

Influence of timbre, presence/absence of tonal hierarchy and musical training on the perception of musical tension and relaxation schemas

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Abstract

The aim of this study is to investigate the effects of timbre, the presence or absence of tonal hierarchy, and the influence of musical training on the perception of "tension-relaxation schemas" in musical phrases. Two musical excerpts taken from the Baroque 'tonal/metric' and contemporary 'nontonal/nonmetric' repertoires constituted the stimuli of the experiment. Two versions of each excerpt were recorded: one 'piano version', in which the piece was recorded with only one timbre, and one 'orchestral version' in which the piece was played by several instruments. In order to avoid the intervention of the parameters of dynamics, interpretation, and conducting and performance of the piece, the same MIDI score was used for both versions. The experiment consisted of a presentation of successive segments of the musical pieces with different lengths to two different populations: 40 musicians and 40 nonmusicians. Listeners were asked to rate the degree of completeness perceived at the end of each segment, giving a completeness or tension profile. Our results showed that the timbre and the presence or absence of tonal hierarchy directly influenced the perception of musical tension-relaxation schemas, while musical training played only a minor role and only in the tonal/metric context.

1 Introduction

In a real music listening situation, we observe different degrees of musical stability and structural importance: chords which have the function of preparing and others which have a function of musical stability [4]. From a hierarchical point of view the unimportant notes, the transition notes, the ornamental notes, create the intuition of expectation, what has been called "musical tension". On the contrary, the hierarchically important notes create a sense of rest or completion, what has been called "relaxation". So, the chords which contain the hierarchically less important notes create strong tensions and wait for the appearance of hierarchically more important chords in order to resolve to a state of relaxation.

Depending on their degree of musical stability, the notes create a schema which is called a "tonal hierarchy" [2]. For all listeners, the tonic and then the dominant, have the highest degree of concordance. The dominant is followed hierarchically by the third and then the other notes of the key, and finally by the notes not belonging to the key. The Western European adult listener who can call upon an explicit/implicit knowledge, is potentially capable of understanding the existing hierarchies

between notes of a key, between chords of a key, and between different keys. The intuition of musical tension and relaxation is partly created on the basis on these "distance" relations [1]. The absence of tonality can result from producing a contrast to the tonal feeling at any instance and whenever possible. Melodically or harmonically the notes, in their succession, do not allow further the research of a tonal center.

1.1 Experimental hypothesis

The experimental approach consists in the presentation of two musical pieces in two different versions: one 'piano version' and one 'orchestral version'. We do not have at our disposal theoretical data specifically concerning timbre. However, the experiment produced results showing that the change of timbre causes a modification in the hierarchical coding of the existing relations between musical events.

From the listener's point of view, the organization of musical tension and relaxation is constructed in a hierarchical way. In a nontonal and nonmetric piece of music, a hierarchical description cannot be observed. In our experiment we thus sought to compare judgements of tension in both tonal and atonal contexts.

The third question refers to the differences in the way musical pieces are processed by two different populations: musicians and nonmusicians. One can, therefore, suppose that the difference between explicit knowledge—based on specialized musical education—and knowledge acquired implicitly through listening experience may result in different perceptions of musical tension and relaxation schemas.

2 Method

2.1 Subjects

Eighty (80) subjects participated in this experiment: 40 professional musicians and 40 nonmusicians. Their average age was 30 years. The musicians were selected on the basis of their theoretical knowledge, evaluated with regard to their education in harmony and ear training, and independently of the number of years they practiced an instrument. The nonmusicians had not received any musical training aside from organized musical activities at the primary school level.

2.2 Stimuli

Two musical excerpts taken from the Baroque and contemporary repertoire constituted the stimuli of the experiment: the *Ricercare* in six voices by J. S. Bach (measures: 153-179) and the first movement of *Six Pieces for Orchestra*, op. 6 by A. Webern (1956 version).

In order to avoid the intervention of parameters other than pitch, rhythm and timbre that create tension and relaxation schemas (such as dynamics and timing differences introduced in the course of musical interpretation), all the notes were programmed using a computer and synthesizers, securing in this way the same rhythmical structure, the same intensity, the same tempo and the exact duration notated in the score. Two versions of each excerpt were presented: one piano version, in which the piece was recorded with only one timbre, and one orchestral version in which the piece was played by several instruments. The piano version of the Webern was simply a piano reduction of the orchestral score and that of the Bach was a piano reduction of the Webern orchestration. In both cases the piano version preserved the register of the notes in the orchestral version.

The segmentation criteria of the two pieces were based on timbral changes in the score and more, for the Bach excerpt, on the passage from one key to another one (modulation) as well as on other criteria such as the interruption of an ascending or descending series of notes. In this way, the two excerpts were divided into 23 segments of different lengths and each segment included all the previous ones. Both pieces were presented to each

subject in either the piano or the orchestral version. The same tempo was used in both versions. In order to reduce the length of the experiment, an interruption was introduced in the middle of each piece at which point the succeeding segments restarted from the middle and not from the beginning.

