Towards a participatory approach for interaction design based on conceptual metaphor theory: a case study from music interaction

Book Section

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Keywords

Interaction Design, Music Interaction, Conceptual Metaphor, Image Schema, Participatory Design

Abstract

"Music Interaction" is the term for interaction design within the domain of music. In areas such as music, the ability to engage effectively in certain activities tends to be restricted to those who have acquired detailed knowledge of domain-specific theories, terminologies, concepts or processes. It can be challenging to design or enhance user interfaces for software able to support novices in these kinds of musical activities. One promising approach to this challenge involves translating musicians' implicit domain knowledge into patterns known as conceptual metaphors, which are metaphorical extensions of recurring patterns of embodied experience applied to abstract domains, and using this information to inform interaction designs for music. This approach has been applied experimentally with some success to designing user interfaces. However, to the best of our knowledge, this present work is the first to consider in detail the use of Conceptual Metaphor Theory as a key component of a participatory design process. In this chapter we present a participatory ap-

proach to Music Interaction design based on the principles of Conceptual Metaphor Theory. We posit that such an approach will facilitate the development of innovative and intuitive interaction designs for both novices and experts alike.

1. Introduction

The recent advent of music video games such as Guitar Hero (Harmonix 2005) and Wii Music (Nintendo 2008) has afforded those with limited knowledge of music the opportunity to experience the pleasure of collaborating with others to produce music, albeit in highly simplified respects through interacting with games controllers. Although the popularity of such games reflects music's pervasiveness within society, in general they afford limited engagement with the structural properties of the music, focusing instead on note-on note-off accuracy. Thus the ability to engage with, understand and analyze more technical aspects of music such as voice leading and harmonic and rhythmic progressions is generally restricted to those with detailed knowledge of the terminologies, notations and processes used in the domain. Since such knowledge is often only acquired through detailed academic study, many novices who wish to interact with the structural properties of music on a deeper level are excluded from doing so. Furthermore, it can prove challenging to create user interaction designs for music software that can facilitate the exploration and manipulation of the structural properties of music without requiring detailed pre-existing knowledge of the domain. We hypothesize that if we can represent detailed domain knowledge that experienced musicians have acquired in a manner that exploits pre-existing and universally held embodied knowledge, we will be able to lower some of the barriers to structural understanding of musical concepts. Furthermore, we posit that such an approach would result in Music Interaction designs that were intuitively usable to both experts and novices alike.

A promising foundation for this work can be found in the identification of "recurring patterns of our sensory-motor experience" (Johnson 2005) known as image schemas. These image schemas, which it is argued form the basis of our understanding of abstract

concepts through the creation of conceptual metaphors (Johnson 2005), are often identified through methods such as the analysis of spoken and written dialogue. Exploring the application of image schema, conceptual metaphor and embodied theories in diverse domains have have reported encouraging results. These domains include:

- Music theory (Saslaw 1996, 1997; Zbikowski 1997a, 1997b; Brower 2000; Larson 1997; Johnson 1997; Johnson and Larson 2003; Eitan and Granot 2006; Eitan and Timmers 2010).
- Interaction design (Hurtienne and Blessing 2007; Hurtienne et al. 2008; Treglown 1999).
- Sound Interaction design (Antle et al. 2008; Antle et al. 2009).
- Evaluating Music Interaction designs (Wilkie et al. 2009, 2010).

Applications of image schema, conceptual metaphor and embodied cognition theories to interaction design (Hurtienne and Blessing 2007; Hurtienne et al. 2008; Treglown 1999) and Sound Interaction design (Antle et al. 2008; Antle et al. 2009) to date have focused primarily on using image schemas and conceptual and embodied metaphors as a bridge between the requirements and the user interface controls. However, the use of conceptual metaphors as a tool for facilitating design discussions with domain experts is, to the best of our knowledge, as yet unexplored. In this chapter we present a collaborative approach to interaction design within the domain of music, using domain-specific conceptual metaphors derived from dialog betweeen experts to elicit the functional requirements for a gesture-controlled interactive system. These functional requirements are then used to develop materials for participatory design sessions with musicians, with the aim of designing a wearable instrumented jumpsuit for exploring and manipulating chord progressions.

