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Analysis of conceptual metaphors to improve music software: The role of prior experience in inclusive music interaction design

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ABSTRACT

An open challenge for interaction designers is to find ways of designing software solutions capable of enhancing the ability of users with differing levels of knowledge and capabilities to perform tasks that normally require specialised domain expertise. This challenge is particularly demanding in areas such as music analysis, where complex, abstract, domain-specific concepts and notations occur. One promising theoretical foundation for this work involves the identification of what are assumed to be conceptual metaphors and image schemas. These constructs are grounded in prior sensory-motor experiences of space, force, orientation and interactions with other bodies and are identified through analysing discourse. These theories have already been applied with some success both to musical concepts and, separately, to user interface design with the intention of creating more intuitive designs through exploiting these prior sensory-motor experiences. However, the present work appears to be the first to combine these hitherto distinct bodies of research. We hypothesise that if we can identify the conceptual metaphors and image schemas used by musical experts to structure their understanding of music, we can utilise this information to develop a general theoretical framework to aid designers in systematically improving their designs, providing a foundation for inclusive music interaction design and thus opening up software normally restricted to domain experts to a wider and more varied user population.

A possible methodology for the development of such a framework is discussed along with details of a study to apply the conceptual metaphors and image schemas used by a small group of experienced musicians to an evaluation of Harmony Space.

Categories and Subject Descriptors

H5.2. Information interfaces and presentation (e.g., HCI):
User Interfaces: Theory and methods.

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General Terms

Design, Human Factors, Theory.

Keywords

Embodied cognition, image schemas, conceptual metaphors, tonal harmony, Harmony Space, inclusive design, prior experience

1. INTRODUCTION

Music is an intrinsic part of our culture. It is used to aid relaxation; reflect the mood of social situations; as an accompaniment to religious services; and to enhance the appeal of interaction designs through incorporating audio output as part of the interaction model - for example when moving a file to the trash can. More recently, as well as providing a backdrop to everyday life and interactions, music generation and mixing has become an increasingly popular pastime. For example Apple supply Garage Band, an application for creating and producing music tracks, with their operating system software and interactive games based on music such as Rock Band and Guitar Hero have turned millions into living room rock stars.

Pervasive though music is, technical understanding of the medium and specifically how it is constructed, is usually restricted to those with specialist domain knowledge. Harmonic progression in particular is a difficult concept to grasp as it involves knowledge of domain-specific terminology and notation. This situation is in stark contrast with the philosophy of inclusive design, specifically that consumer products should be designed to minimise exclusion of users [7][10]. Although in the context of inclusive design, exclusion generally refers to users with reduced motor, cognitive and sensory capabilities [7][10], when considering the effective use of music software, lack of specialist domain knowledge can impair the quality of user interactions, and thus in this instance we extend the definition of excluded users to incorporate those who are also excluded or hindered through lack of domain knowledge.

In order to redress the balance, we hypothesise that if we can establish a means by which we can translate the specialist knowledge used by domain experts when analysing an excerpt of music into a user interface which effectively communicates this information, exploiting pre-existing embodied knowledge and experience, it may be possible to systematically improve the quality of interaction designs to empower a wider range of users who may have been previously excluded from using such software through a lack of specific capabilities or domain knowledge, to carry out complex musical tasks.

One promising theory for analysing abstract concepts such as harmonic progression uses the conceptual metaphors exposed through language to identify a number of constructs named image schemas. These image schemas, characterised by Johnson as "recurring patterns of our sensory-motor experience", provide people with the ability to structure abstract concepts by applying perceptions of their prior sensory-motor experiences of space, orientation, forces and interactions with other bodies to different domains [6]. For example, one concept prevalent in language is that of one object containing another, evidenced by phrases such as "put the toys in the box", "he walked into the auditorium" or "she is in a bad mood". All of these make reference to one entity being contained by another, even if that containing entity does not fully enclose its contents or is not a physical container in its own right. All of these examples which are claimed to be based on prior sensory-motor experiences of containment, make use of the CONTAINER image schema.

More importantly however, image schemas can be applied to abstract concepts, through the process of cross-domain mapping, creating conceptual metaphors [9]. For example the phrase "He's going up in the world" demonstrates the mapping of the UP-DOWN image schema onto the more abstract concept of career progression, creating the conceptual metaphor PROMOTION IS UP; progressing in one's career, i.e. being promoted, is likened to being physically above other people.

