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Background

In spite of the arguments developed so far about the cognitive status of the underlying musical structure, the following questions remain unanswered: How are underlying events abstracted? How does the listener derive hierarchical structures from the musical piece? Recently, hypothesis about the metaphorical nature of music cognition have been enounced, highlighting the assumption that metaphorical thinking -present in the language used to conceptualise music- might, at some extent, model musical experience.

In this paper, it is hypothesized that the underlying musical structure is metaphorically experienced, based on the implicit use of basic image-schematic structures developed during the life-course of an individual's embodied interaction with the environment. By means of a process of cross-domain mapping, the listener uses knowledge from a given domain to understand information in another domain.

Aims

To test the hypothesis that the underlying voice-leading is metaphorically experienced, through the activation of a blockage-release of blockage image-schema.

Method

31 musicians listened to 9 melodic fragments that represent examples of interrupted underlying structures, paired with 3 musical reductions (contour, rhythm and voice-leading). 3 visual animations corresponding to three image-schemas (up-down, blockage-release of blockage and inter-onset beats) were used to prime the activation of a cross-domain mapping process, in order to hear A in terms of B, being A the musical piece and B the structural feature highlighted by the reduction. It was assumed that, to the extent that the primed image-schema corresponds to the feature highlighted in a given reduction, the match fragment-reduction would be weighted higher in that pair than in the other ones.

Results

Data analysis found significant differences between the three different conditions of exposure to the experience of the underlying voice-leading. They estimated higher the match fragment-voice leading reduction when they were primed with the blockage-release of blockage image-schema.

Conclusions

Results bring strong support to the assumption that metaphorical thinking models the experience of hierarchy in music, and that structural metaphors are used not only as linguistic constructs but also as internal models of cognitive processing that listeners activate during the experience of the underlying musical structure.

INTRODUCTION

The analytical tradition that flourished during the past century within the domain of Music Theory developed a body of musicological works that

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propose a description of tonal structure in terms of a hierarchical organization. Some of them describe music hierarchy in a way that is similar to descriptions provided by models of human cognition (Cohen, 2000). They are called models of underlying structure or reductional models, in that they attempt to account for a level of experience where a work is grasped as a single pattern or unitary structure, rather than as a concatenation of atomic elements, patterns or composite of parts (Benjamin, 1979). In these models, relationships between hierarchical levels take the form of a one-to-many correspondence.

The model of underlying musical structure

One of the pioneers in proposing a musicological approach of the hierarchical structure of tonal music –and the first who understood a musical work as a one-to-many correspondence between tones- was the German musicologist Heinrich Schenker ([1906] -1990); ([1922]-1987); ([1925]-1994); ([1926]-1996); ([1935] –1979) who developed a model of underlying musical structure. According to him, the underlying organization of a tonal piece has its origin in the fundamental structure, a two-part harmonic-contrapuntal pattern with a configuration formed by the fundamental line and the bass arpegiation, and that is intended as an *archetypal unity* (see Schenker, 2004). The composing-out of a tonal piece unfolds its hierarchical organization under the form of an inclusional hierarchy (Cohn & Dempster, 1992) that proceeds from the fundamental structure -at the deepest level- to the musical surface throughout three hierarchical strata: the background, the middleground and the foreground. The peculiar arrange of pitch events that emerges from the elaborative processes that unfold the fundamental structure is called the underlying voice-leading. In the linear progressions substantiated by the underlying voice-leading some structurally more important events lead other events, structurally less important, in such a way that the latter *prolong* the phenomenal existence of the former. Prolongation, as an attribute of the underlying voice-leading, is characterized in Schenkerian sources (Salzer [1962]-1990; Salzer & Schachter, 1969; Forte & Gilbert [1982] - 1992; Cadwallader & Gagné, 1998; Schachter, 1998) as a comprehensive expression that conveys different composing-out ideas, such as "the elaboration, development, manipulation and transformation of underlying principles" (Salzer & Schachter, 1969, p. xix). Implicit in the unfolding of the underlying structure is the idea of establishing connections between tones that are not adjacent in the sequence of events of the musical piece. Temporal deployment of these connections is guided, according to Schenker, by an *organic force* that permanently strives to attain the tonal goals that govern the underlying structure.