2.3 Apparatus

Different sampler configurations were used depending on the orchestration needs of each piece:

- piano version of Bach and Webern: KURZWEIL 1200
- orchestral version of Bach: ROLAND U 220 RS-DCM sound volume, PROTEUS /2 16 BIT Multi-Timbral digital sound module, ROLAND SP-700 16 BIT Sample player.
- orchestral version of Webern: AKAI S3200 Sample player, ROLAND JV-880, PROTEUS /1 EMU, KORG M1r EX, ROLAND SC-55 Sound Canvas.

2.4 Procedure

The experiment consisted of the presentation of 23 units of successive stops of different duration. Each group of subjects was divided into two subgroups of 20 persons and each one of those listened first to one of the two versions of each piece. The concepts of tension and relaxation were addressed through the notion of the degree of completeness of a phrase of language. The subjects were asked to evaluate the degree of completeness of the musical phrase using a 7-point scale corresponding to impressions of completeness varying from not at all complete (1=strongest tension) to very complete (7=strongest relaxation). Listeners rated the perceived degree of completeness felt at the end of each segment. The series of successive judgments thus gave rise to a kind of completeness (or, inversely, tension) profile for each piece. We were primarily interested in differences in these profiles between single timbre and multi-timbre versions of each piece, although effects of musical training and degree of variation of tension in tonal/metric and nontonal/nonmetric pieces were also examined.

3 Results

Analyses of variance were performed to study the effects of the factors timbral version (piano vs. orchestra), musical training (professional musicians vs. nonmusicians), and segment on completeness judgments. The results of the analysis of variance are presented separately for the two pieces. The main effects are first examined, followed by the effects of their interactions.

3.1 Timbral version

It was found that the effect of timbre was very significant for both pieces. In total, all the values of the degree of completeness for the orchestral version were greater than those for the piano version [Bach ($F(1.76)=16.043$, $p<.0001$); Webern ($F(1.76)=18.559$, $p<.0001$)].

3.2 Segment

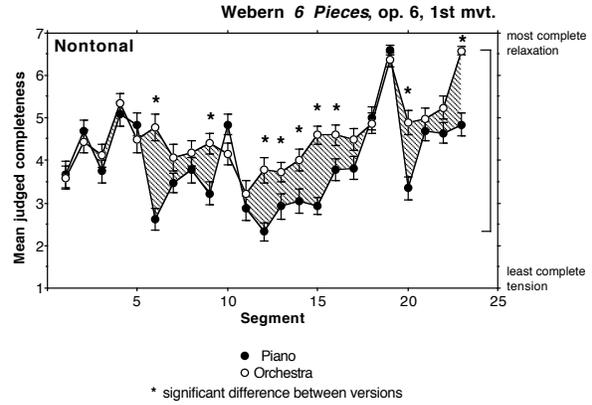
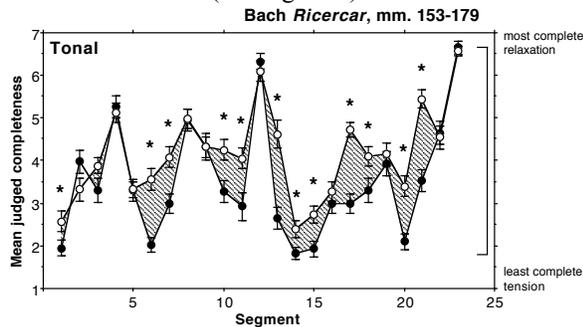
Using multivariate analysis of variance, it was found that the effect of segment was highly significant [Bach ($F(22.1672)=58.941$, $p<.0001$); Webern ($F(22.1672)=25.092$, $p<.0001$)], indicating that judged completeness varied significantly across the piece in both works.

3.3 Musical training

There was no global effect of musical training for either piece [Bach ($F(1.76)<1$); Webern ($F(1.76)<1$)].

3.4 Interaction between segment and timbral version

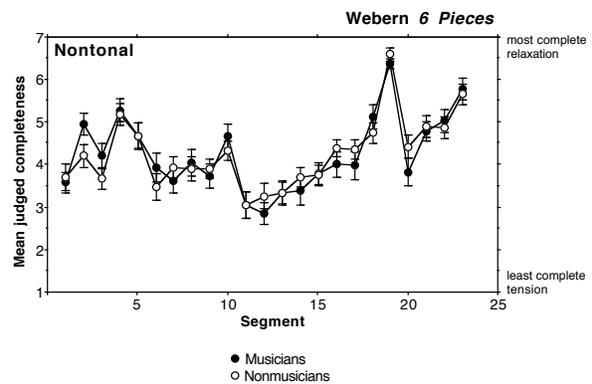
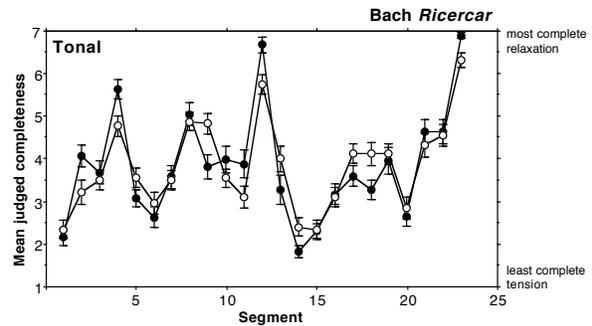
This interaction was highly significant for both pieces [Bach ($F(22.1672)=5.974$, $p<.0001$); Webern ($F(22.1672)=4.860$, $p<.0001$)] indicating that the tension profiles were globally different for the piano and orchestral versions (see Figure 1).



