Sixth International Conference on Music Perception and Cognition. University of Keele, Keele, 2000.

The role of performance in the cognitive reality of the hierarchic structure.

Favio Shifres e Isabel Cecilia Martínez.

ICMPC 2000 Proceedings paper

The role of performance

in the cognitive reality of the hierarchic structure

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Introduction

Studies in music performance provide evidence about the ability of the performer to communicate attributes of the musical piece to the listener, such as meter (Sloboda, 1983), phrasing (Repp, 1992; Todd, 1985), dynamics of rhythmic gestures (Gabrielsson, 1987), texture hierarchy (Palmer, 1996b, 1989), among others. Thus, musical structure turns apparent in the performance and, therefore, this is the most illustrative focus to represent music (Palmer, 1996a). Even though it might not exist a real performance of a musical piece, at least it does exist as a virtual one in the mind of both the analyst and the performer .

Performance microstructure - the set of modulations of tempo, dynamics, articulation, pedalling, vibrato, tuning, etc. which the performer displays beyond the score instructions) characterises the "personality" of a performance. It is well known that this microstructure is highly controlled during an expert performance. Possibly, the structural representation which monitors the performance is based on structural attributes of higher organisational order such as tonality. Little is known about the incidence of the relation between tonal structure and performance. Thompson & Cuddy (1997) discovered that performance microstructure is very important in the cognition of psychological distances between different tonalities. The microstructure of different voices is particularly special in this process. Thus, expressive components of the voice leading within complex textures seem to be related to the understanding of the tonal relationships of the musical piece.

At the same time, many studies about the representation of the musical structure on the listener have been developed. An important body of research has focused on the analysis of the listeners representations according to concepts derived from theoretical models. Some principles of different theories of musical structure have already started to be explored (Deliège, 1987; Dibben, 1994; Krumhanls, 1995). In connection to this research tradition Serafine, Glassman & Overbeeke (1989) have provided evidence about the ability of listeners to match a melody with its rendered underlying structure, pointing to the cognitive reality of the hierarchic structure. It is noticeable that, even though it exists great interest to investigate the ways in which structure is communicated during performance, this issue has not been treated in the studies concerning the listeners representation of musical structure.

The aim of the present work is to verify the results of the mentioned study (Serafine et al., 1989) taking into account the incidence of some peculiarities of the performance. In doing so, different performances are used as independent variables.

The analysis of the underlying voice leading would seem to be important in the rendition of a coherent performance (Cook, 1990; Rothstein, 1995). However, it does not seem to be a clear evidence of the existence of objective indicators of a hierarchic representation in actual performances. Cook (1987) studies the timing related to the structure in a Bach prelude, providing same evidence about timing in relation to long term prolongational structure. However, in a small scale he presents only partial information interpreted in an ambiguous way.

This paper focuses on the study of timing as an attribute of the microstructure. During the performance, timing reveals both a low-level way of organisation related to psychoacustical phenomena and a high-level way that involves structural organisation (Penel & Drake, 1998; Repp, 1998). A second aim is to analyse the underlying voice-leading as a potential source of timing.

Study of Performance

Two restrictions limited the selection of the stimuli used by Serafine et al. (1989):

1. Given the interpretative nature of the reductions and in order to take the interpretation provided in that study, it was possible to select only the four analysed examples reported there.
2. Taking into consideration the importance of the vertical timing (chord asynchrony) to analyse the problem of the underlying voice leading (Palmer, 1989, 1996b) the study was focused on monophonic musical pieces -as the stimuli were not obtained via MIDI, the only procedure which has proved appropriated for the study of vertical timing at present - reducing the possibilities of selection to only one musical piece.

Even though the mentioned restriction constrains the scope of the present study, it is considered that the results may provide useful evidence to future endeavours focusing on performance.

Method

The Performances

Six expert performances of the Bourré I from the Suite Nro. 3 in C Major for solo cello by J. S. Bach (measures 1 to 4 - with the upbeat) were selected (Figure 1A). The melody shows a sequence of six rhythmic groups of 2, 2, 4, 2, 2, and 4 beats each, in which the last duration is always the longest. The performers were Paul Casals (PC), Pierre Fournier (PF), Maurice Gendron (MG), Mitislav Rostropovich (MR), Paul Tortelier (PT) and Yo Yo Ma (YM).

