in business. Maltz et al. (2013) specify that many businesses have experienced social and public pressure (p. 344) to play more roles to satisfy multiple stakeholders. Beschorner and Hajduk also highlight the need for social legitimacy in business activities (2017, p. 32). These scholars express need of socially responsible and favorable yet highly profit-making device in business.

Another reason for the significant attention paid to CSV is its advocates' belief in its capability to replace (Porter & Kramer, 2011, p. 76) and complement other more socially-oriented business concepts such as CSR (Szmigin & Rutherford, 2011, p. 172), bottom of pyramid (BoP), blended value, inclusive business, and social entrepreneurship (Dembek et al., 2016; von Liel, 2016). For instance, Porter and Kramer specifically emphasize additional values in CSV compared to CSR, such as CSV' power to integrate itself into business while CSR is isolated type of activity apart from key business (2011, p.76).

To briefly summarize the significant advantages of CSV over these neighboring concepts according to Porter and Kramer's definition, CSV is a more business- and profit-oriented concept than other mentioned business models. Therefore, most CSV cases that are reviewed in the literature emphasize CSV's benefits as *measurability* (Porter et al., 2012; Maltz & Schien, 2012; Pfitzer, 2013; Mohammed, 2013), *financial sustainability* (Pirson, 2012), *profitable business opportunity* (Lassch & Yang, 2011), *economic competitiveness* (Dubois & Dubois, 2012, p.281), and being *time and cost efficient* and *productive* (Kramer &Porter, 2011), on top of other social, ethical, philanthropic, and environmental benefits. Where neighboring concepts like CSR, BoP, and social business, often give up economic advantages for social gains (Dubois & Dubois, 2012), CSV aims to have social impacts from those similar business models that maintain (or enhance) economic advantages. Therefore, CSV is unique for its win-win aspect (Caligiuri, 2013).

3.2 Three Frameworks: Methods, Criteria and Process of CSV

While previous section focused on meanings of CSV, this section introduces three theoretical frameworks: '*three-level method of CSV*,' '*five Criteria of CSV,'* and *'four-step CSV process.'*

Porter and Kramer not only enlightened the advantages and need of CSV in the 2011 article, but also suggested how this business model could be achieve through a *three-level method of CSV*. Table 1 describes methods how business could be achieved in three levels of sophistication and impact. At first level, a business strategist reconceive product and market by determining new demand and develop product accordingly. At level 2, CSV is found by redefining and improving productivity through appropriate modification in existing value chain. At the final level, CSV influence positively beyond the business and its value chain. CSV Level 3 induces both social and economic benefits by local cluster development, to which the business belongs.

Table 1 'The three-level method of CSV'

No.	CSV Levels
1	**CSV Level 1**: reconceiving products and markets
2	**CSV Level 2**: redefining productivity in the value chain
3	**CSV Level 3**: enabling local cluster development

Three level methods describe how CSV become a win-win business strategy that aim to achieve both economic and social goals in one. Having two required goals, Maltz and Schein (2012), further divide hierarchy between two. Analyzing many business strategies aim to create shared value, they

categorized, “economic-first” or social “mission-based” standpoints of business goals. Their interpretation clearly illustrates that CSV target for two groups of stakeholders. Interviewing ten CSV practitioners, they also imply that some practical business goals do not appear visibly as shared value, yet leaning towards one side whether it is social or business perspective.

Maltz and Schein’s review and exploration of Porter and Kramer’s theory illustrate two clear goals in CSV as economic and social goals. However, these two objectives alone do not warrant CSV a unique theory apart from other similar preceding concepts like corporate social responsibility. Spitzeck and Chapman’s (2012, p. 501) translated Porter and Kramer’s original concept well without much alteration. Conducting a case study to empirically assess CSV as theory, they established five major guideline of CSV that further expands and specifies the two goals of CSV. In Spitzeck and Chapman’s five criteria, CSV is portrayed as an integrated socially beneficial activity (Criteria 3) into entire business strategy (Criteria 1) while boosting competitiveness of the business (Criteria 2). They also emphasized CSV has to display visible outcome and measurable impact (Criteria 4 & 5) (Table 2).

Table 2 ‘Five Criteria of CSV’

No.	Five Criteria of CSV
Criteria 1	Refer to corporate policies and/or operating practices.
Criteria 2	Enhance the competitiveness of the firm.
Criteria 3	Improve social conditions in communities.
Criteria 4	Show clearly which strategic projects create the most impact relative to investments.
Criteria 5	Use clear metrics related to stakeholder demands.

Criteria 1 and 2 specify how an economic goal is planned, while Criteria 3 shoes how social goal is established. Criteria 4 and 5, on the other hand, reflects Porter and Kramer’s concerns how CSV become more attractive alternative to other socially oriented business activities. Two criteria highlights CSV’s measurability. After the first seminal article on CSV in 2011, Porter et al. (2012) published another article that focus on measuring aspect of shared value.

Porter et al. (2012) defined four steps for creating shared value. While the early two steps formulate a strategy that creates shared value, the latter two steps measure the strategy. The first step is to identify the social issue that is most compatible with a business’ profit activity. Then, based on the diagnosis, the company must develop a strategy and implement it. Later, as a step to measure the strategy, CSV needs to be tracked and results must be measured. By doing so, the strategy could be evaluated objectively to determine whether it is successful or needs modification in the future. Figure 1 illustrates these four iterative steps to creating shared value as a strategy. The four-step-diagram explains that the case in this study only provides to the first two steps of creating shared value.

Figure 1 'Four-step CSV Process' (adopted from Porter et al., 2012, p. 4)

4 Case Study

The selected case is a collaborative new product development (NPD) project that involves three independent parties that include a design consultancy, a MNC, and a social business. The case was selected as one of the rare projects where practitioners' motivations and contributions were clear and the project had been attempting to create shared value since the planning stage. However, CSV is still an uncommon academic lexicon, this project is acknowledged by many other collaborators and stakeholders under more descriptive titles such as *financially sustainable social design project* or *economically competitive business with sustainable donation*. The project was initially raised by the MNC, which began to invest its enormous resources into building new sales platforms and brand experience spaces, called, 'brand shop.' Within this larger scope, the MNC sought to develop various brand products that could be displayed and sold in the space. A design consultancy firm was engaged in this NPD project and proposed that the MNC collaborate with a social business to create shared value. While the MNC is a successful automobile producer, and the social business is a shoes manufacturer, the design consultancy's proposal was realized and a collaborative project was determined to develop driving shoes as a new product line.

The case study is conducted qualitatively with four project manager interviews. After collecting the data, there were three sets of analysis. The first part of the analysis compared the six identified project goals with three CSV frameworks that were introduced in the literature review. First analysis employed 'Three-level Framework of CSV.' The second part of the analysis compared the six goals with 'Five Criteria of CSV.' Finally, 'Four-step CSV Process' was matched to the practical goals.

4.1 Three Sets of Analysis: Comparing Six Practical Goals with Three Frameworks

After collecting and analyzing data of all interview transcripts, six project goals (coded Goal 1 to Goal 6) were identified. The middle column of Table 3 illustrates the six extracted project tasks from the case study, and the right column indicates the perspectives that determined the goals. This section has two purposes: to evaluate whether these goals are valid CSV problems by comparing them to Porter and Kramer's definition, and to elucidate gaps and limitations of the current definition of Porter and Kramer's CSV to interpret a design practice.

Table 3 Project Goals

No.	Project Goals	Origin of the Goals
1	**Goal 1**: Aim to increase financial profit by increasing public reputation as socially responsible yet friendly, and intends to create financially sustainable social activity	MNC
2	**Goal 2**: Aim to create an attractive and innovative brand space that will eventually function as the main sales platform and be competitive in the industry 4.0	
3	**Goal 3**: Aim to sustainably donate shoes to developing countries for social, health, and educational improvement	Social Business
4	**Goal 4**: Aim to fundamentally contribute to local economy in two countries where shoes have already been donated. By building local factories and developing local human technical infrastructure, manufacturing processes and donations become more efficient.	
5	**Goal 5**: Aim to create new business opportunities for further sustainable growth	
6	**Goal 6**: Aim to be innovative, unexpected, attractive, exciting, and fun	MNC & Social Business

A commercial goal of the project, in contrast to a socially-led goal, was cited frequently during the interviews. The new product development (NPD) was initially discussed with a strong economically-driven mission. For instance, the MNC decided to invest significant resources on a project that creates a brand shop. The brand shop is intended to let consumers interact and experience the brand in closer and enjoyable position. The new space, therefore, aims to yield prospective economic profit, and the NPD project is a sub-project within the larger scheme, so that new product can be displayed and sold in the brand shop. The NPD project, on top of this higher project's economic goal, also seeks to increase the MNC's social reputation through the new product.

Goals 1 and 2 both describe economic goals; however, they also match with some aspects of CSV. First, Goal 1 seems to reflect reputation-driven CSR (Porter & Kramer, 2012, p.76) as a reaction to external pressure (p.65) on a company's profit legitimacy. On the other hand, Goal 2 resembles "economics-first CSV" (Maltz & Schein, 2012, p. 61), in other words, shared value for financial benefits.

Many CSR activities often give up financial benefits for social benefits; therefore, they are likely neither to become financially sustainable (von Liel, 2016), nor to assist profit maximization (Porter & Kramer, 2011, p.76). CSR is interdependent on other financial aid or business activity because it is often not self-sustainable or lucrative activity. However, CSV is a profitable solution (p.70; Pfitzer et al., 2013); therefore, it is financially sustainable (Harrison & Coombs, 2012; Lassch & Yang, 2011; Verboven, 2011). Since this NPD project aimed for independence, it is overachieving some criteria for at traditional CSR. However, because the product did not achieve profit maximization directly, NPD is not CSV either.