2. Embodied Understanding of Abstract Concepts

As briefly outlined, research into the development of conceptual models has led to the hypothesis that our understanding of melody, harmony, rhythm and other musical concepts is grounded in struc-

tures named image schemas (Saslaw 1996, 1997; Zbikowski 1997a, 1997b; Brower 2000). Image schemas may be defined as repeating patterns of our sensory-motor experiences of space, orientation, forces and interactions with other bodies in our environment (Lakoff and Núñez 2000; Johnson 2005; Rohrer 2005, 2007). These image schemas are typically identified through the analysis of linguistic expressions in spoken or written text. In such an analysis, it is important to distinguish between literal or metaphorical uses of images schemas. For example compare the phrase "put the toys in the box" with the superficially similar phrase "the melody is in the key of C". In both examples, the preposition "in" suggests the use of the CONTAINER image schema. However, in the first example the container is a tangible object, while in the second example, the container, the key of C, is an abstraction.

The real power of image schemas in this context is that their inherent structure can give rise to a number of entailments which can then be used to carry out intuitive reasoning operations. For example, if we consider the nested containers shown in Figure 1 below, we can infer quickly and intuitively, without the need for formal reasoning, that if an object is inside a container and that container is itself inside another container, then the object must be inside both containers.

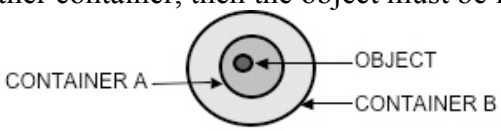

Fig. 1 Representation of the relationships between OBJECTS and nested CONTAINERS

Mapping image schemas onto corresponding aspects of a target domain to create conceptual metaphors enables us to structure our understanding of abstract concepts in other, often unrelated, domains such as music, philosophy or arithmetic (Lakoff and Núñez 2000; Johnson 2005). For example, analysis of the seemingly simple phrase "the melody starts in C major and moves up to G major", a simplified portrayal of which is shown in musical notation in Figure 2 below, reveals a number of metaphorical mappings, all of which have a corresponding representation in standard music notation:

- The CONTAINER image schema has been mapped onto the target domain of key, resulting in the conceptual metaphor A KEY IS A

CONTAINER FOR MELODY. This mapping is demonstrated in standard musical notation by the declaration of the key signature in terms of numbers of flat or sharp notes at the beginning of each stave.

- The UP-DOWN (sometimes referred to as VERTICALITY) image schema has been mapped onto the target domain of pitch, resulting in the conceptual metaphor HIGH PITCH IS UP/LOW PITCH IS DOWN. This mapping is exemplified by the position of the stave lines in standard music notation, as the vertical position of a stave line is directly proportional to the pitch to be sounded.
- The SOURCE-PATH-GOAL image schema, a representation of which is shown in Figure 3 below, has been mapped onto the target domain of melody, resulting in the conceptual metaphor MELODY IS MOVEMENT ALONG A PATH. This mapping is demonstrated in standard music notation by considering each note on a stave to be a location within a path where the final note marks the end of the path.

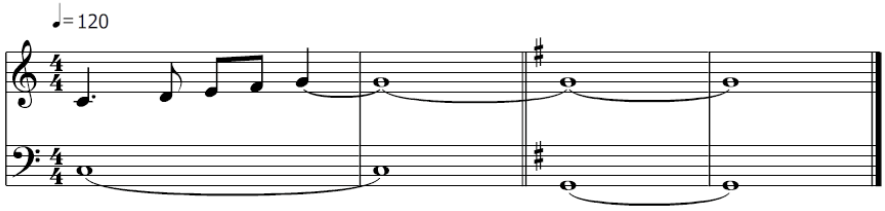

Fig. 2 Simple melody and bass line, illustrating modulation from the key of C major to G major

Furthermore, applying the principles of metaphorical entailment allow us to deduce that, based on the example given above, the key of G major sounds after the key of C major and that G is higher than C with respect to the melody part (assuming octave equivalence).

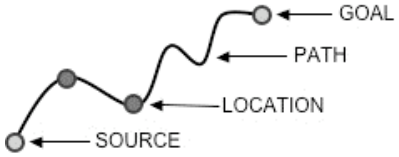

Fig. 3 Representation of the SOURCE-PATH-GOAL image schema showing LOCATION objects on the PATH

The Invariance Principle (Zbikowski 1997b) is the cognitive phenomenon whereby only aspects of the source domain which appear to be coherent with the target domain retain their salience. In general, inappropriate aspects of mappings are automatically and tacitly ignored. For example, in the case of the conceptual metaphor defined above, MELODY IS MOVEMENT ALONG A PATH, only the applicable aspects of the SOURCE-PATH-GOAL image schema are perceived to map to the concept of melody, namely the start and finish points and the locations, all of which map to notes within the melody.

Following this principle, although alternative mappings between different image schemas and the target domain are possible, the number of image schematic correspondences between the source and target domains tends to be indicative of the usefulness and likely retention of the mapping. For example, as Zbikowski (1997b) notes, fruits do not readily map to pitch.