Thus, the collection of versions, although reduced, show famous interpreters whose interpretative styles are both different and widely recognised, representing a large range of qualified interpretations of the piece.

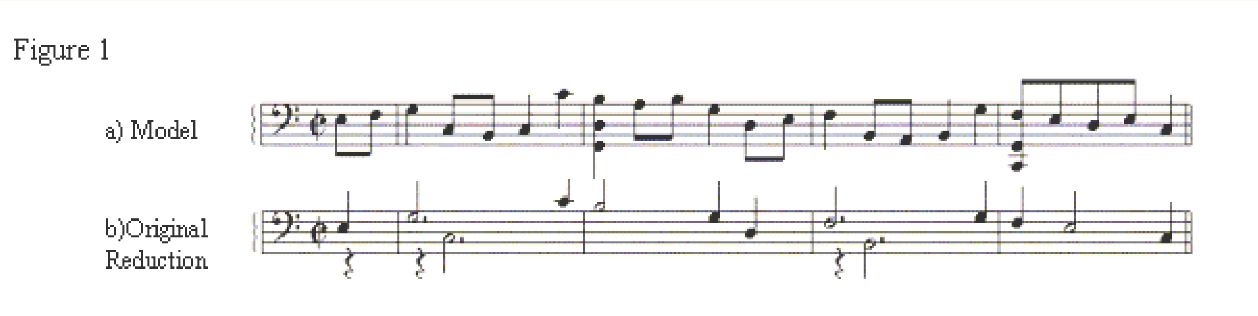

Figure 1. a) Bourré I from C Major Cello-Suite by J. S. Bach, m. 1-4. b) the foreground reduction - by Serafine et al. (1989).

Procedure of Measurement

A standard software of sound edition (Sound Forge 4.5) was used for the analysis. It displays wave forms (amplitude envelops). The measurement of the onset from the cello signals present difficulties, mainly because of the noise produced by the bow, before the pitch is clearly defined. As the performer intuitively operates with that interval of time to regulate the onset, it was considered that the timing would be determined by the moment in which the sound is perceived as one melodic tone. The predominant non-legato articulation made easier the task providing clear wave decays for each note. However, the low register, the arpeggi, and the original recordings condition added a great deal of noise and confusion to the onset of certain notes. Therefore, it was followed an aural procedure in which segments increasingly smaller of the wave were subjected to aural testing. Both researchers analysed the performances separately. Differences between the two measurements of each onset were not higher than 10ms. In those cases in which the difference was higher, the agreement was reached through Inter ratter sessions. Thus, both visual and aural cues were considered, and then â€"if necessary- further analysis of the fundamental frequency and spectrogram were run.

In that way, 22 inter-onset intervals (IOI) were determined. The onsets 2-1 (measure 2 first beat) and 4-1 correspond to a chord â€" which, according to the possibilities of the cello is performed as arpeggio-. In such cases, the considered onset corresponded to the highest pitch, since this is the one represented in the reductions. Each IOI â€"measured in milliseconds- was divided by the nominal value of the note according to the tempo of the performance. It is obtained dividing 15.000 (the number of milliseconds of a minute, divided by 4 â€"the number of quavers which are contained in a single temporal unit, the half-note) by the actual average duration of the minimal unit. A proportion of deviation of the actual performance from the nominal value was obtained. These values were graphically represented as profiles of expressive timing, in which the horizontal axis represents time and the vertical one represents the expressive deviation of each note. The value 0 represents the nominal timing.

Results

Overall characteristics of timing

BasicTempo (BT). Determining the tempo is important since: i) it is basic to calculate the timing profiles, and ii) it is probable that different tempi give rise to encoding the timing in different ways, given that there is an optimal zone for the detection of the temporal variations (Drake y Botte, 1993). The more varied the timing modulation the least applicable the procedure explained above in order to obtain the basic tempo of a performance, because sharp variations produce strong deviations from this proportion (Repp, 1998). It is expected that the selected fragment does not show this problem provided that dance style and tempo require a particular adjustment in timing. However, due to considerations of technique performance, the two chords (mm. 2-1 and 4-1) might modify substantially the IOI average. Therefore, they were removed in order to calculate the basic tempo, considering only 20 IOI. The tempi used by the cellists comprised a range of ï•¨ï€ = 59 (MR) a ï•¨ï€ = 88 (YM) [PC = 83; PF = 71; MG = 85 y PT = 74].