It is unclear whether Goals 1 and 2 aimed for shared value or CSR. Goals 3 and 4, on the other hand, seem to have a closer resemblance to CSV's criteria because not only do they aim to "jointly create commercial and social value" (Marquis & Park, 2014, p.28), but they also align with two of the three ways of creating shared value. Porter and Kramer offered three ways of creating shared value (Porter & Kramer, 2011; Porter et al., 2012) and they have been adopted and explored by many scholars (Spitzeck & Chapman, 2012; Lee et al., 2014). The three-level methods (Table 1) include reconceiving products and markets, redefining productivity in the value chain, and enabling local cluster development (Porter & Kramer 2011).

The first path to creating shared value is reconceiving products and markets based on careful study and alignment of consumer and social needs. The shoe manufacturer' business and social mission aligned within this project; the new NPD project also aims to undertake one-donation-per-purchase policy that the social business already had. The shoe company initially achieved its public fame by having a meaningful social mission: donating shoes to children in the developing countries and supporting elementary education initiatives. A solution to this philanthropic yet financially sustainable mission is already embedded in the social business rather than being a uniquely defined task during the NPD project.

As expressed in Goal 3, the social business is a company that was originally founded by understanding and aligning social needs and users' needs. The founder, instead of creating a one-time charity, formulated a new business system. A pair of popular shoe model from a developing country is customized for urban consumers in advanced market, and some profits produced from shoes are designated to donate the company shoes to developing countries. The modified version of shoes attracted high demands in a new market, and enabled the company to be both a competitive shoe business and a shoe donor at the same time. In this case, the shoe company and the NPD project aim to achieve CSV at the first level.

During the case study, the social business demonstrated that it also aimed to expand its social and business achievements by planning for more effective donation and production systems. The shoe company deliberately built two new factories in the two areas where their shoe donations have been delivered for many years (Goal 4). With this new system, it has insured that the local areas' economic development is achieved by securing more local job opportunities and vocational training. Routes of shoe donations have become easier and faster, and shoe production costs became lower. This new strategy seems equivalent to the third way of creating shared value because the shoe company aims not only to improve its internal system but also to engage in local communities' economies that have significant influence on its value chain.

Goals 3 and 4 matched with two methods of Porter and Kramer's *Three-level framework of CSV*. Assuming the shoe company has already been creating shared value as defined by Porter and Kramer, this project also creates shared value because all collaborators in the NPD project agreed to follow this one-for-one donation policy. However, as maintaining commercial profit and competitiveness are one of the most important factors that distinguish CSV from CSR or social businesses, Goals 3 and 4 still do not elucidate how this project plans to contribute the companies' financial competitiveness.

Goal 5 provides some suggestions for how this project is relevant to produce business profit. The case was described as a plan for a new product development project. To sustainably donate shoes to developing countries, it is important for the shoe company to be financially competitive to survive and excel in the highly saturated shoes industry. As a pioneer of the one-for-one business model, the company admits having significant marketing and media privilege that endows them with profits, but the company feels that it is not enough to secure sustainable business growth. Interviews show that the company puts enormous efforts into developing new products and finding new business opportunities for ongoing growth. Goal 5 expresses clearly that this project is specifically intended to achieve new business opportunities (Porter & Kramer, 2011) that could potentially deliver higher profits to the shoe business.

The previously-discussed five goals reflect clear social and/or commercial motives. Goal 6 is apart from the previous five goals in terms of the social and business spectrum. The interviewees mentioned that one important motivation is being "innovative, unexpected, attractive, exciting, and fun"; Goal 6 appears to not belong to either the social or business categories. The goal is one of the most frequent and important aims of this project according to the participants, and it does not directly aspire to economic success or tangible social impact. It is designers' or stakeholders' strong motivation and emotional stimuli that enable them to stay engaged and become creative,

adventurous, and innovative. Most of the interviewees valued such emotional motivations, believing that such motivations allowed them to tolerate any difficulties during the project and meet all collaborators' single agreement at the end.

To enhance the first set of comparison between six project purposes and 'Three-Level Methods of CSV,' another framework, 'Five Criteria of CSV' is employed to match with identified practical goals. Abiding strictly by Porter and Kramer's articles, Spitzeck and Chapman's (2012, p. 501) five conditions of CSV are proper and straightforward. Table 4 summarizes the five major criteria of CSV and compares them with the designated project goals from the case study.

Table 4 Five Criteria of CSV

No.	Five Criteria of CSV	Project Goals
1	Refer to corporate policies and/or operating practices.	Goal 1 & Goal 2
2	Enhance the competitiveness of the firm.	Goal 1 & Goal 2
3	Improve social conditions in communities.	Goal 3 & Goal 4
4	Show clearly which strategic projects create the most impact relative to investments.	Goal 1, Goal 2 & Goal 5
5	Use clear metrics related to stakeholder demands.	Not applicable

Evaluating the NPD project with these five criteria shows clear goal matches with the main agenda of CSV. Through this process, another gap between design and the theory can be identified: a mismatched part of the principle is identified. CSV is based on an important strategy criterion: measurability (Porter et al., 2012, p. 15), scalability' (Pfitzer et al., 2013, p. 101), or a clear metric (Spitzeck & Chapman, 2012, p. 501). Porter and Kramer (2011) and many other scholars have emphasized CSV's measurability (Maltz et al., 2011; Porter et al., 2012; Mohammed, 2013; Szmigin and Rutherford, 2013; Lee et al., 2014) as one most unique and significant benefits that distinguishes it from other neighboring concepts. In other words, profits and benefits of CSV must be "measurable and demonstrable" (Maltz & Schein, 2012). According to those reviewers, measurable profit is the reason for existing (Pfitzer et al., 2013) for CSV that goes beyond being financially sustainable (Harrison & Coombs, 2012; Lassch & Yang, 2011; Verboven, 2011) or accepting a tradeoff of social benefits with public legitimacy for a company's private gain (Dubois & Dubois, 2012).

The profit measurability of this project is hampered because the product was launched recently and is not mature enough to be evaluated. For instance, the results of Goal 2 could possibly be measured through market sales; however, it is too young to evaluate at the moment, since the project output is still on sale and a new product model has not been fully implemented into the shoe business' collections. Another reason behind difficulty measuring profit is that most of six project objectives do not have direct connections to organizations' measurable profits. For example, Goal 1's "improved reputation," Goal 3's "sustainable donation," and Goal 6's "innovative and creative catalyst" are not the clear and financially-measurable properties.

Followed by two theoretical frameworks on CSV, Porter et al.'s '*Four-step CSV Process'* is adopted to describe the 6 NPD goals. The framework articulates CSV as a four-step iterative process (Figure 1). While first two steps plan and generate shared value, the next two steps functions as phases to measure outcome and impact. While the case in this study focused on steps one and two of Porter et al.'s (2012) shared value creation cycles, some scholars infer that CSV is an initiative for business strategy. For example, some scholars, such as Maltz and Schein (2012), Spitzeck et al. (2013), and Caligiuri et al. (2013) decided to explore and enhance the shared value framework by focusing on its main role as an initiative of social and business innovation. With this as the focal point of CSV, an outcome's measurability is subsequent to its role as a trigger for a successful strategy.

This interpretation of CSV as an initiative could help bridge the gap between Goal 6 to other goals with theoretical implications. While Goal 6 tends to be an outlier by centering a designer's emotional and ethical motivations as catalysts for this type of project, validity of Goal 6 can find its rationalization not only through the vocabulary of design but also through its role as an initiative.

4.2 Discussion

The first and the second set of analysis revealed a lack of explanation of a significant design goal through the language of CSV; the NPD project's aim to be innovative, unexpected, attractive, exciting and fun could not align with both three methods and five criteria of CSV. In other words, there is a lack of explanation on non-economic and non-social goals in existing CSV frameworks.

Case analysis through five criteria and four-step process of CSV discover that the theory could be further specified into various foci and magnitudes. For instance, future studies need to define which specific stages of the process are investigated or what specific levels will be relevant to the design practice. The NPD project clearly shows its goals and solutions within the first two steps of the strategy-building stage, and is aimed levels one and three of CSV. Expanding this niche, future study can focus on how design enhances building strategy (steps one and two) of shared value at level one and what elements in design expedite or guarantee finding new business opportunities.

5 Conclusion

Porter and Kramer's approach creating shared value is a popular, promising business theory, yet still ill-defined in design field. Reviewing a single product development case that aimed for shared value, this paper has attempted to find limitations and gaps of current business theory to analyze design practice. The case study revealed two challenges and possible routes for future research to integrate design practice and business concepts.

This paper arrives at the conclusion that there is a significant gap and need for design researchers to establish the framework of CSV to integrate it into design practice. The reviewed case is a project for a new product development project. NPD is known to be an important tool (de Maio, Verganti, & Corso, 1994, p. 178) and strategy (Porter, 1980). The case in this project focuses on how its project is arranged and processed, explained through steps one and two in the CSV cycle. CSV is applied into a particular product design process as an initiative. Neither the four-step process map, three-level framework, or five CSV criteria showed how to trigger and achieve the process. Future study should investigate what design factors expedite successful outcomes and what designers' roles should be as actors, "enablers," who generate new type of value, or "form-forgivers," who add or enhance value on top of existing value, for this kind of NPD project (Heskett, 2016).

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The Design and Social Enterprise Ecosystem: How can design be applied to a developing social enterprise ecosystem?