Recent work by Hurtienne and Blessing has concluded that designing interactions which conform to simple conceptual metaphors grounded in prior experience such as MORE IS UP - another metaphorical extension of the UP-DOWN image schema - to user interface widgets such as sliders, appears to lead to superior interaction models, as evidenced e.g. by timing data. [3]. More recent work by Hurtienne, Israel and Weber into redesigning an invoice verification and posting application concluded that using the image schemas elicited through the context-of-use-analysis as a meta-language for the analysis and design processes helped to focus on the essential user interface requirements [5].

Our research aims to extend this work, in part by drawing on the work of Zbikowski [12] and Saslaw [11] who applied image schema theory to the conceptual models of music theorists. In particular, the present work aims to investigate whether knowledge of the conceptual metaphors and their constituent image schemas used by music experts can be applied to the design and analysis of user interfaces aimed at empowering a wider range of users to carry out complex musical tasks such as harmonic analysis and composition. The ultimate aim is to investigate whether this work can be used to derive a general theoretical framework for designing similar interfaces in the future.

2. METHOD

In order to develop such a framework, we must first establish the conceptual metaphors and their constituent image schemas used by musical experts when analysing excerpts of music. Since conceptual metaphors are commonly exposed through language, it is proposed to derive this information through decomposing the dialogues between experts as they discuss aspects of the structure of an excerpt of music. The results of this analysis will then be used to evaluate examples of music software to establish if their user interfaces support the conceptual metaphors and image schemas identified.

It is proposed that the data gathered from these evaluations will then be used to develop a general theoretical framework, taking the form of a set of heuristics, design principles, user requirements and interaction design patterns, to aid designers of similar software packages to systematically improve the quality of interaction designs, reducing the categories of users who are excluded from using the software and thus empowering such users to carry out complex musical tasks.

In order to establish whether the framework does indeed aid designers in the challenge of improving music interaction design, it is proposed that two user interfaces be developed, both based on the framework but using different representations. For example harmonic progression could be represented both as a line graph and as part of a 3-dimensional journey space. Subsequent evaluations of both implementations will then be carried out, focusing specifically on the aspects of the implementation which have been derived from the framework, with the aim of establishing further improvements.

3. CURRENT STATUS

3.1 Identifying Conceptual Metaphors

A short study was carried out to validate the feasibility of the proposed approach. A group of 3 musicians, all of whom had been educated to at least undergraduate level in music and were experienced concert performers, were provided with a short excerpt of "Laudate Dominum", a sacred motet by Monteverdi, and asked to collaborate on answering a series of questions. The questions were focused on general aspects of the harmonic and melodic structure with the intention of eliciting a detailed and lively discourse, maximizing the opportunities to expose the conceptual metaphors used by the musicians.

The dialogue was analysed by comparing the comments made with the linguistics examples in [2][3][4][5][6][8] in order to identify the conceptual metaphors used. Since many of the image schemas that ground the conceptual metaphors have dependencies or relationships to each other, alternative interpretations of the dialogue are possible. In situations where the conceptual metaphors used were ambiguous, the surrounding context of the dialogue was taken into account in an attempt to make a more accurate decision.

The resulting analysis revealed that the musicians used a number of conceptual metaphors to structure their understanding of the excerpt. For the purposes of a subsequent software evaluation, conceptual metaphors that did not specifically relate to harmonic analysis were eliminated from the analysis. Table 1 below summarizes a selection of the identified candidate conceptual metaphors used by the musicians.

3.2 Software Evaluation

A preliminary evaluation was then carried out of Harmony Space [1], a tool to assist novices in understanding the basic principles of tonal harmony and harmonic progression (see Figure 1 below), using the candidate conceptual metaphors and image schemas identified. Harmony Space was chosen for the evaluation as the user interface is specifically designed to exploit users' understanding of spatial and movement metaphors in order to present harmonic information in a manner which is more easily comprehensible.

Table 1 – Examples of conceptual metaphors

Conceptual Metaphor	Examples
HARMONIC PROGRESSION or MODULATION IS MOVEMENT ALONG A PATH	<p>“... it just jumps from G into C...and then A minor...then D minor...then back to G major...”</p> <p>“Leading us back into the G of course.”</p> <p>“...I'd say I'd modulated to something else.”</p>
A KEY IS A CONTAINER FOR NOTES	<p>“...they just go back to the tune again straight away in A minor...”</p>
LOW PITCH IS DOWN	<p>“...I like the bit where it goes down to E major.”</p>