Relative Modulation Depth (RMD). It is the IOI coefficient of variation (DS/Mean), and allows the comparison between the amount of temporal variation of all the examples even though if they are performed in different tempi. The degree in which it is possible to detect the temporal variation also depends of the level of dispersion of the sequence (Drake & Botte, 1993). The RMD ranged from 0.24 (MG) to 0.71 (MR) [PC = 0.45; PF = 0.30; PT = 0.42; y YM = 0.33]. The tempi utilised by the cellists presented a trend to correlate negatively with RMD with a marginal significance (considering the small number of degrees of freedom) of $r_{(4)}$= -.753; $p < .084$. This suggests an association between slow tempi and greater variability.

Comparison of the Timing Profiles

The timing profiles were graphically averaged using the arithmetic mean of each IOI. (Figure 2A- Error bars displays DS).

Some features of this mean refers to the voice leading:

Groups 2 and 5 (inner voice, see figure 1b): they are performed slightly faster than groups 1 and 4 respectively, which show the same rhythm. An ANOVA Repeated Measures which considered the 6 Performances as a within subjects factor and the Voice (upper - lower) as a between subjects factor showed a significant effect of Voice ($F_{[1,5]}$ = 15.781; p = .003). The interaction Voice-Performance was not significant, indicating that the faster performance of motives 2 and 5 was a common strategy. The criteria of "slower, more emphatic" as a principle within -context, suggests that a lengthening implies the emphasis of the lengthened note. Notice that, as the rhythm of the piece involves both quarter notes and eighth notes, a shorten does not necessary imply an actual short value.

Groups 1 and 4. Group 1 emphasises the E and the G as belonging to the I degree, being F far more shorter. While in group 4 a similar behaviour would be expected, it shows a longer E and in a trend of lengthening toward F (the 7^{th} of V chord). However, E and F show both high DS suggesting the use of different strategies.

Groups 3 and 6. They exhibit a similar timing. The non structural A (in 3) and D (in 6) are shorter. Evidently, the eighth notes following the arpeggi tend to compensate the time demanded by its execution. However, the non structural notes seem to absorb this compensation. Again, these points show high DS revealing different strategies.

In order to analyse both the differences between versions and the use of common strategies it was run Principal Component Analysis in which two factors expressed together the 72.45 % of the profiles variance. A Varimax rotation distributed this total in two factors (42.66 % and 29,80 %) which can be interpreted as different timing strategies. These factors present different characteristics which are described as Properties of the strategies. Properties relevant to the reduction presented are analysed (Figure 2b).