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The United Kingdom's social enterprise sector has grown radically over the past two decades, as a result of various government-led efforts to create an environment which enables social enterprise development. However, financial weaknesses still impede the sustainability and growth of most social enterprises. Typically, businesses recognise design as an important factor in the growth of their potential competitiveness which is crucial to making profits, and as a tool enabling stakeholders and organisations to work better as a system. Design is thus regarded as potentially playing a significant role in overcoming the financial weaknesses of social enterprises, in order to encourage their growth and sustainability. To date, few studies have been undertaken on the use of design for social enterprises, so there is insufficient data about the relationship between stakeholders and the role of design. This current research project proposes the need to study how encouraging the strategic use of design can address the growth and sustainability of social enterprises, from the multiple stakeholders' perspectives in the social enterprise ecosystem.

social enterprise ecosystem; role of multiple stakeholders; use of design; sustainable development

1 Introduction

Globally, social enterprises are becoming increasingly popular because their innovative approaches to business activities contribute to human development and economic prosperity (Samia, 2008). Some governments, therefore, encourage them to grow and become more sustainable organisations (Phillips, 2006; Teasdale, 2011; Burstyn, 2013; Blundel & Lyon, 2015). The United Kingdom government, for example, has established policies and initiatives to create an environment which enables the social enterprise sector to flourish (British Council and SEUK, 2015; Cabinet Office,

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2016). The UK currently has the world's most advanced institutional support structure for social enterprise (Nicholls, 2010) with over 70,000 UK social enterprises contributing more than four per cent of GDP (British Council and SEUK, 2015; Cabinet Office, 2016), and playing a significant role in delivering and reforming of public services (DTI, 2002; British Council and SEUK, 2015). Despite the UK government's efforts, however, weaknesses persist in social enterprises' finance, which affect their sustainability and growth (Social Enterprise UK, 2011;2013;2015;2017). The author's recent study hypothesises that design could be used to help social enterprise overcome financial difficulties.

Commercial businesses evidently recognise using design as an important factor in the growth of their potential competitiveness and sustainability (Roy & Riedel, 1997; Borja de Mozota, 2003; Best, 2010; Hertenstein, et al., 2013; D'lppolito, 2014; Holland & Lam, 2014). Joziasse and Selders (2009) note that design adds different values according to an organisations' specific positions, purposes, sectors and needs. Design can achieve four objectives (Joziasse & Selders, 2009): (1) increasing profits, (2) increasing brand equity, (3) innovation through maximising the efficiency of technologies and knowledge and (4) improving organisations, environments and societies. Since the late 1960s, this has led to wider changes and controversies in the design culture which can be characterised as 'social benefits' (Bason, 2010). The accompanying changes and arguments are partly captured by the social entrepreneurship movement, social enterprise creation and, more broadly social innovation (The Young Foundation, 2006; Ellis, 2010). Bason (2016) maintains that design can provide a platform for solving problems in social innovation and social entrepreneurship/social enterprise through the cooperation of various fields, users and suppliers.

Despite the claims associating social enterprise with design, there is still insufficient evidence to demonstrate that the social enterprise sector, especially small-and-medium-sized organisations, have used design strategically. This research aims to develop a better understanding of how design can be used to strategically improve the UK's social enterprise ecosystem, to encourage the sustainable economic development of social enterprises. The study's objectives are to: (1) explore how the UK's social enterprise ecosystem was established and developed, (2) investigate the roles of multidisciplinary stakeholders in the UK's social enterprise ecosystem, and (3) identify the current state of design knowledge and the use of design in the UK's social enterprise ecosystem.

2 Research Methodology

The research project comprises four phases: exploration, investigation, development and evaluation. The outcome of this paper draws mainly on the project's initial exploration: an investigation of the UK's existing social enterprise ecosystem, identifying the status of design knowledge and use of design among key stakeholders. The study employed a combination of qualitative and quantitative methods, including both primary and secondary research tools.

Literature reviews initially sought an in-depth understanding of the research context: design, social enterprise and the social enterprise ecosystem. An overview of design studies identified the comprehensive roles of design, ranging from businesses to societies. Studies of social enterprise ecosystems were examined to classify their key elements. A case study - the United Kingdom - was then chosen because it has had the world's most highly-developed institutional support structure since the late 1990s (Nicholls, 2010) and is a country which recognises the value design can bring to the business and/or the public sphere (Innovate UK, 2015). The UK case was examined to understand the configuration of the social enterprise ecosystem in a national context. Two of the UK's social enterprise related projects - 'Good Finance' and 'Better by Design' - were selected as case studies where design is used at social enterprise ecosystem level. Both cases met the current study's selection criteria: (1) addressing social enterprise problems, (2) design's problem-solving role, (3) they are led by key stakeholders in the UK social enterprise ecosystem. Exploratory interviews were then conducted with seven respondents from the social enterprise sector (including academics, policy directors, a managing director, and a membership officer) and four respondents from the

design sector (including an academic and strategy director, a research & evaluation manager, and a programme manager - two of whom had working experience in the social enterprise field) to gather their perspectives on the current the UK social enterprise ecosystem, explore their awareness of design in the system, and to gain an overview of the relationship between the social enterprise ecosystem, the role of stakeholders and of design. These interviews were conducted face-to-face, or on skype, or by phone-call. The exploratory interview data was thematically analysed. Figure 1 is an overview of the current study's research design, with the correlation of the Phase one objectives and the research methods.

Figure 1: Research design of the current study

3 Social enterprise and the social enterprise ecosystem in the UK

Social enterprises adopt business practices to achieve their mission but operate with manifold configurations as co-operatives, non-profit organisations (Spear, 2006) and social purpose for-profits firms (Volkmann, et al., 2012). Social enterprise thus does not fit neatly into the traditional categories of private, public or non-profit organisations (Doherty, et al., 2014). This distinctive characteristic of social enterprises often causes ambiguity describing them. Some research suggests that the core features of social enterprises can be used to capture a definition (Thompson & Doherty, 2006; Peattie & Morley, 2008; Moizer & Tracey, 2010): a social enterprise must (1) have primarily social objectives, (2) be a business whose primary activity involves trading goods and services, and (3) re-invest any surpluses generated principally in the community, rather than distribute them to shareholders and owners. This study, by comparing existing definitions of social enterprise, proposes a working definition: ***a social enterprise aims to solve social (and environmental) problems through economic activities.***

Social enterprises are now seen in many countries as catalysts for economic growth and social renewal, because of their influence. Improving the quality and impact of social enterprises can

directly contribute to both reducing social inequality (Cabinet Office, 2006) and improving the national economy (British Council and SEUK, 2015; Cabinet Office, 2016). The UK particularly recognises the significant contributions of social enterprises in terms of the national economy and social development. The UK government emphasises the importance of policies for social enterprises development as a means of creating social opportunities, building civil society, investing in marginalised communities, and providing a mixed social welfare economy (McCabe & Hahn, 2006). Since the late 1990s, in the UK - which has the world's most highly-developed institutional support structure (Nicholls, 2010) - social enterprises have received strong government support through various policies and initiatives (DTI, 2002; Office of the Third Sector, 2006). Following the first mention of social enterprise in the UK's policy landscape - the national strategy for neighbourhood renewal report 'Enterprise and Exclusion', produced by the Treasury of Tony Blair's New Labour government in 1999 (Treasury, 1999; Teasdale, 2011; Ridley-Duff & Bull, 2016) - various institutions and policies have emerged to promote the development of the UK's social enterprise sector. In the early 2000s, the UK government sought to create and maintain a stable macro-economic environment in which businesses - including social enterprises - flourished (DTI, 2002). The Social Enterprise Unit (SEU) was established in the Department of Trade and Industry (DTI) in recognition of its contribution to the UK business environment and the national economy (DTI, 2002), and the UK's first social enterprise strategy was published by the DTI (DTI, 2002; British Council, 2015; European Commission, 2014). The Social Enterprise Coalition (SEC) was established to secure government support and improve the operating environment for social enterprises (Social Enterprise Coalition, 2003; British Council, 2015).

As a result, in the mid-2000s the number of social enterprises in the UK increased sharply (from around 5,300 to 55,000) (The Guardian, 2013), and the UK government sought to create appropriate conditions for social enterprise to thrive by establishing a Social Enterprise Action Plan (Cabinet Office, 2006; British Council, 2015; European Commission, 2014). The UK government's Social Enterprise Action Plan hoped to encourage more people to understand social enterprises, raise awareness of potential investors and customers, ensure that social enterprises have access to business support and finance, and support inclusion in public service delivery (Cabinet Office, 2006; European Commission, 2014). In the 2010s, the UK government's support for social enterprises became concrete and specific, and the Public Service (Social Value) Act (European Commission, 2014; British Council, 2015) - a guide to legal forms for social enterprise - was published by the Department for Business Innovation & Skills (DBIS) (DBIS, 2011). The SEC was rebranded as Social Enterprise UK (SEUK) and SEL was integrated with SEUK (Third Sector, 2011). Thus, over the past two decades, the UK's social enterprise sector has made considerable progress, establishing an environment in which the development, growth and sustainability of UK social enterprises have become more favourable, as a result of the government's approach and the response of the sector itself (British Council, 2015). In order to help the sector develop further, it is important to understand its key components and the interrelationships of all these elements.

3.1 Essential components of the UK social enterprise ecosystem

Just as biological species in ecosystems share their fate with each other, so do firms in a business ecosystem: ***"If the ecosystem is healthy, individual species thrive. If the ecosystem is unhealthy, individual species suffer deeply"*** (Iansiti & Levien, 2004). Each business in the 'ecosystem' affects and influences other businesses, creating a constantly evolving relationship in which each business must be flexible and adaptable to survive, as with biological ecosystems (INVESTOPEDIA, 2017). However, relatively little research has been conducted on the ecosystems of the social enterprises, using terminology and the conceptualisation of 'ecosystems' in social enterprise by practitioners (CASE, 2008; Ashoka, 2014; European Commission, 2014;2015; NESTA, 2015; British Council, 2015), , or academics (Bloom & Dees, 2008; Grassl, 2012; Lee & Hwang, 2013; Roy, et al., 2015; Hazenberg, et al., 2016a;2016b;2017), and few studies have attempted to expose the conceptual elements of a social enterprise ecosystem. The current study therefore sought the opinions of practitioners and

scholars in the social enterprise field in order to define the social enterprise ecosystem, and understand the 'ecosystem' of social enterprise and to further expose its conceptual elements. A definition of the social enterprise ecosystem was reached: ***a network and system relationship comprising various stakeholders in the social enterprise domain, including government, intermediary organisations, social enterprises and consumers.***

Using this definition, this study attempted to reveal the fundamental components of a social enterprise ecosystem. "The conceptualisation of a social enterprise ecosystem is based on commonly recognised features able to contribute to providing an enabling environment for social enterprise including the potential to address key constraints and obstacles" (European Commission, 2015). Some researchers have already conceptualised the components of a social enterprise ecosystem. The Centre for the Advancement of Social Entrepreneurship (CASE) (2008) claims that a social enterprise ecosystem can be seen as having two principal divisions: capital infrastructure, and the socio-economic and cultural environment. The capital infrastructure offers essential resources for the success of social enterprises, and the socio-economic and cultural environment creates the conditions in which social enterprises and their capital providers operate (CASE, 2008). This broad environment includes social enterprise policy, media relations, economic and social conditions.