On the other hand, in the field of psychology of music, the cognitive-structuralist view generated one of the most fruitful research traditions, posing interesting questions and looking for explanations about the ways in which listeners encode music hierarchy (see Sloboda, [1985]- 1996; Krumhansl, 1990; Dowling & Harwood, 1986; Mc Adams & Bigand, 1994; Aiello & Sloboda, 1994; Deustch, 1999; Howell, West & Cross, 1984; Howell, Cross &West, 1991; Deliege & Sloboda, 1997, for an overview). Differences can be found between the experimental models produced but, in general, all of them recognize the existence of a hierarchical dimension of music organization. From a psychological point of view, theories of underlying structure claim that experienced listeners assign a relative structural importance to the events organization of a musical fragment, according to previously acquired stylistic information about the regularities of a given musical idiom that are stored in long-term memory (see, for example, Lerdahl & Jackendoff, 1983). It is a cognitive assumption that, to the extent that this knowledge is available while listening to a tonal composition, it will be implicitly used to understand the unfolding of the underlying musical structure.

However, the explanations developed so far about its cognitive status are not sufficient to provide answers to the following questions: How are underlying events abstracted? How does the listener derive hierarchical structures from the musical piece?

Embodied cognition

Recently, hypotheses about the metaphorical nature of music cognition have been enounced, highlighting the assumption that metaphorical thinking -present in the language used to conceptualise music- might, at some extent, model musical experience. According to them (Lakoff & Johnson, 1999) imagination, traditionally related mainly to the domain of creativity, seems to play a central role in all what concerns to the processes of understanding, reasoning and attributing meaning to our every day experience (Johnson, 1987).

The central assumption of this study is that imagination plays a primary role in music cognition and that by means of imagination we assign meaning to music while listening, performing, composing, or conceptualising it. In particular we are going to posit that the way we understand and convey meaning to music is, at least in part, mediated by a process in which we use some basic cognitive image-schematic structures that were been developed through our active interaction with the environment, and that by means of a metaphorical process, named cross-domain mapping (Lakoff, 1990; 1987) we use knowledge coming from a given experiential domain, for example the physical domain, to understand

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information belonging to other domain, in our case the domain of the sonic-musical structure.

The image-schematic structures that organize our basic knowledge are acquired during the course of our sensory motor experience with the environment and are activated unconsciously when we are grasping meaning in different areas of knowledge. Therefore, our understanding of music would also be a consequence of the embodied, imaginative structures or forms of imagination that grow out of our bodily experience.

Metaphorical thinking is used to assign meaning to categories and concepts in our everyday language (see Gibbs 1994, Kemper 1989, Lakoff and Johnson, 1980). Metaphors are also present in the language used to conceptualise music (see for example Zbikowsky, 2002; Saslaw, 1997-1998; Guck, 1991).

Music has a metaphorical propensity to convey concepts or images that are profoundly tied to the individual's experience of the world. For example, musical meaning seems to be inherently tied to the temporal unfolding of the stream of sonic events (Johnson and Larson, 2003).

The experientialist approach (see Larson, 1997; Lakoff, 1993; Lakoff & Johnson [1980]-1998; Lakoff, 1987) brings strong support to the assumption that hierarchy in music might be *also* understood in terms of a cross-domain mapping categorization process. According to this view, if the listener experiences musical structure as a metaphorical process, he will assign categories to sounds.

Some of these theoretical postulates about the underlying musical structure have been enounced yet as conceptual metaphors (see for example Zbikowski, 2002; Saslaw, 1997-1998; Larson, 2004). Is it therefore possible to think that some of these metaphors might at some extent model musical experience? Even though conceptual metaphors are abundant in those theoretical writings, the use of image-schematic knowledge in the listener's experience of the underlying musical structure was not tested experimentally so far. Therefore, the underlying musical structure might be hypothesised as an *imaginative construct* which descriptive value needs to be interrogated.