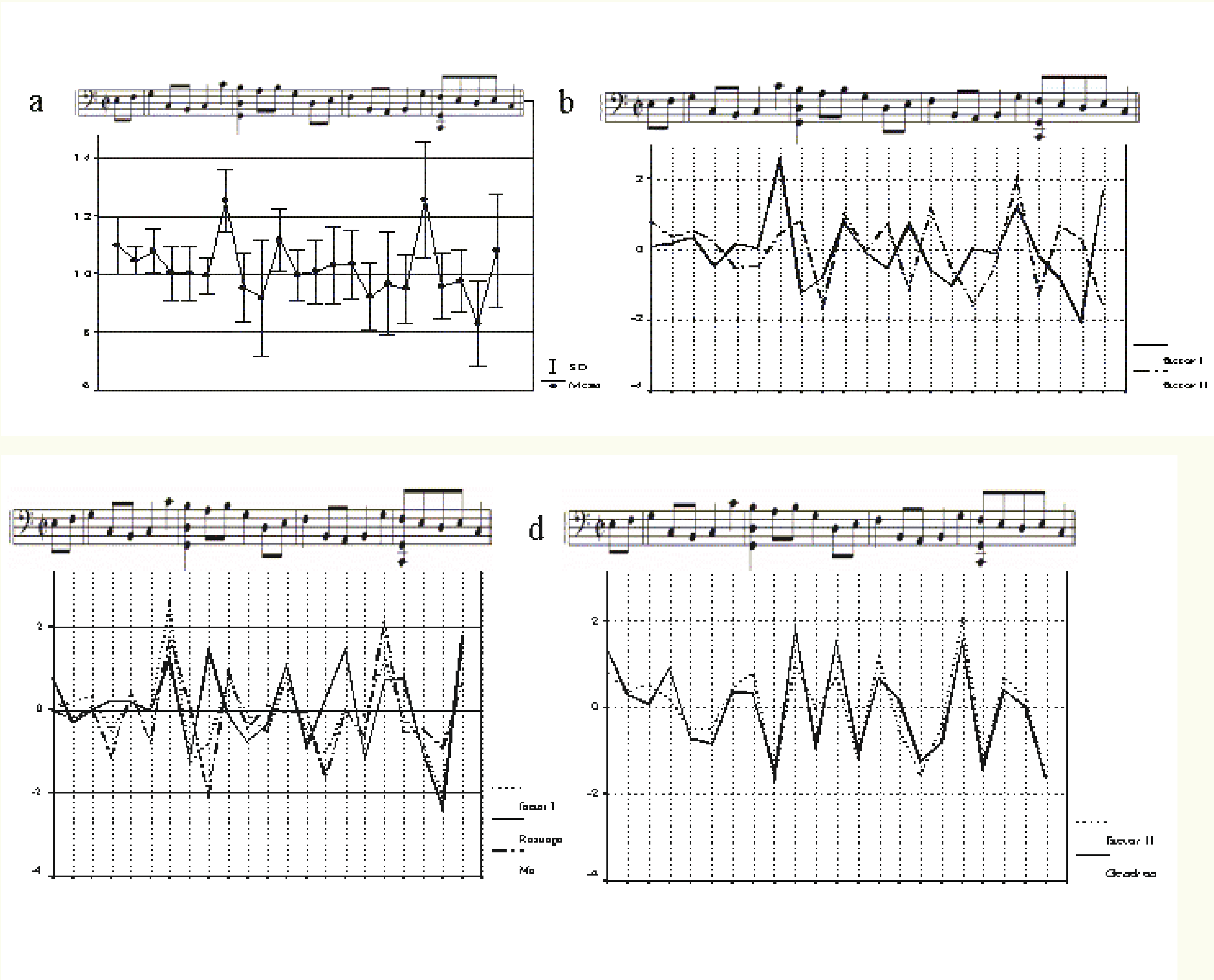

Figure 2. A) Means of the timing profiles. B) Factors I and II. C) Comparison of Factor I with the performances of Rostropovich and Ma. D) Comparison of Factor II with the performance of Gendron.

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Group 1. Although components appear to be very similar, factor I shows a higher relative duration of the first note (E).

Group 4. While factor I (FI) lengthens the passing-tone E, factor II (FII) shortens it. Thus, taking into account that the rhythm, emphasises F because it is a quarter note, FI reinforces the interval E-F and FII, D-F (this will be named Property A)

Group 3. A great lengthening of the C characterises FI. Inversely, FII lengthens the B. The later is largely emphasised by the noticeable shortening of the A. Thus, FI shows a relative emphasis of the A, while FII dissembles it. (Property B).

Group 6. In the parallel motive the emphasis is almost reversed in the first note: now is FII which emphasises the G previous to the arpeggio. At this point it emerges a conflict between the metric position of the tones and their condition as belonging to the C Major chord. In both factors, timing is used to search the equilibrium. In m. 4-1, FI privileges the metric component and FII the tonal one (emphasising the E). On the contrary, in m. 4-2 the pattern is reversed, and FII emphasises the metric component while FI does the same with the tonal one. Therefore, the final emphasis of FI is E-C and the one of FII is D-C (Property C).

Analysis of the individuals performances

Fournier presents the highest loading with FI (.908; PT: .778,YM: .738 y MR: .642) while Gendron does it with FII (.893; PC: .661) - Figure 2d. However, according to the analysis of the Properties A, B and C, Rostropovich seems to exaggerate the Property A (as representative of FI which is opposite to FII which emphasises A) and fits with FI concerning properties B and C (figure 1c). Rostropovich is thus an "exaggerated" example of FI. Conversely, Ma accords with FII in property A (showing a lower loading: .479!), while it is almost neutral in properties B and C. Thus, Ma might well qualify as a case of Factor I which tends to approach to Factor II precisely in A, B and C.

Discussion

The analysis of expert performances of the first phrase of the Bourré I from the Suite No. 3 by Bach revealed that renown artists use a variety of timing strategies. However, it is possible to find some commonalties: for example, the acceleration of the lower voice reveals that timing is used to differentiate polyphonic principles in this monophonic texture. Thus, timing strategy is operating on the clarification of particular features of the voice leading, at least in a overall sense. Another communality is the lengthening of the IOI involving arpeggi.