Moreover, a social enterprise ecosystem, according to the European Commission (2014), relates to the characteristics of market and non-market environments including legal, financial, institutional, cultural, political and socio-economic aspects, and is an environment which operates in many ways to support or restrict social enterprise activities from thriving in specific contexts. Hazenberg et al. (2016b; 2017) argue that social enterprise ecosystems and various types of social enterprises may be formed differently, depending on a range of historical, legal, political cultural, social and economic structures. Table 1 shows the elements of a social enterprise ecosystem, explored by the Centre for the Advancement of Social Entrepreneurship (CASE) (2008), the European Commission (2014) and Hazenberg et al. (2016a; 2016b; 2017). Among these studies, the European Commission (2014) and Hazenberg et al. (2016b; 2017) conducted studies of the comprehensive components of social enterprise ecosystems at the national level in the UK. The earlier study by Hazenberg et al. (2016a) explains how English and Scottish social enterprises have developed differently because of historical (genetic) and institutional/environmental (epigenetic) factors.

Table 1: The elements for the conceptualisation of social enterprise ecosystem

CASE (2008)	European Commission (2014)	Hazenberg et al (2016b; 2017)
Financial capital	The policy and legal framework for social enterprises	Procurement policies/regulation for social innovation
Human capital	Tax exemptions and incentives	Financial activities for ecosystem growth
Intellectual capital	Publicly-funded support measures for social enterprises	Impact and dissemination
Social/political capital	Network and mutual support mechanisms	Collaborative stakeholder systems
Policy & politics	Marks, labels and certification systems	System drivers
Media	Systems for measuring and reporting social impact	Training and education in support of ecosystem growth
Economic and social conditions	Social investment markets	Inclusive labour market practices
Related Fields	Other specialist support and infrastructures available to social enterprises	

Source: Adapted from CASE (2008), European Commission (2014) and Hazenberg et al (2016b; 2017)

For the comparison and analysis of these three studies, the current study established criteria: (1) factors which are commonly mentioned in the three studies, and (2) themes which can be used to

categorise elements common to the three studies. The current research can confirm that the conceptualisation of a social enterprise ecosystem requires four crucial components through comparison and analysis of these three studies with the criteria: (1) policy and regulation structure, (2) finance and investment, (3) business development support, and (4) collaboration and networking. The four fundamental elements are explained as follows:

(1) Policy and regulation structure: policy frameworks for social enterprises are found within a broader policy framework aimed at the socio-economic, civil society, non-profit sector, active labour market policy or social inclusion policy. Social enterprise legislation also follows a broad range of approaches: firstly, applying the existing legal form to take into account the characteristics of social enterprises, and secondly, creating the legal status or qualification of the social enterprise (European Commission, 2015).

(2) Finance and investment: Many social enterprises struggle to access external capital when capital supplies are scarce, especially when they start with subsidy dependence or when they grow (DTI, 2002). These components show the overview of publicly or individual funding or investing for social enterprises' development (European Commission, 2015).

(3) Business development support: As with any other business, social enterprises need good corporate culture training. Social enterprises often lack commercial and managerial capabilities (Peattie & Morley, 2008; Doherty, et al., 2014), so it is essential to recognise their needs and provide appropriate advice and support (DTI, 2002).

(4) Collaboration and networking: This factor can be used to construct a framework for social enterprises to interact with governments, intermediaries, and other organisations with characteristics and goals similar to those of social enterprises. It also provides practical guidance and advice as a mutual support mechanism, plays a role in advocating the field, and interacts with various organisations (DTI, 2002; European Commission, 2015).

Design is evidently still not perceived as an essential component of the social enterprise sector. It is important to understand the key players in this field in order to find out how strategic use of design can be introduced and effectively integrated in their work.

3.2 Key players in the UK's social enterprise ecosystem

Although the European Commission (2014) and Hazenberg et al. (2016a; 2016b; 2017) explored the fundamental features of the UK social enterprise ecosystem, only the European Commission (2014) study disclosed specific stakeholders related to the essential elements of the UK's social enterprise ecosystem. Hazenberg et al. (2017) mapped the key stakeholders and the relationship of each stakeholder in the social enterprise ecosystem at national level across the Europe, including the UK (England and Scotland). Referring to those earlier studies, the current study attempts to expose the role of key stakeholders in the social enterprise ecosystem and to summarise the support programmes or activities each stakeholder carries out according to the ecosystem components.

Firstly, the main stakeholders in the policy and regulation structure of the social enterprise ecosystem are the government and various government departments. Their fundamental role is to enact policies and legal forms which encourage the growth of social enterprises and the wider sector. In order to carry out this role effectively, they must listen to what social enterprises really want, as other stakeholders claimed. Important and influential strategies and policies for the UK's social enterprises sector include the Social Enterprise Strategy (2002), the Social Enterprise Action Plan (2006), "Building a stronger civil society: a strategy for voluntary and community groups, charities and social enterprises" (2010). They also participated in supportive programmes and/or activities for social enterprises, including 'Good Finance project' and the 'Buy Social Corporate Challenge', led by intermediary organisations including SEUK (a national body for social enterprises) and UnLtd (a foundation which represents social entrepreneurs).

Secondly, government and various intermediary organisations including the Big Lottery Fund, Big Society, Big Issue Invest - play a significant role in developing finance and investment in the social enterprise sector, by providing direct investment, donations or loans to social enterprises. Other organisations - SEUK and Inspire2Enterprise - provide consultative information on the financial support social enterprises can access, rather than direct investment, loans, or donations. The government has regularly investigated the social enterprise sector since 2012, publishing reports on social enterprise market trends in 2013, 2015, and 2017. This governmental investigation has exposed the financial market conditions of social enterprises and some of the barriers social enterprises face in accessing financial markets. The Design Council has also conducted a project to identify how social entrepreneurs can better access social finance.

Thirdly, as with finance and investment factors, business development support is related to various stakeholders. Stakeholders provide support for the practical business operation of social enterprises, including building business models, marketing, accounting, etc. SEUK contributes by leading social enterprise campaigns, including the 'Buy Social Corporate Challenge', 'Social Saturday', and the 'Buy Social Campaign'. Those campaigns are intended to raise awareness of social enterprise in the private and public sectors and encourage people to buy social enterprises' products and services. UnLtd provides specific business support to start-up social enterprises. Inspire2Enterprise helps social enterprises with bespoke business supports for social enterprises' development stages, problems, and needs. The Department of for Business Innovation & Skills conducted a study of business support for social enterprises in 2011, to identifying gaps and market failures in business support for social enterprises in a changing economic environment (DBIS, 2011).

Lastly, some intermediary organisations are involved in the advocacy of collaboration and networking element of the social enterprise ecosystem, encouraging or providing a platform for networking and collaboration between social enterprises or social enterprises with agencies, local and/or central government. SEUK, for example, leads the 'Social Enterprise Place programme' to promote, raise awareness, and build the markets for social enterprise by communicating with local stakeholders (Social Enterprise UK, 2017a). Table 2 is an overview of existing programmes and supports with various key stakeholders. More organisations can be included in the ecosystem's constitutional categories, and some organisations perform multiple roles within the sector.

Despite the large number of players in the UK's social enterprise ecosystem, accessing finance and/or funding remains the most significant barrier to sustainability and growth of social enterprises in the UK (Social Enterprise UK, 2011;2013;2015;2017b). Social enterprises' access finance can be divided into two categories: (1) obtaining grants or loans from the social investment market, and (2) increasing their income through trading goods and/or services. Many social enterprises, for example, struggle with applying for social investment and have a perception that the funding ecosystem pressures them to expand too quickly (Design Council, 2014b). Many supportive measures are available to support start-up social enterprises, but it is less easy to find specific support for a social enterprise to expand its business scale. Furthermore, according to some UK social enterprise ecosystem stakeholders, although the UK's social enterprise ecosystem includes a pluralistic network of stakeholders operating in different sectors, it is fragile because of commissioners' and markets' lack of awareness of social enterprise.

Design is not integral to social enterprise infrastructure support, which may be an underlying reason why design is not utilised strategically in this sector, especially among small-and-medium-sized organisations. Arguably, effectively introducing design into this sector will have to occur at the policy and ecosystem level. The role of design in the commercial sector will therefore be examined to pinpoint good practices which can be applied to social enterprise at both the organisational and ecosystem levels.