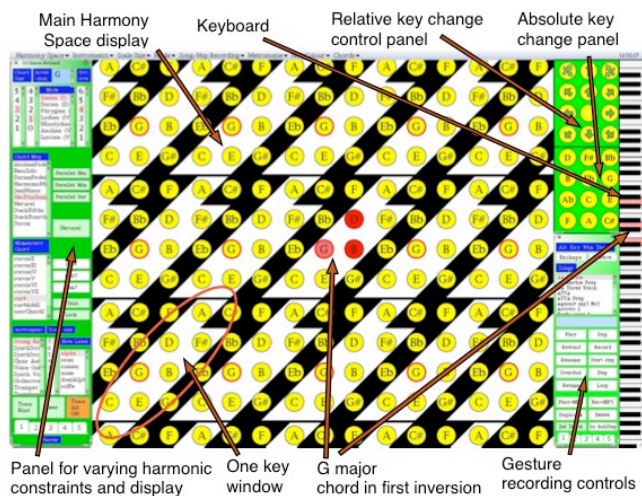


Figure 1 - Screenshot of Harmony Space configured in G major

The evaluation revealed that a number of the conceptual metaphors and image schemas were supported in the user interface either through visual display, interaction components or through audio output. For example the conceptual metaphor, A KEY IS A CONTAINER FOR NOTES is supported in Harmony Space by the white key window, highlighted in Figure 1 above. Table 2 below shows a selection of the conceptual metaphors utilised in Harmony Space and the frequency with which they appeared in the dialogue between the musicians (the frequency of use is an approximation due to the difficulty in identifying conceptual metaphors noted earlier).

Table 2 - Selection of the conceptual metaphors used in Harmony Space and their approximate frequency within the dialogue

Conceptual Metaphor	Approx. Frequency
HARMONIC PROGRESSION/MODULATION IS MOVEMENT ALONG A PATH	20
A KEY/CHORD IS A CONTAINER FOR NOTES	10
CHORDS/KEYS HAVE A RELATIONSHIP	3

Some areas where the design could be improved were identified. Support for one conceptual metaphor in particular, (HIGH PITCH IS UP) LOW PITCH IS DOWN, a metaphorical extension of the UP-DOWN image schema also identified by Zbikowski [12], is lacking in the Harmony Space user interface, but clearly identifiable in staff notation where pitch is presented vertically on staff and ledger lines.

The evaluation also revealed the potential for a new method of applying conceptual metaphors and image schemas to user interface design, namely through audio output. Although audio output is a common feature of most, if not all, music software, the support for the conceptual metaphors and image schemas through audio output has not been systematically investigated to our knowledge, and is therefore particularly interesting in this instance.

The results of the preliminary study and evaluation (full details of which can be found in Wilkie, Holland and Mulholland [13]) indicate that the proposed methodology for identifying conceptual metaphors and image schemas and applying them to evaluations of software is sound. However further work is needed to establish whether enhancing the user interface of software such as Harmony Space to more effectively utilise the conceptual metaphors and image schemas identified would enable users who would have perhaps been previously excluded from using such software through disability or lack of domain knowledge to carry out complex musical tasks.

4. CONCLUSIONS

Previous research [3][4][5] has already shown that image schema and conceptual metaphor theories which are grounded in prior sensory-motor experiences holds much promise for better understanding of users' conceptual models. However further work is needed to establish a means in which this information can be employed to systematically improve interaction designs such that they can be utilised by a wider range of users with diverse abilities and characteristics.

4.1 Future Work

Future work will focus on developing a greater understanding of the conceptual metaphors and image schemas used by musical experts to structure their understanding of music by conducting further studies using alternative musical representation formats, for example piano roll notation, guitar tablature, figured bass and video footage of performances. The results of these studies will be used to systematically analyse further examples of music analysis software. It is intended that the information elicited through these studies and evaluations will be used to develop a general theoretical framework for designing aspects of music interactions in a manner that enables access for a diverse user population.

The preliminary work discussed in this paper contributes to this research by providing a foundation upon which to base further studies and by furthering our understanding of the cognitive constructs used by musical experts to structure their interpretation and understanding of excerpts of music and the concept of harmonic analysis.

4.2 Expected Contribution

Our research is expected to make the following contributions to the field: i) improve understanding of the conceptual metaphors used by experts in the domain of musical theory and analysis ii) improve understanding of how this knowledge can be applied to the analysis and design of user interfaces for music iii) establish a general theoretical framework for designing the user interfaces of music software packages aimed at empowering a wide range of users to carry out complex musical tasks such as harmonic analysis and composition.

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