Differences in the timing strategies range from global aspects (i.e. adopted tempo) to local effects (i.e. performance of non-chord tones). In spite of the rhythmic features, it was not possible to find any association between a specific tempo and particular strategy of timing. Contrarily, extreme tempi (Ma and Rostropovich) both were identified with the same factor II.

Noticeably, differences in the timing strategies appear to be connected to the prolongations at the voice leading level. Thus, observing the reduction in figure 1b, FI y FII may be understood as different strategies to the performance of the passing notes and neighbour notes.

There would not be expressive deviations in order to point to the phrasing or the texture because the fragment is short and monophonic. In that way, tonal and rhythmic-metrical components would be the more relevant to the microstructural organisation of the example. Some of the temporal variations could be explained as a result of bottom-up processes involved in rhythmic and melodic perception (Drake, 1993). But the lack of similar timing patterns which match similar structural patterns reveals the existence of other sources related to the deeper musical structure.

Very different strategies could be observed not only between the artists but also within a single musician. For example, Rostropovich uses two different strategies to face a similar structural problem: in m. 2-2 it privileges the metric structure and lengthens the note in the strongest metric position. On the contrary, in m. 4-2 shortens the note in the strongest metrical position and emphasises the note which is tonally structural. It seems, then, that neither the metric structure nor the underlying voice leading are able to explain separately, all the temporal alterations.

Study of Listening

In order to verify the influence of the performance in the representation of the hierarchic structure Experiment 1by Serafine et al. (1989) was followed. In that experiment subjects listened to both a model melody and two reductions â€" true and foil reductions in schenkerian terms- and match one of them to the melody. In our experiment different versions were used as independent variables, under the assumption that subjects will tend to choose the foil if it displays notes which, although non structural, are emphasised by the performer. For example, if the foil displays a E in m. 2-4 (Property B) instead of D (Figure 1a and 1b - compare to Figure 3 b) subjects will prefer it more while matching with the Rostropovich's performance (who emphasises the E) instead of while listening the GendronÂ´s version (who shortens the E).

In order to minimise the effect of repetition of the same piece on the learning of its own structure, the number of versions was reduced, selecting those which represented the most interesting interpretations to be tested. Thus, GendronÂ´s version (representing FII) and MaÂ´s and RostropovichÂ´s ones (representing FI with different tendencies in the Properties and extreme tempi) were used.

Method

Subjects

N = 40 (60 %, with moderate musical experience - mean = 4.8 and 40 % without musical instruction). Mean age = 21.4 years (18 - 36).

Stimuli

Stimuli consisted on three of the performances studied, played by Gendron, Rostropovich and Ma. Besides four reductions for each of them were synthesised. The first, Original (Figure 1b), is the one proposed by Serafine et al. (1989). The other three, Foils A, B and C, present only note different from the Original (figure 3). The change in FA refers to Property A. It is observed that B was not replaced by A; it was added instead, due to the remarkable emphasis on B as a consequence of the arpeggio. So, eliminating it would have distorted the task. For this reason, FA is "less reduced" , that is to say, corresponds to a more superficial level. FB presents a change which refers to Property B (D changes by E). FC presents a change which refers to property C (E changes by D).

Figure 3. Foil reductions used as lure. FA: B changes for B-A from m. 2 (Property A). FB: D changes for E from m.2 (Property B). FC E changes for D from m. 4 (Property C).

Both the tempo and the timing profile of the corresponding version were kept as the reductions. For each note of the reductions the onsets measured in milliseconds were determined according to the way in which the artist played them in the original version. However, as the reductions did not include the arpeggi, the whole previous IOI sometimes sounded unmusical - with a break that interferes its continuity-, for that reason, a proportional shortening of this lengthening was implemented . Parameters of dynamics and timbre (cello) were kept constant all along the 4 reductions.

Procedure

In each trial, subjects listened the melody (Model) and two reductions (1 and 2) in the following sequence: Model, 1, 2, Model, 2, Model, 1, Model, 2, 1. One of the two reductions was always the Original, and the other was a Foil. After listening to the sequence, subjects: 1) chose "the best reduction of the model", and 2) indicated how sure they were of the answer - not sure, more or less sure, or very sure. There were two warm-up examples taken from another fragment. It was included a 15 second fragment from other pieces for cello by Bach in order to "separate" the trials, with the purpose of spacing the repeated listening of the same fragment. The whole session lasted approximately 20 minutes.