Table 2: Key stakeholders in the social enterprise ecosystem

	Key stakeholders	Support programmes

Components of SEE	Direct involvement	Indirect involvement	or activities
Policy and Legal structure	Government • Cabinet office • Department for Business, Innovation and Skills • Department for Communities and Local • Government Department for Work and Pensions • Other Government Departments	Co-operatives UK Social enterprise UK UnLtd British Council Nesta Design Council	Good Finance (website) Buy Social Corporate Challenge Buy Social campaign Buy Social dictionary Social Enterprise Places
Finance and Investment	Cabinet Office Big Lottery Fund Big Society Capital Social Finance UK UnLtd Big Issue Invest Social Invest Business ACCESS	Co-operatives UK Social enterprise UK Real Ideas organisation Inspire2Enterprise Social Enterprise East of England School for Social Entrepreneurs Young Foundation Nesta Design Council Flip Finance Department for Digital, Culture, Media and Sport Department for Business, Energy and Industrial Strategy	Good Finance (website) Buy Social Corporate Challenge
Business development support	Real Ideas organisation UnLtd Social Firms UK Inspire2Enterprise Social Enterprise East of England School for Social Entrepreneurs British Council Flip Finance Matter&Co	Social enterprise UK Social Enterprise Solutions Social Enterprise Mark company Young Foundation Nesta Design Council Department for Business Innovation & Skiils	Buy Social Corporate Challenge Accelerator programme Social Enterprise Places Social Saturday Buy Social campaign Buy Social dictionary
Advocacy of collaboration and networking	Social enterprise UK UnLtd Co-operatives UK British Council	Social Enterprise Solutions Social Enterprise Mark company Inspire2Enterprise Social Firms UK School for Social Entrepreneurs Young Foundation Nesta Design Council Flip Finance	Social Enterprise Places Buy Social Corporate Challenge Social Saturday Buy Social campaign

4 Design's expanding role in the business sector

Design is understood differently by individuals and organisations, covering a broad range of activities and outputs (Henderson & Whicher, 2015). According to the Danish Business Authority (2011), design is narrowly understood as producing a certain quality and the process of crafting products, and is recognised as part of knowledge – an extensive field characterised by innovation, and multidisciplinary strategic processes. Design need not be limited by types of design: graphic, product, or service design. Broadly, the design process includes both technical design (including engineering for manufacture) and non-technical design (including experience and identity) (Design Council, 2011). Several reports have already found considerable evidence for using design as a mechanism for business development and innovation (Hertenstein, et al., 2001; Danish Design Centre, 2003; Design Council, 2007; 2008; 2012; 2014a). Design can play a significant role in promoting the growth and sustainability of enterprises e.g. design has a number of meanings for businesses including designing for function, aesthetic appeal, ease of manufacture, sustainability, reliability or quality, and business processes themselves (DTI, 2005). These design roles can increase profits by adding value to businesses (Design Council, 2014a) and increasing brand equity by implementing and strengthening a company's brands and delivering its value and uniqueness to the outside world (Design Council, 2014b). Using design in enterprises is widely recognised as a significant element of a company's sustainable development through influencing increasing potential competitiveness and improving the quality of products and/or services (Roy & Riedel, 1997; Borja de Mozota, 2003; Best, 2010; Hertenstein, et al., 2013; D'lppolito, 2014; Holland & Lam, 2014), and design today is applied in a wide variety of business areas. Accordingly, to understand the broader contribution of design in business, Na et al. (2017) developed an accessible 'design spectrum' tool. The role of the design in their design spectrum is as follows: (1) designing (product/production/communication/service), (2) design strategy (managing design), and (3) corporate-level design thinking (managing the company). The design spectrum briefly describes the various roles of design. The current study refers to Na, et al.'s design spectrum to examine the current status of design knowledge and use of design at social enterprise ecosystem level in the UK.

4.1 Current UK understanding and use of design at the social enterprise ecosystem level

The UK is among the more advanced countries which recognise the value of design in the private and public sectors (Design Council, 2007;2011;2013;2015a;2015b). Various UK studies have examined the value of design to help accelerate innovation and growth of businesses and/or public services (Design Council, 2011;2015b; Micheli, 2014; Design Commission, 2014, Innovate UK, 2015). The UK government views design as playing a central role in its strategy for economic growth and rebalancing (DBIS, 2011), recognising design as an integral part of the sustainable development of the UK national planning policy framework (Department of Communities and Local Government, 2012). Design was identified as having the potential to support both the UK government and businesses and to strengthen UK competitiveness (Design Council, 2013). However, despite the acknowledging the value of using design in the UK's business and public sectors at national level, most important stakeholders in the social enterprise ecosystem have poor understanding or a negative perception of the design approach, which makes understanding the intention of using design in the UK's social enterprise ecosystem problematic. To date, this research has identified only two cases of using design strategically in the UK's social enterprise ecosystem level: (1) design influenced directly at the systematic level of the social enterprise ecosystem, and (2) design applied at the operational level of social enterprises.

The first case – the 'Good Finance Project' – is led by a wide range of key stakeholders in the social enterprise ecosystem across government, intermediary organisations, and design associations, to improve access to social investment information for charities and social enterprises. This project appears to be the first attempt to consider the use of design to improve the finance and investment component of the social enterprise ecosystem. Before this project was conducted, a Design Council

study exposed a problem in the social finance market - social enterprises' difficulty in obtaining appropriate funding and support - and tried to identify better solutions to this problem (Design Council, 2014b). Several later studies have shown that it is necessary to help social enterprises and charitable organisations to obtain social investment effectively (Social Enterprise UK, 2015; Alternative Commission on Social Investment, 2015; Cabinet Office, 2015). The Good Finance project responded directly to those studies, and created a digital platform to educate and guide social enterprises and charities to appropriate investment opportunities (Snook, 2016). In this project, design provided a new perspective on social enterprises' investment needs. According to Snook (2016), "Good Finance is the most developed design-led project in the sector to date but there is huge potential to use the iterative, user-centred and collaborative approaches offered by design for a range of sector challenges."

Another case of using design in the UK's social enterprise ecosystem level is Better by Design which was developed by key stakeholder Big Lottery Fund Scotland. Although this case study is not directly related to the social enterprise ecosystem development, it demonstrates the importance of using design in solving problems in participating organisations and achieving their main purpose. This project encourages third-sector organisations to achieve sustainability by supporting the maximum change process to better meet the needs of their current and future beneficiaries (Big Lottery Fund, 2014). To achieve this, fifteen third-sector organisations applied for the two-year support package to accompany the funding. Each organisation received bespoke support through the programme. According to the Big Lottery Fund (2014), the programme "guides the organisations through a design-led change process that draws on insight from a wide range of stakeholders and uses innovation and practical design tools and techniques to put people at the centre of the services they want and need." In this project, design was used to provide a simple framework to help people map and share patterns, connections, and change opportunities which enabled them to identify and share problems. The role of design in the programme also enabled stakeholders to gain new insights and develop new perspectives on the unmet needs and services currently offered (Big Lottery Fund, 2014).

The current study examines two cases of using design at the social enterprise ecosystem level in the UK, giving a glimpse of some opportunities which can be beneficial in developing a social enterprise ecosystem. The design spectrum was applied in both cases, and the Good Finance project is an example of how design can be used strategically to dovetail with the social enterprise ecosystem. Better by Design has shown that design can play a bespoke role to fit the problems and purposes of individual organisations. The current research believes that if the key stakeholders are aware of the positive impact of design on their role, it may be advantageous to developing the social enterprise ecosystem.

4.2 The anticipated relationship between the role of design and the essential components of social enterprise ecosystems in the UK

Design can play a variety of roles, depending on the situation, and is particularly useful for problem-solving (Borja de Mozota, 2003; Holland & Lam, 2014). The two cases of using design in the current social enterprise ecosystem demonstrate design's influential role in problem-solving. This study seeks to explore existing challenges facing the UK's social enterprise ecosystem, drawing on exploratory interviews with experts and key stakeholders in the UK's social enterprise ecosystem. Key findings from the expert interviews with key stakeholders in the UK social enterprise ecosystem, and about the difficulties faced by the UK's social enterprise ecosystem appear below.

Firstly, stakeholders are required to establish policies and regulation structures which encourage the growth and development of social enterprises and its sector, evaluating and developing it by reflecting social enterprise needs and opinions. However, the current policy and regulation structure fail to reflect the real needs and/or opinions of social enterprises, and there are practical barriers to implementation. Some policy directors in the social enterprise field confirmed that this may be due

to a lack of awareness of social enterprise, even though the policy-makers are key stakeholders. They also appear to lack understanding and knowledge of social enterprise needs. Secondly, key players in finance and investment – including the Cabinet Office, Big Society Capital, UnLtd, etc., – should make it easier for social enterprises to access capital, because most social enterprises currently experience difficulty accessing finance and applying for grants and loans. In order to solve those problems, The Good Finance project has used design, but the current study research questions how many social enterprises, social entrepreneurs and other intermediary organisations are aware of Good Finance, and how it impacts on the real market. Thirdly, business development support stakeholders should play an extensive role in providing support at various social enterprise business stages. Social enterprises need different business development support from stakeholders depending on their business step, scope, size, purpose, etc., However, most stakeholder support is at the start-up phase, and support for business development to encourage expansion is often inadequate. Lastly, most of the study's interviewees indicated that the UK's public and private sectors have little knowledge of collaboration and networking, partly because of inadequate communication in those areas. Collaboration and networking stakeholders can play a role in building networks between social enterprise and lobbying government or private businesses to increase awareness of social enterprises.

This research suggests that design can help develop the social enterprise ecosystem by solving the UK social enterprise challenges mentioned above. Four specific design roles can contribute to resolving the UK social enterprise ecosystem's challenges. Firstly, social enterprises can include design in their business strategy, to raise awareness of social enterprise and deliver value to the public and private sectors. Social enterprise activities contribute value to the economy, society and the environment, depending on their business and social (environmental) purpose. Secondly, design can play a role in enhancing understanding of social enterprise needs. In the wider business sector, tactical use of design improves understanding of customer needs (Chen & Venkatesh, 2013; Holland & Lam, 2014). Thirdly, design can play a role as a strategic problem-solving tool to identify the gaps between what stakeholders do and what social enterprises really need, and be applied to bridge the gap. The role of design can be regarded at the operational level of the social enterprise ecosystem as one of the social enterprise ecosystem's main purpose: to reduce the gap between social enterprises and stakeholders. Lastly, design can play a role at the operational and systematic level, improving interaction and communication between key players and social enterprises to encourage a better mutual relationship.