In this paper, the experience of the underlying structure as an abstraction will be interrogated running an experiment on categorization, in which it is expected that subjects perform a cognitive process in which they understand the underlying structure in metaphorical terms (see Lakoff, 1987).

Here we hypothesize a cognitive view of the voice-leading principles in terms of the conceptual metaphor of musical forces. This approach, founded on the ideas of Schenkerian tradition, arguments that the imaginative nature of the underlying musical structure representation relies on the way music unfolds in time, conveying a sense of direction that brings tonal coherence to the musical structure. Some elaborative processes such as, for example, linear techniques and melodic or harmonic prolongations applied to the unfolding of the underlying structure (see Cadwallader & Gagne, 1998; Salzer, 1962) prompt the activation in music perception of an imaginative and/or creative process, by means of which it is possible *to hear x as y* (Larson, 1997) that it to say, to assign sounds to categories. This process is the result of the interaction between musical forces -that arise from the internal make-up of the piece of music- and the mental processes activated by the listener.

The experience of music will be understood as a dynamic process that originates in the energetic quality that emerges from the musical piece, which is mapped with the dynamic patterns that emerge from the listener's environmental experience. The dynamic quality of tonal music arises from the interaction of tensional features of the sonic organization, for example, the tendency of the fundamental line to go downward, the tendency of unstable tones to move towards the closest tones, and the general tendency of musical discourse to reach the final goal. To hear a tone as unstable means also to hear it as an embellishment of a more stable note, that is to say, to hear it as embellishment of another note *in a more remote level* of musical structure (Larson, 1997). The tendency to hear certain tone combinations as inherently stable is an emergent property of the interaction of simple perceptual mechanisms (Huron, 2001) being some of them universals and others culturally determined. According to Lerdhal (2001) the idea of musical forces in action begin to build a psychological account of what Schenker called *the will* of the tones, that is to say, intuitions relative to expectations and melodic tensions.

Rationale

In our study, we will test the listener's experience of the Schenkerian interrumpted structure. The interrupted structure is a two-parts organization of the musical phrase that establishes a kind of internal phrase division that takes the form of 3 2// 3 2 1 or 5 4 3 2// 5 4 3 2 1 in the fundamental line and I V//I V I in the harmonic motion (see Schenker [1935]1979; Cadwallader & Gagne, 1998; Forte & Gilbert, ([1982]-1992).The listener will create meaning experiencing, consciously or unconsciously, the interrumpted structure in terms of the structural metaphor BLOCKAGE-RELEASE OF BLOCKAGE (Saslaw, 1997-1998).

In the experiment, melodic fragments are confronted with different musical reductions of those fragments. A musical reduction is understood as a *simplification* of the surface level of the piece. In each reduction some structural properties are kept while others are dismissed. A priming paradigm is used in order to activate a particular image-schema that the participant is assumed to use in the process of cross-domain mapping, to hear A

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in terms of B, being A the musical stream of events of the tonal piece and B the structural features highlighted in the musical reductions.
It is assumed that, to the extent that a given image-schema corresponds to the characteristic structural feature that is highlighted in the reduction, the latter is going to be weighted higher as a match to the musical piece than other reductions.
When we say that the particular feature that is highlighted in each of the reductions *is* in the musical fragment we are positing that when we listen to the musical piece we *hear* the piece *in terms of all of those reductions.* The key issue is that each of the primings is activating a determined image-schema that prompts the listener to think more in terms of one structural feature than in the others. Therefore, through a process of cross-domain mapping, participants will tend to match higher the reduction that conveys the structural feature that correlates with the image-schema that was activated by the priming.
General hypothesis: The underlying voice-leading is understood in terms of some structural metaphor.
Specific hypothesis of this experiment: the underlying voice-leading of the interrupted structure is understood in terms of the sub-metaphor Blockage-Release of Blockage from the Force metaphor.
Prediction:
When a voice-leading reduction from an interrupted structure is primed with a Blockage-Release of Blockage visual image, participants will estimate higher the association between musical fragment and reduction; when the same reduction is primed with a different visual image participants will estimate lower the association between musical fragment and reduction.