Design

There were three sequences for each performer, which compared Original/ Foil A (Property A test), Original / Foil B (Property B test), and Original/ Foil C (Property C test). Thus, the whole test consisted of 9 trials, which were presented in different orderings according to 1) an order within the pair; 2) the Foil that belongs to the pair; and 3) the performer.

Results and Discussion

Data for 1 or 2 responses and confidence ratings were translated into a single score ranging from 1 (very sure 2) to 6 (very sure 1) where 3 and below represented "2" and 4 and above represented "1". Then, data were translated to represent 1 = Original and 2 = Foil. Thus, the chance value is 3.5.

Due to an error in the recordings of the test, the Property C test for Rostropovich performance could not be run (Figure 4). This contingency obliged to consider data separately. However, as Property B test was run twice, these data were used as a measure for the reliability of the responses. A T test indicated that the means of responses for the two Property B tests for Rostropovich performance was not significant ($t_{(39)}$=.845; p = 403).

Predictions:

1. Property A test: while listening the pair Original/FA, subjects will prefer Original for Gendron and Ma and FA for Rostropovich;
2. Property B test: while listening to the pair Original/FB, subjects will prefer Original for Gendron, FB for Rostropovich and an intermediate value for MA;

3. Property C test: while listening to the pair Original/FC, subjects will prefer Original for Rostropovich and (at a lesser extent) MA and FC for Gendron.

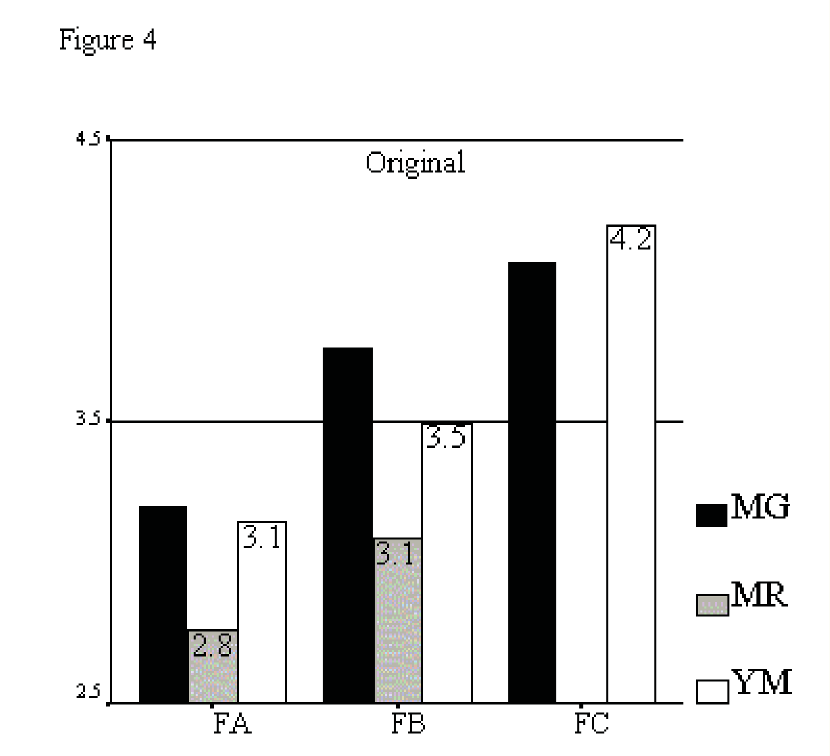

Figure 4. Means of the ratings for the different foils (A, B and C) against the Reduction in the versions by MG, MR and YM. The lower the value of the ratings the higher the preference for the Foil

Results indicate that:

1. FA and FB tended to have higher ratings for Rostropovich than for Gendrom, according to the prediction. A 2 (Versions) x 2 (Properties) ANOVA repeated measures showed a F value moderately significant for the factor Version ($F_{[1,39]} = 5.058$; $p = .030$). In other words, Rostropovich's performance is better reduced by both FA and FB than by the Original. Besides, FA and FB reduce better the Rostropovich's performance than the Gendron's one.
2. Ma does not show significant differences with Gendron ($F_{[1,49]} = .72$; $p = .790$). This reveals that, although the Ma's performance shows a timing profile more similar to Factor I, the timing similarities related to FII in Properties A, B and C are communicated to the listeners.
3. Although listeners preferred more FA for Rostropovich than for the other cellists, FA was more chosen than the Original for the three artists. Possibly, FA represents indeed a more superficial level of reduction than Original. Thus, subjects could be chosen the more superficial reduction.
4. Predictions do not explain why while listening to Gendron's performance, subjects choose most Original in the Property C test than in the Property B test. However, they do explain why listeners choose it while listening the Ma's performance and why the rating for that version is higher in Property C test.
5. Property B test is the one which is closest to the prediction: listeners prefer the Original for Gendron's performance, FB for the Rostropovich's one and hesitate between both of them for Ma's one. Although the corresponding ANOVA was not significant, a post hoc analysis found a marginal significance for the difference between Gendron and Rostropovich ($F_{[1,39]}=3.49$; $p=.069$).
6. Finally, a significant main effect of Reduction for Ma and Gendron ($F_{[2,78]}=6.822$; $p=.002$) indicates that the way in which the Foil is composed is very important. Therefore, the composition of the lure permits to appreciate the extent of the conclusions. The lure composed by Serafine et al. for this melody included two different notes which did not belong to the local context. If in SerafineÂ´s test the lures used would have been different, containing notes which in fact belong to the local context, results would have possibly been different also.

Notice that in this experiment the task was rather different than the task in the Serafine's experiment because subjects had to listen the true reduction much more times than the foils, and this did not happened in SerafineÂ´s test. And, although the results are not clear in this sense, it would be useful an experimental design in which the number of times each reduction is listened to would be better balanced.

General Discussion

The analysis of the performances showed different timing strategies. Many differences are related to the relative lengthening of the structural notes compared to the more superficial ones. Possibly, the variety of timings may be the manifestation of diverse ways to conceive musical structure in reductional terms.

The main aim of the present study was to verify performance effects in the representation of the tonal structure. Although the fragment employed seems a priori not to require of noticeable timing variations in order to be expressively performed, the values of the RDM (Relative Modulation Depth) revealed different modalities for the microstructural control.

The performer's possibility to emphasise notes which are in weak metric positions through subtle enlargements, reveals that the aspects of timing combined to conditions of melodic-tonal coherence may exert an important action in the mental configuration of the underlying structures. Although the findings are not strong, mainly due to the limitations of a design highly constrained, it is possible to state that musical performance has incidence in the matching task of a melody with its rendered structure. On the one side the timing strategies may reveal the kind of structural representation of the performer and on the other side they may convey such structure to the listener.

From a structural point of view, different microstructures may facilitate or interfere the processes of tonal tension and relaxation in the listeners representation. This is congruent with the findings of Thompson & Cuddy (1997). However, it may appear to be in contradiction with important concepts of the theory which does not take into account duration's aspects. Noticeably, the reductions presented here are very near the surface, a context in which rhythm is taken into consideration by the theoretical framework.

Related to this, it is important to state that listeners tend to match much stronger the option which presents a more superficial (even subtle) level. Although it is necessary to investigate more this aspect, it could reveal that the reductional process is not automatic; instead, it requires an activation. If the listener can not activate this process, he will remain at a more superficial level. If this holds water, it might stand out the role of performance as activator of the process of reduction.

Although the results are very incipient they talk about the needs of considering the findings of listening studies according to the research about microstructural components of performance. It is particularly relevant to those studies which intend to generate ecologically valid contexts. Although it has been investigated only one aspect of the microstructure, possibly other attributes have similar or even more incidence than the timing on the hierarchic listening. It is assumed that the dynamics and the control of tuning and vibrato -in instruments which allow it- may be powerful attributes which provide important cues to the listener during the abstraction process of the tonal hierarchies.

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Bourré I from Suite No. 3 in C Major for Cello Solo

(Artists. Company. Number)

Casals, Paul. EMI. CDH - 7 61028 2

Fournier, Pierre. Archiv Produktion. Stereo 449 711-2 gior 2

Gendron, Maurice. Phillips. 442 239-2

Ma, Yo Yo. CBS Masterworks. M2K 37867

Rostropovich, Mstislav. EMI. 7243 5 55365 2 5

Tortelier, Paul. EMI. 7243 5 73526 2 8

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