Figure 2: An overview of the study's findings and discussions

5 Conclusion

The study's aim was to understand the comprehensive social enterprise ecosystem, using the UK as a case study to explore the role of stakeholders in the ecosystem and identify their perceptions of using design. The study examined four important elements for the social enterprise ecosystem in the UK: (1) policy and regulation structure, (2) finance and investment, (3) business development support, and (4) collaboration and networking. Multiple stakeholders across central and local governments, intermediary organisations such as SEUK, UnLtd, Inspire2Enterprise, etc., - supportive organisations for social enterprises - and social enterprises themselves are involved in the ecosystem. Each stakeholder has different responsibilities in social enterprise ecosystem development. The results of this research illustrate that social enterprises remain poorly understood in the public and private sectors, with gaps between key stakeholders and social enterprises. Key players either do not hear the voice of social enterprises or fail to fulfil their needs. Furthermore, most stakeholders in the UK's social enterprise ecosystem have little understanding of design and are largely unaware of the influence of design. However, the excellent case study of the Good Finance project demonstrated how design can be applied in solving problems for the social enterprise ecosystem, especially in finance and investment among the fundamental elements of social enterprise ecosystem. This research suggests that strengthening connections between the role of multidisciplinary stakeholders in the social enterprise ecosystem and using design can lead to social enterprise ecosystem improvement and to seeking how best to support the sustainable development of social enterprises. Although the study identified the potential relevance of the relationship between stakeholders and design, it did not investigate in depth the practical role of design to address the problems of social enterprise ecosystem and the weaknesses of social enterprises. A further in-depth study will be conducted to hear the real voice of social enterprises about the UK's social enterprise ecosystem and using design in their organisations. The case study of South Korea's social enterprise ecosystem is also considered, and compared with that of the UK. The Korean government emphasises the importance of policies for social enterprises development (McCabe & Hahn, 2006), referencing the UK's policy, regulations and model in order to grow its social enterprise sector (McCabe & Hahn, 2006; Park & Wilding, 2013; Park, Lee & Wilding, 2016). However, the social enterprise policy established by the Korean government has greater concrete purpose than that of the UK (Park, Lee & Wilding, 2016). The current study will later explore how design can be applied to solve challenges in social enterprises and the social enterprise ecosystem with a comparative analysis of the case studies of both countries - South Korea and the UK's social enterprise ecosystems.

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Exploring the Pop-up Shop for Co-design Research

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Temporary physical spaces are increasingly used as catalyst to engage consumers and users in co-design activities. Whilst there are published insights into the design and facilitation of these spaces, a systematic view on their research opportunities and design requirements is still missing. This paper takes a first exploration into the employment of physical pop-up shops for user and stakeholder engagement. It analyses theory from marketing and human geography from a design research perspective to formulate design requirements for pop-up shops with the goal of engagement and co-design. It also proposes to categorize pop-up shop research as experience prototyping for the near future, thus firmly placing it into the framework of the design research landscape. To illustrate this proposition, it uses data from three cases of an iterative pop-up shop research project. Finally, it discusses conclusions about the requirements and opportunities for co-design in pop-up shop research.

co-design, user engagement, pop-up shop, experience prototyping

1 Introduction

Both interaction design and open innovation design have made explorations into the use of temporary spatial interventions (Maxwell, Woods & Prior, 2013; Teal & French, 2016; French, Teal & Raman, 2016). The goal of these interventions with names like 'designed engagement places', 'pop-up environments' or 'experience labs' is to create engaging experience platforms for users and stakeholders to co-design. For the purpose of this paper, co-design is defined as "designers and non-designers working together using making as a way to make sense of the future" (Sanders & Stappers, 2014: 5). Pop-up spaces for co-design are meant to be collaborative places, where design researchers, users and design artefacts make meaningful connections. Innovation is an important goal of these spatial interventions.

> *Designed Engagement aims to not only engage people in dialogue to collaboratively explore ideas and differences in views, but to engage them in creative exploration of new ways of doing things to work towards preferable futures.* (Teal & French, 2016: 6)

Engagement platforms that include physical space, as opposed to 'immersive labs' that use virtual reality (VR) simulation (Martinez, Isaacs, Fernandez-Gutierrez, Gilmour & Scott-Brown, 2016) often draw on the so called interstitiality. Temporary spaces appear and disappear within more stable environments and are perceived as physical in-between places. As such, they can disrupt spatial and

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temporal routines and offer new alternatives for users (Harris, 2015: 597). Artist-led spaces like 'happenstance' are ways of "activating the space such that people who inhabited it worked towards a particular goal outside of their normal routine" (Maxwell, Woods & Prior, 2013: 202).

Retail pop-up shops are another example of spaces for co-design. Pop-up shops are temporary and highly experiential physical spaces that have been predominantly used by brands for marketing goals. However, the fact that commercial stakeholders always have an agenda they impose on consumers/users has led design researcher to neglect the knowledge created by pop-up retailing literature. Meanwhile the willingness of consumers to collaborate is increasing as they seek "consumptive/ creative balance" (Sanders & Stappers, 2008) and opportunities to mix passive consumption with the choice to engage in creative experiences.

In practice, the problem that users who are currently motivated to co-design are mostly highly involved and knowledgeable users that differ significantly from the majority of consumers (Hoyer, Chandy, Dorotic, Krafft & Singh, 2010: 289), might be tackled by pop-up shop research. Moreover, diverse stakeholders who do not have the mind set (yet) to engage in more focussed co-design activities, could be engaged. In order to attract broader and more diverse groups of users and stakeholders into co-creating products and services at different stages of the design process, entire pop-up shop concepts or certain properties could be utilized.

Aiming at exploring the pop-up shop for co-design research, this paper will first develop an operational definition of the pop-up shop by analyzing literature from marketing and human geography about successful pop-up shop properties. It will further develop this definition from the perspective of experience prototyping and user engagement and place the resulting research approach into the landscape of co-design (Sanders & Stappers, 2014). It will then delve deeper into putting this theory into practice, illustrating the approach using data from a pop-up shop research project which included three iterations. The goal of this exploration is to provide a systematic view on the co-design opportunities of pop-up shop research and its related design requirements.

2 Theory and methodology

2.1 Methodology choices

The leading question of this paper is: What is a pop-up shop research approach and how does it fit into the broader landscape of design research?

This study champions a performative social sciences methodology: Collaborative practices are created and recreated daily within distinctive spatial contexts. The designer, her students and other network partners are human actors interacting with the pop-up itself as a "nonhuman actor" (Latour, 1994) to unfold a presence. From this grounded-in-action perspective, reality is the outcome of a joint mediation between the "built-in properties" (Fairhurst & Putnam, 2004: 18) of objects and the objectives of human subjects. This methodology matches well with

> *… 'constructive design research', which refers to design research in which construction – be it product, system, space or media – takes center place and becomes the key means in constructing knowledge.* (Koskinen, Zimmerman, Binder, Redstrom & Wensveen, 2011: 5)

Taking into consideration these methodological choices, the first sub-question must be: What are the relevant design properties of the pop-up shop that fit the objective of co-design, translated into the language of existing concepts in co-design?

The resulting proposition of a pop-up shop research approach then needs to be contextualised using a model of the broader design research landscape. The model developed by Sanders and Stappers (2014) was chosen. This model knows several categories which fit well with findings of the first sub-question, including the intent of engagement, the time horizon in the near future (e.g. next generation) and the mindset of co-design (a continuum between 'designing for users' and 'designing with users').

Once defined and contextualized theoretically, the pop-up shop approach needs to be fleshed out in practice. How is pop-up shop research rolled out? Which methods are best used to collect data?

> *Pop-up environments are by definition limited in time, and therefore require close monitoring and responsive facilitation to ensure the most effective use of resources, however these intensive, condensed environments or specific events within larger pop-ups can be directly instigated by researchers, providing the opportunity to embed data gathering and a focus on thematic topics of interest into the space from the outset.* (Maxwell, Woods & Prior, 2013: 201)

With the complexity of pop-up research in mind, the final sub-question of this paper is about the opportunities and challenges of pop-up shop research. To illustrate the theoretical proposition and explore this last question, the data of a pop-up shop research project with three iterations will be used. The different methods of data gathering will be reported in the description of each iteration.

2.2 Design properties of successful pop-up shops

What are the relevant design properties of the pop-up shop for the objectives of co-design? Literature on pop-up shops currently revolves around pop-up retailing. Warnaby, Kharakhorkina, Shi & Corniani (2015: 303) define pop-up retailing as "an experientially orientated consumer-brand interaction, taking place within a particular, albeit temporary, 'territory'". They identify three distinguishing characteristics of pop-up retailing from existing literature: (1) a highly experiential in-shop environment; (2) a focus on promoting a brand or product line; and (3) availability for a limited period of time, with this essential ephemerality aiming to create a sense of urgency, to stimulate purchase or other actions. However, Warnaby et al. (2015) similar to most other marketing scholars (De Lassus & Freire, 2014; Gursch & Gursch, 2014; Haas and Schmidt, 2016; Kastner, 2015; Klein, Falk, Esch & Gloukhovtsev, 2016; Pomodoro, 2013; Russo Spena, Caridà, Colurcio & Melia, 2012; Surchi, 2011), focus on the marketing objectives of global brands: to promote brand/product lines in 'brand pantheons', to test new markets and to sell seasonal or limited editions of product. Interestingly, human geography scholars (Andres, 2013; Colomb 2012; Ferreri, 2015; Ferreri, 2016; Finan, 2015; Harris, 2015) mostly take the perspective of small business and cultural start-ups on temporary spaces. These authors describe the pop-up shop as a community shop catering to alternative lifestyles (Ferreri 2015; Ziehl & Osswald, 2015) which they call the 'tribal shop'. It is the so-called placemaking that is the result of a successful pop-up spacing which revalues vacant retail space. This is particularly successful when cultural or small business initiatives work closely together with local residents. The result is a reevaluation of the space after the temporary experience, a new recalled identity of place (Finan, 2015; Moore-Cherry, 2017).

The temporary use of vacant or derelict spaces by a pop-up shop is not new. Temporary shops, galleries and restaurants emerged in the U.S. at the turn of the new millennium. In Europe, pop-up shops 'officially' appeared some thirteen years ago, when in 2004 the high fashion label 'Comme des Garçons' opened a temporary guerilla shop furnished in an abandoned bookshop in Berlin, Germany (Alexander & Bain, 2016). Since then, unusual and unique locations have been associated with pop-up retailing. Temporary shops predominantly pop up in upcoming urban environments all over the world, albeit in highest frequency in global cities.