□ Figure 1: The effect of orchestration of tension profiles.

3.5 Interaction between segment and musical training

This interaction was significant only for the Bach piece [Bach ($F(22.1672)=3.662$, $p<.0001$); Webern ($F(22.1672)=1.029$, n.s.)] indicating that musicians and nonmusicians completeness profiles differed (slightly) for tonal/metric music, but were nearly identical for nontonal/nonmetric music (see Figure 2). However, no differences between musicians and nonmusicians were found for the completeness profiles across the different timbral versions.



□ Figure 2: The effect of musical training on tension profiles.

4 Discussion

This study confirms the experimental hypothesis that the timbre plays an important role in the perception of relationships of musical tension and relaxation. As for the way that the musical timbre was evaluated by the listeners, it was found on the one hand that the perception of the relation between musical tension and relaxation changes considerably with the existence of a timbre modification and on the other hand that the judgements of completeness showed a reduction in the orchestral version compared to the piano version. During the execution of the same score from the timbre of the piano, the same notes which have been interpreted from different instruments start at the same time. This is the result of an unison because in our case they are played by just one timbre with a sharp attack. In other words, in the orchestral version we perceive different instrumental sources whereas in the piano version we hear only one complex chordal event, probably due to perceptual fusion based attack synchrony.

Our results concerning either the hierarchical representation or the presence or absence of tonal and metric hierarchies confirm the hypothesis according to which the listener proceeds with a hierarchization of the musical information irrespective of its structure (tonal/atonal). The profile analysis of the Bach piece implies the existence of a highly hierarchical structure. The analysis of the non-hierarchical Webern piece suggests that, in spite of the absence of key and meter, there are points of varying musical stability: these can also be stable, creating the impression of rest (points of great stability where the musical tensions seem to be resolved), of middle stability (when the notes or the chords to which they belong have less structural significance) of less stability (when the notes create to the listener a strong expectation impression) and finally of a strong instability (when the notes or the chords are not non-significant, establishing the intuition of a strong tension. To each note of the musical discourse a structural importance can be attributed, because it belongs to a hierarchically important chord or because it creates the sense of expectation of the arrival of an essential chord or of a more important note. It is, therefore, verified that music is certainly not the result of a simple succession of sonorous events (notes), but the product of a complex hierarchical organization. Listeners possess implicit knowledge which allows them to perceive this complexity.

As far as musical training is concerned, our results show that the relations between musical tension and relaxation observed by musicians and non-musicians do not differ significantly or differ only slightly. A simple

observation of the profiles of responses given by musicians on the one hand and non-musicians on the other clearly suggests the development of implicit knowledge of the tonal hierarchy for the Bach excerpt. As for the Webern piece, which is characterized by the absence of key and meter, the schemas of tension and relaxation observed by the nonmusicians do not differ from those observed by musicians. The correlation between the two groups of listeners underlines the fact that the perception of musical tension and relaxation seems to depend very little on specific musical training.

5 Conclusions and Perspectives

On the basis of these results, we are led to conclude that:

1) Changes of orchestration can influence the hierarchical coding of the existing relations between musical events.

2) Western European adult listeners have similar reactions to tonal and atonal music, whether they are musicians or non-musicians. They possess explicit and/or implicit knowledge of the tonal hierarchies, which allows them to perceive and quantify the relation of musical and relaxation developed in the flow of the musical phrase by recognizing specific weights of pitches.

3) Within the context of tonal/metric and nontonal/nonmetric music, the contrast between the judgments on tension and relaxation schemas indicates that the listeners hierarchize the musical information giving rise to musical tension and relaxation as heard in the context of a musical piece; in this way, they succeed in apprehending a certain coherence and unity in complex musical pieces. Thus, it can be concluded by our results that there is a direct implication of the timbre on the musical perception of tension and relaxation schemas.

It could be consequently supposed that a similar research on a population of children could produce different results and an interest in the genetic evolution of the implicit knowledge about music in the human being could be developed. It could be equally interesting to evaluate the effects of other factors, such as the social origin and the cultural differences (oriental/occidental). In addition, the phenomenon of unison for other timbres producing a longer attack (violin, flute) could be studied.

In the absence of key, the harmony does not appreciate the succession of tension and relaxation any more. According to [3] (p. 73), "an atonal surface is a sequence of events and its pitch-space is flat". Our results on the hierarchical representations of segments, concerning the non-hierarchical piece of Webern, allow us to maintain that the atonal surface of the piece does not constitute a flat space and leads us, therefore, to

modify somewhat Lerdahl's conclusions. A continuation of the research in this same direction will be necessary to examine this subject in depth.

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