METHOD

Stimuli

i) animations that are neutral representations of the main features of the proposed image-schemas were used as visual primings (P): P1) Activating image: *Ball exerting force in a determined direction, then facing an obstacle that blocks the action, trying again and finally overcoming the blockage.* This visual image would activate the BLOCKAGE-RELEASE OF BLOCKAGE image-schema*;* P2) Non-Activating images: *Ball moving alternatively up and down*; *Ball flashing at different inter-onset intervals*. These visual images would not activate the BLOCKAGE-RELEASE OF BLOCKAGE image-schema.
ii) 9 musical fragments selected from the literature of Western Art Music that are examples of interrupted underlying structures, were used as musical samples.
iii) musical reductions (R) that highlight different structural attributes were composed for each musical fragment: R1) underlying structure reduction; R2) other reductions: melodic contour, rhythm.

Experimental Design

Each trail design was organized as follows:
P (visual priming) – M (Musical fragment) – R (musical reduction) – Sound signal -Time to answer.
The test contained 63 trails, formed by combinations of the 9 musical fragments according to the agreement between priming and reduction. The relationship between priming and reduction resulted in the following combinations of the different experimental trials:
Fit between Priming and Reduction: P1 – R1 (9 samples); P2 – R2 (9 samples);
No Fit between Priming and Reduction: P1–R2 (18 samples); P2–R1 (18 samples).
9 foil reductions were included to prompt continuous attention to the unfolding of each reduction in order to produce the goodness-of-fit response. Trails were aleatorized in such a way that each participant listened to a different order of samples presentation.

Apparatus

The experiment was run using DRT experimental software from Empirisoft Co.

Subjects

31 professional musicians, average age 29 years, average musical experience 16 years, volunteered to participate in the experiment.

Procedure

In the first part of the experiment subjects completed a warm-up session containing a tutorial with information about the organization of the experimental trial and practice of the expected task. Information about what a musical reduction consisted on was also provided. Participants were told that they were expected to perform a goodness-of-fit task that consisted on relating the musical fragments with the musical reductions of those fragments. Visual primings were described as fragments of visual information that were used to separate the musical trials and help the participant to concentrate in the music that follows, but which they nevertheless had to attend to.
The final instruction about the task required the subject to follow this order: i) pay attention to the visual priming, ii) listen to the musical fragment, iii) listen to the musical reduction, iv) as soon as the sound signal was heard press a Yes Key to say that the reduction Is a Fit, or No Key to say that the reduction Is not a Fit of the musical fragment and v) then press another key to say how sure he/she is of the answer, using a 9 points scale that ranges from 1 Not Sure to 9 Sure.
Subjects were tested in two individual experimental sessions.

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RESULTS

Goodness-of-fit responses were converted into a 18 degrees scale that ranged from 1 Not Fit to 18 Fit. The means of the responses to the different combinations of Priming-Reduction were obtained.
In order to see if subjects understood the interrupted structure in terms of the Blockage metaphor we might just need to compare two groups of responses:

1) Voice Leading Reduction – Blockage-Release of Blockage Visual Image
2) Voice Leading Reduction – Different Visual Image (Up-Down; Flashing Beats).

Nevertheless, if differences were found between those two groups of responses we might think that they were not an outcome of the association between Reduction and Priming but just of a pure priming effect. In other words, differences could reflect the priming effect *per se*. Therefore, it was necessary to have a control group in which to contrast those two different primings with another reduction. If, in this control group there are no differences between the two types of priming, then it is possible to assert that the differences found in the previous groups are due to the association between priming and reduction and not to the effect of just the priming alone.
Therefore, the means of the goodness of fit responses to the four combinations of priming-reduction were compared (see above *Experimental Design*). We can see the results in the graph below:

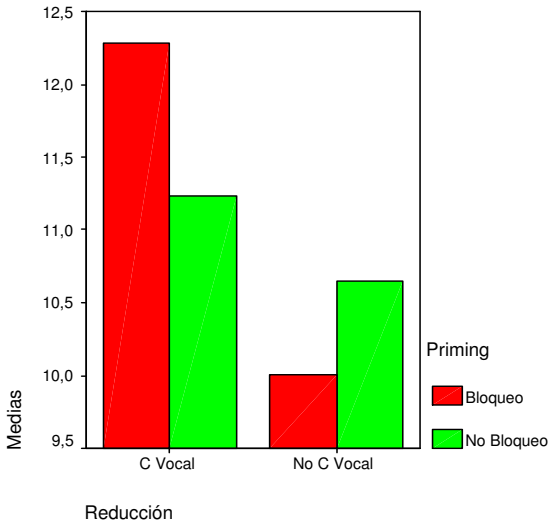

Figure 1. Means subject'responses to the four combinations of Priming (Blockage/No Blockage) and Reduction (Underlying Voice Leading [UVL]/ No Underlying Voice Leading [No UVL]).

An Anova repeated measures, with 9 Musical Fragments x 2 Musical Reductions (Voice leading reduction - other reductions) x 2 Visual Primings (Activating image-Non activating image) as factors was run.
Factor Visual Priming was not significant, meaning that results are not due to its unique effect. Factor Musical Reduction was significant ($F[1, 30]=14.947$; $p<.001$). This result could be informative of potential differences in the subjects' appreciation of the compositionality of the different reductions.
Most important to our purposes is that the Interaction between Reduction and Visual Priming was significant ($F[1, 30]=7.608$; $p<.01$). Results confirm the prediction: when subjects are primed with the Blockage-Release of blockage visual image, they estimate the association between the musical fragment and its Voice Leading reduction higher; and conversely when they are primed with different visual images they estimate the association between fragments and their Voice Leading reductions lower.

DISCUSSION

Results bring support to the general hypothesis that metaphorical thinking shapes music experience, in particular the listener's experience of the underlying structure of tonal compositions. Once an image-schema has been activated, a cross-domain mapping process takes place and the participant uses it to hear A in terms of B, being A the sonic streams of events of the musical piece and B, in this case, the underlying voice leading of the interrupted structure of tonal music, highlighted in the musical reduction. To the extent that a given image-schema corresponds to the characteristic structural feature that is highlighted in the reduction, this reduction is weighted higher as a match to the musical piece than other reductions.
Therefore, structural metaphors are not only used as linguistic constructs but also as internalized models of cognitive processing that listeners activate during the experience of attending to aspects of the underlying musical structure. Structural metaphors are based in systematic correlations inside our experience. They influence the way we assign meaning to our actions. They have properties that form Gestalts, that is to say, groups of properties that operate as wholes, or put it differently, as unitary structures that can be understood as a one-to-many correspondence. They ascribe to the prototypical nature of human knowledge, operating as cognitive reference points. They are applied automatically and regularly to assess aspects of reality. Structural coherence, understood as a metaphorical experience, occurs when a person is capable of overlapping a multidimensional structure of elements and/or properties of an object on the

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structure that corresponds to another object. In the case of musical structure, tonal coherence occurs if the listener is capable of categorizing sounds in terms of structural features. Our results support this assumption.

The approach of Lakoff & Johnson (1980) relative to the analysis of metaphorical knowledge as a factor that shapes our experience, then, supports hypotheses of the experience of musical structure in metaphorical terms. If the theories relative to the principles of musical structure are useful to explain certain phenomena of music cognition then it is the work of psychology of music to derive formulations that turn to be demonstrable by means of experimentation.

The underlying structure *is* an imaginative construct which descriptive value needs to be interrogated. The aim of the present research intended to fulfil this purpose. If music, in words of I. Cross (2004) is in essence a domain that embodies, synchronizes and intentionalizes sound in action, it is a fruitful avenue of investigation to go deeper inquiring the relationships between those aspects that involve the embodied experience in musical practice as a factor that activates imagination. It is also remarkable that in the core of Schenker's seminal idea of organicism, developed in his descriptions of the underlying musical structure through the numerous conceptual metaphors, including the Force metaphor tested in this experiment, it is hidden the experientialist approach of embodied cognition.

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