There is strong consensus in pop-up research that millennials, with their hedonic and experiential motivations, are the demographic group which feels most attracted to temporary spaces (see for an overview Taube & Warnaby, 2017: 389). This diverse group of people born between 1980 and 2000 are more extraverted and leisure-values oriented than earlier generations (Twenge & Campbell, 2012). Raised in a time of accelerated technology use and globalization, they are well-informed consumers using online information, blogs and peer reviews for product orientation. Offline and embodied, they are predominantly looking for experiences and the identification with products and their producers (De Lassus & Freire, 2014; Gursch & Gursch, 2014). They are "always on the move, are driven by the wish to freely live temporary and exciting experiences" (Pomodoro, 2013: 342). The pop-up shop, which typically lasts several days to several months and often has a restricted or

exclusive product range satisfies these needs (Alexander & Bain, 2016; Haas & Schmidt, 2016; Warnaby et al., 2015).
Scarcity of time and product displayed can thus be marked as the first property of the pop-up shop. It creates a sense of urgency and novelty with potential users. Approached from the perspective of co-design, the effects of scarcity need to be balanced with the comparatively high investment in design, equipment and manpower needed to conceive, build and maintain a successful pop-up space. Rather than months, one day to one week seems affordable.
Both marketing and human geography authors describe the pop-up shop environment as discovery-driven and designed to facilitate consumer engagement. Creating a memorable experience is an important aspect of pop-up activity. While the first studies into the experience economy (Pine & Gilmore, 1999) stressed the involvement of consumers in a theatrical environment, more recent research points to the immersive power of retail spaces engaging active consumers with makers and product experts (Caru & Cova, 2007). Immersion, the experience of entering a multi-sensory space which immediately identifies itself as 'a different world', can be marked as the second important pop-up property.
Warnaby et al. (2015) suggest distinguishing between design, ambient and social cues. Fused with elements such as décor, flooring and furnishing, ambient cues like music, lighting and scent, as well as social cues like positive staff interaction, create emotional and behavioral effects on user engagement (Taube & Warnaby, 2017). Pop-up shops must be multi-sensory and interactive. Scent, sound, sight, taste, touch and movement must be addressed. As immersiveness and interactivity play an important role in engaging the user in an overall theme, this property is particularly important when the pop-shop is predominantly used for the goal of co-design.
Human geography authors also describe pop-ups as in-between spaces existing in the cracks of dominant orders or "residual spaces" (Harris, 2015: 596) left out of time and place. As such they work like an interruption (Ferreri, 2016) or festival (Ferreri, 2015) disrupting urban aesthetics and movement routines with unusual locations and exterior shop designs. The visual interruption creates a "surprise effect" (Taube & Warnaby, 2017: 388) and openness for exploration on the side of the user. This property is often referred to as the aesthetic interstitiality of pop-up spaces. Some marketing scholars also stress the event character of pop-up retailing (Pomodoro, 2013; Warnaby et al., 2015). Human geographers refer to this phenomenon as eventual interstitiality (Harris, 2015). Applying aesthetic interstitiality (finding and designing unique spaces) and augmenting eventual interstitiality (using probes or tool kits that engage users into specific activities) designers could use this pop-up shop property to engage users/consumers in co-design.
Finally, the physical pop-up shop integrates digital, social media and mobile (Gursch & Gursch, 2014; Pomodoro, 2013; Alexander and Bain, 2016). Given the need to maximize interest in a pop-up activity over a short period of time, social media assumes great importance in three temporal stages: the pre-experience stage, the pop-up experience itself and the post-experience stage (Warnaby et al., 2015). This applies also for design researchers who want to attract and engage multiple and/or diverse groups of users.
Combining marketing and human geography literature, an operational definition of a pop-up shop as a temporary and highly experiential physical space contains the following properties:

- A limited time frame of one day to one week (playing into scarcity or hype),
- an immersive, multi-sensory and interactive shop environment,
- aesthetic interstitiality (unusual location and/or exterior shop design),
- eventual interstitiality (using design probes and/or tool kits)
- social media co-creation in pre-experience, experience and post-experience phases.

2.2.1 User engagement in the design research framework

How does this operational definition match with existing concepts in co-design research? From a design perspective, pop-up shops are spatial artefacts which are highly experiential. Representing an

integrated experience around a new concept, product or service, they could be categorized as an experience prototype.

> *… an experience prototype is any kind of representation, in any medium, that is designed to understand, explore or communicate what it might be like to engage with the product, space or system we are designing. (Buchenau & Suti, 2000: 425)*

In a pop-up shop, users and stakeholders shape this prototype with their own bodies and senses. They can actively participate and give feedback. This embodied interaction has a number of advantages over purely digital interaction. Stappers (2006) makes a strong argument for bodily involvement of users in the conceptualizing phase of design. With digital tools, logical thought and verbal expression are supported.

> *What is supported much less well is people's skills in spatial reasoning, associative thought, overview, empathic thinking, informal discussions and serendipity. (Stappers, 2005: 96)*

Pop-up shop research allows the immersion of users in an integrated experience which is connected to a temporary physical space, but can also contain digital interaction, virtual reality (VR) and augmented reality (AR). Martinez, Isaacs, Fernandez-Gutierrez, Gilmour & Scott-Brown (2016) describe co-creation, immersion and 'perspective taking' as three distinctive techniques to swap the role between designer and user. Their intention is to serve users. In pop-up shop research, the focus is on engaging users. For this intent, immersion and opportunities to co-design are linked. On the other spectrum of co-design, prototypes are utilised to provoke users (e.g. Boer and Donovan, 2011). Depending on the concept of the particular pop-up shop, pop-up research can be provoking, but this is not the core strength of the approach.

Its strength lies in engagement. Pop-up shops can engage (attract, immerse and motivate to co-design) ordinary users and otherwise difficult to reach communities. They do this by popping up as spatiotemporal in-between (interstitial) spaces in neighbourhoods. Moreover, the near-future orientation of pop-up shops, combined with the effect of scarcity, engages curious user groups like "emergent consumers" and "market mavens" who bring valuable feedback to design (Hoyer, Chandy, Dorotic, Krafft & Singh, 2010: 288). Hoyer et al. (2010) discuss the motivations of users for co-design. Financial or social status benefits play an important role, but so does pure enjoyment. Hedonic motivation and a pleasure to explore and learn are reasons to visit and co-design in a pop-up shop. Pop-up shop research as a special approach in experience prototyping can thus be situated in the 'engaging' slice of the landscape of design research on the layer of the near future (e.g. next five to ten years).

Figure 1. The design research landscape as proposed by Sanders and Stappers (2014, page 13, figure 6).

As embodied interactions, pop-up shop concepts can vary in the degree of co-design with the user. The stars in figure 1 indicate the locations of three iterations of pop-up research conducted. In order to illustrate the theoretical proposition made in this chapter and to further explore opportunities and challenges of pop-up space research, the three iterations and their position in the landscape will be shortly described in the consecutive chapter.

3 Three pop-up shop research examples

In 2016, The Hague University signed the Retail Agenda, a national open innovation network initiated by the Ministry for Economy and representatives from all provinces. Responding to the significant disruption of the retail sector caused by the move to online and changing consumer values and purchasing behaviour, this network of municipalities, highstreets multiples, SMEs, branch intermediaries and real estate stakeholders started working more closely together. In prder to engage (parts of) this network into co-creation, the 'Retail Innovation Lab' started a research intervention consisting of an iteration of pop-up shops. They were conceived as experiential engagement platforms around different themes, working together with Industrial Design and Communications students. With a cross- disciplinary learning module of ten weeks, it embedded this project across different curricula. The three following examples concern learning iterations of this pop-up shop research.

3.1 In Bloom: the fuzzy front end

Figure 2 Logo of the pop-up shop.

In early 2016, a Dutch grower's cooperative (twelve flower and plant growers) approached the 'Retail innovation Lab' with the goal of discovering the flower preferences of Millennials. Their aim was to find out why young people do not buy flowers and what their product preferences were. The lab suggested to use a pop-up approach to explore the following research questions:

How far could a flower/plant pop-up experience change students' very perception of these products? And: Which use would students attribute to these products?

Industrial Design Engineering students conceived a stand-alone pop-up shop in the central hall of the University. International Communication Management students came up with a name, 'InBloom', and communication strategy and a Small Business student coordinated the process. The growers provided flowers and plants, but were confined to the role of sponsor. By this their influence on the conception of the pop-up shop was kept minimal.

Figure 3. Co-design inside and opening outside the 'In Bloom' pop-up shop.

The brief provided to students included the pop-up shop properties which were stated earlier in this paper as design requirements. The pop-up was scheduled to be open for five days, from April 4 to April 8, 2016. For research purposes, students collected data with a short questionnaire at the pop-up entrance and again at the exit. They collected 173 valid questionnaires before, 135 directly after, and 36 valid questionnaires three weeks after the pop-up experience. The questions focused on the visitors' perception, imagination and chosen interactive activities. The author of this paper spent at least an hour every day at the pop-up, talking to visitors and keeping a logbook.

The Communication students created a story around the 'In Bloom' pop-up which was strongly communicated through the logo (figure 2), released two weeks before the opening. The design students came up with a construction of two domes connected by a tunnel, crafted using plastic tubes and a foil cover. They also designed an interactive tree which sent out sound upon touch as the centrepiece of the pop-up shop. Furthermore, there were a visual, auditory and olfactory presentations of flowers including a lounge space. Finally they created work stations where users could paint or eat flowers.

One day after the opening, the University's internal magazine published the following:

> *When you walk into the aluminium igloos on a green carpet, you enter another world. Fresh flowers colour the walls, the smell does take you to a beautiful spring day in nature and the music moves you further: to a distant place with trickling water and chirping birds. And that's all while you're just in the main atrium.* (Link, 2016)

During the five days of 'In Bloom', more than 2,000 students, staff and neighbourhood residents visited. Judging from the questionnaires, it was the perceived oddness of the artefact in this place as much as the flower theme which drew their attention. But the interstitiality of the pop-up shop not only attracted them visually, it also triggered their curiosity, which made them take time to visit the space. Their question "What is this?" was not answered conclusively by the facilitators on site, in order to allow for ambiguity. They were just told that it was a research project and that they were free to touch and explore.

The questionnaire data of 50% of the respondents revealed that the pop-up experience had made them aware of the added value flowers and plants could have for their working environment and/or homes. Even three weeks after the pop-up experience, 30% of the visitors still looked differently at flowers and plants. In personal conversations, many stated that they would want to have more flowers and plants in their lives if only they had the space and time to care for them.

On the day following the opening of 'In Bloom' some people came back to have lunch, meet or work in the pop-up shop. They all stressed the opportunity the space provided to decompress. Many

pointed out that it was the full sensory experience that drew them to the space, particularly the scent. Photos and stories were shared by users on Facebook and Instagram. At some point between the third and fourth day of the pop-up shop, user comments aligned on the space as a "restorative flower oasis". For the flower and plant growers these results were revealing. They realized that millennials strongly connected to their plants, but could not interact with the kind of products presently on offer in shops. It encouraged them to start thinking in a completely different way about offering the experience of flowers and plants to this user group in the future.
In terms of co-design, users developed and shared ideas in different ways. They participated in a 'name the flower' contest and in flower tastings, shared their thoughts on postcards and communicated experiences and ideas with the two facilitators in the shop. As users were thus actively co-designing a future product/experience, the 'In Bloom' pop-up shop is positioned as the star on the upper right side in figure 1.

3.2 The Donut Factory: communication and commercialization

Figure 4. Flyer of the pop-up shop.

Once a year, the lab gives retail students the opportunity to pitch an innovative concept for pop-up shop research. The winning concept receives financial support and help with coordination. In early 2017, a group of five Small Business & Retail Management students came up with the idea to create a customizable donut shop. They received a delivery of fresh donuts from a local bakery every morning. The added value of the retail concept was the customization of the product with different toppings and warm 'glazing', as well as the fun experience around that customization. The goal of 'The Donut Factory' pop-up shop research was to test this innovative retail format in vivo and to communicate it to local retail entrepreneurs.

'The Donut Factory' took place for a week in May 2017 using a part of the University's innovation space which needed to be completely re-designed. Similarly to 'In Bloom', students were briefed on the pop-up properties discussed earlier in the paper as design requirements. To adapt research to this type of pop-up shop and its position in the design process, the method was changed.

Questionnaires were dropped in favour of observation based on a conceptual framework (Varshneya, Das & Khare, 2017: 349, figure 8) which connects experiential value to user behaviour, in this case customer satisfaction and willingness to pay. Donuts were actually sold, but users could determine the price they wanted to pay. The researcher visited the pop-up every day for two hours to observe and talk to customers and conducted interviews with all participating students.

Figure 5. Inside 'The Donut Factory' pop-up experience.

The Communications students conceived a 'happiness theme' around the experience of 'The Donut Factory' which was well communicated by the logo on flyers (figure 4) and on the project's Facebook page. Design students made a wheel of fortune for donut customization options as well as a selfie wall with slogans including "Donut is happiness with sprinkles on it" and "Donut ever give up!". According to customer interviews, the selfies were widely shared on social media. Interestingly, interviews also revealed that users connected a 'guilty pleasure theme' with the pop-up experience. Students and lecturers spending time in the pop-up space mentioned that allowing themselves to eat this kind of unhealthy food was both an exception to their diet and an exceptional pleasure.

At the end of the week, 'The Donut Factory' donated more than 3000 euros in profit to a good cause. The user satisfaction and willingness to pay had been very high, proving the experiential value of the pop-up shop. Visiting retailers invited the students to bring their pop-up shop to a local street. The students concluded that their retail concept could be taken to the market. They realized however, that the scarcity effect of the pop-up matched with the co-created 'guilty pleasure theme' and concluded that the concept needed to be rolled out as pop-up retailing (as opposed to a permanent shop).

In terms of co-design, there were no extra activities with probes or toolkits like the ones at 'In Bloom'. Arguably, the co-creation on the usability of this retailing concept and the donut customization done by users counts for a middle position on the 'designing together with users' scale. Also, the retailing concept was almost situated in the here and now. That is why 'The Donut Factory' figures as the star in the middle-downward position in figure 1.

3.3 To-Kiss-Or-Not-To-Kiss: contextual product development

Figure 6. Clay prototypes of the multicultural kissing couple.

In July 2017, the 'Retail Innovation Lab' had the opportunity to be represented at the prestigious Dutch Design Week in Eindhoven with a research pop-up shop. It collaborated with a lecturer from the Industrial Design Engineering who was doing a Master degree about the concept of a Dutch multicultural souvenir. Together with a group of students she had redesigned two typical Dutch souvenirs: The kissing couple and the stroopwafel cookie. Ten prototypes of the new kissing couple were made from clay and the cookie (a student graduate project) had been enhanced with three flavours based on spices from cultures which had most influenced the country. The research question was: How can souvenir design reflect craftsmanship and co-design related to cultural symbols and identifications? And on a different level: How can a themed pop-up shop engage visitors in co-design of the souvenir?

Figure 7. The pop-up store in the hall of Dutch Design Week (left). The selfie booth with co-creating users (right).

Again, Design Engineering and Communications students participated in the project. Briefings included the pop-up requirements which were stated earlier in this paper. They designed and built a pop-up market booth which was accessible from three sides. One side with a display of the different kissing couples which could also be held and touched. One side where the cookie product could be scented and tasted and one side with a 'step in' selfie booth in Delft Blue style. The selfie booth had wall tile designs from six different cultures and played Arabic music inside. The pop-up shop remained open for ten days during Dutch Design Week in October 2017. Short questionnaires of 130 visitors were collected and around 500 users left visual and oral feedback. Furthermore, the researcher spent three entire days at the pop-up to conduct ethnographic observation.

95 % of the questionnaire respondents recommended visiting the design project to friends and colleagues, in spite of its competition with 24 other projects in the same hall. As word-of-mouth is a variable dependent on experiential value (Varshneya, Das & Khare, 2017: 349, figure 8), it can be concluded that this value was high. After six days, the project featured on the news of NOS1, the main Dutch television network. However, right wing media only used the visual of the Moroccan styled couple to initiate a heated discussion about the status of Moroccan culture in The Netherlands (almost 6000 Facebook posts after two weeks). Unintendedly, the artefact had thus become more of a provotype.

Figure 8. Co-design in the pop-up shop: Cookie tasting and marking personal immigration stories on a huge map.

In terms of co-design, there were several probes as shown in figure 8. However, visitors perceived the actual product design as finished. Their input on the development of the design of the products was minimal. Co-design was also hindered as the available space in the fair was smaller than

promised and visitors could not lounge or linger, which had been possible at 'In Bloom' and 'The Donut Factory'. On the conceptual side, in terms of giving meaning to the overall experience, users and stakeholders (embassies, producers, retailers) left a lot of feedback. The pop-up provided the platform for thinking about a future in which nationality would be more like an aesthetic concept than a cultural or ethical one. For this reason, the star of the 'To-Kiss-Or-Not-To-Kiss' pop-up shop research is placed on the left middle-high position in figure 1.

4 Conclusion and discussion

4.1 Requirements of pop-up shop design for research

Pop-up shop research can be seen as a spatial form of experience prototyping enabling embodied interaction of users and other stakeholders with near-future concepts, products or services. Once marketing goals are taken out of the pop-up shop, its properties can be used by designers and researchers for co-design intentions. The pop-up shop is strongest in engaging users, as opposed to provoking or serving them. In theory and practice it could be demonstrated that the following properties are design requirements:

- Scarcity, restriction in terms of time (one day to one week) with the goal to create a sense of urgency,
- immersive, multi-sensory and interactive shop environment with the goal to prototype an integrated bodily experience for the user,
- aesthetic interstitiality (unusual location and/or exterior shop design) with the goal to create curiosity and open-mindedness with users and other stakeholders,
- eventual interstitiality (using design probes and toolkits) with the goal to increase co-design with the user on particular questions,
- social media cocreation in pre-experience, experience and post-experience phases with the goal to communicate the experience with broader groups of users.

Additionally, the first iterations with pop-up shop research indicate that a space to launch and linger inside the pop-up shop seems to be important for co-design intentions.

4.2 Opportunities and challenges of pop-up shop research for co-design

The opportunities of pop-up shop research lie in the engagement of users and stakeholders that would otherwise be more reluctant to co-design. Pop-up shop research can provide a platform for co-design with difficult to reach communities, resonating with stakeholders that are time constrained as well as with broader groups of ordinary users. Often these kinds of users are not motivated to participate by financial or social status benefits. The pop-up shop allows an integrated experience of near-future concepts, products or services and draws on hedonic and epistemic motivation: The fun of exploring and learning something new.

The practice explorations described in this paper show that users in pop-up shops rather search meaningful experiences than memorable (Pine & Gilmore, 1999) ones. Together with facilitators they construct meaning around technologies, products and services. This is why it seems that pop-up shop research is strongest at the 'fuzzy front-end' of the design process (like 'In Bloom'), or in the stage of commercialization and communication (like 'The Donut Factory'). Also open-ended collaborative design exploration (Mattelmaeki, Brandt & Vaajakallio, 2011) seems to be very suited. Further research will need to proof this.

A major challenge of pop-up shop research is its complexity and high demand in resources. Collaborating with student designers and communicators facilitates lower costs, but it would be interesting to see what professional designers and architects could create as a research pop-up shop. Furthermore, students had the opportunity to work in creative teams across disciplines, and acquired skills to design and build a temporary space. However, they lacked facilitation skills. Finding

out which probes and tool kits might be particularly apt to enhance co-design in pop-up shops, drawing on well-developed facilitation skills, is an important path for further research.

The pop-up shop experience prototyping should also be further explored as a process tool for multiple stakeholder co-design in open innovation projects. The pop-up spaces created by the Retail Innovation Lab allowed for companies, intermediaries and public offices to engage in different stages of the design process. However, what happens when pop-up shops are taken to the location of one stakeholder? Or when pop-up shops are (partly) made together by users and stakeholders? There is much more to discover in pop-up shop research to develop co-design opportunities.

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