The ability to apply image schemas to abstract domains through the process of creating conceptual metaphors via metaphorical mapping makes image schemas and conceptual metaphors extremely useful for intuitive communication and for informal reasoning. Existing applications of these theories to music theory and user interface design will be discussed further in the sections below.

2.1 Embodied Understanding of Musical Concepts

Previous research into the application of image schema and conceptual metaphor theories to musical concepts to date has typically focused on the analysis of the various musical concepts and phenomena described by music theorists. For example an analysis of Riemann's treatise "Systematic Study of Modulation as a Foundation for the Study of Musical Form" by Saslaw (1996) reveals Riemann's understanding of harmonic progression and modulation to be grounded in the CONTAINER and SOURCE-PATH-GOAL image schemas. Saslaw further claims that Riemann's understanding of modulation hinges on the use of the FORCE image schema to allow movement from one key CONTAINER to the next. In a related example of ap-

plying embodied theory to music theory texts, Saslaw (1997) presents a detailed analysis of the text in Schenker's "Free Composition" and Schoenberg's "The Musical Idea and the Logic, Technique, and Art of its Presentation". Arguing that both composers' theories can be attributed to their prior experiences of forces, Saslaw posits that Schenker associates musical progressions with a journey through life, while Schoenberg refers to movement back and forth towards the tonic in terms of a struggle between opposing forces.

Applying the principles of Conceptual Metaphor Theory to the development of a cognitive theory of musical meaning, Brower (2000) identifies the CONTAINER, CYCLE, CENTRE-PERIPHERY, BALANCE and SOURCE-PATH-GOAL image schemas as central to our understanding of harmonic relationships such as the cycle of fifths and the resolution of unstable pitches. By contrast, Larson (1997) focuses on the analysis of short melodic patterns, introducing the concepts of MUSICAL GRAVITY, MUSICAL MAGNETISM and MUSICAL INTERTIA based on the FORCE image schema, arguing that these "musical forces" influence the direction of melodic movement. Larson identifies a series of three and four note stepwise patterns beginning and ending on the notes of the tonic major triad, i.e. "stable" notes, whose formulation was determined by the power exerted on the pattern by each of the three concepts. Through reviewing various texts written by music theorists, Larson identifies a number of hidden repetitions within musical structure that correspond to the patterns he himself identified, suggesting that composition as well as structural analysis is influenced by prior sensory-motor experiences.

In an attempt to establish patterns of association between space and motion and changes in musical parameters such as pitch and tempo, Eitan and Granot (2006) carried out a series of experiments asking participants to specify the movement of an imaginary character in response to various musical stimuli. In general, although the results revealed that a change in a musical parameter was often associated with changing motion, the participants' response to ascending pitch was surprising. Despite associating descending pitch with spatial descent, the association between ascending pitch and spatial ascent was weaker, contrary to the structural inferences of a commonly used conceptual metaphor in Western music, HIGH PITCH IS

UP/LOW PITCH IS DOWN (Zbikowski 1997a, 1997b). In summary, the application of conceptual metaphor theory to musical concepts has led to some promising results, but further work is needed to establish the extent to which even widely accepted image schemas and conceptual metaphors are an active mechanism in particular cases.

2.2 User Interface Design Using Image Schemas

It is instructive to contrast conceptual metaphors with other kinds of metaphor. The use of what are known as user interface metaphors is a technique frequently recommended to interaction designers (Preece et al. 1994). The aim of this technique is to allow users to readily make inferences about how to operate unfamiliar user interfaces by mapping existing skills and knowledge from some familiar source domain. However, the much narrower use specifically of image schemas and conceptual metaphors to drive user interface design has received relatively little attention.

Discussing the design of a basic file management system, Treglown (1999) concluded that Conceptual Metaphor Theory holds promise as a foundation for user interface design. Echoing his conclusion nearly a decade later, Hurtienne and Blessing (2007) argued that a design could be considered intuitively usable if the user can subconsciously apply prior knowledge when interacting with a design. Exploring the potential of using conceptual metaphors as a technique for developing more intuitive interaction designs, they designed a series of basic user interfaces using slider and button controls. The layout and configuration of the controls were designed variously either to support or contradict basic conceptual metaphors such as GOOD IS UP and MORE IS UP. Participants were asked to select the most appropriate button or move the slider in the most appropriate direction based on their response to a simple phrase employing the conceptual metaphor under investigation. In general, the results of experiments indicated that configuring the controls to support the conceptual metaphors led to a reduction in response times.

Investigating the potential of image schemas as a "metalanguage" for the analysis and design of an invoice verification and positing system, Hurtienne, Israel and Weber (2008) concluded that

such an approach encouraged them to focus more on the essential user interface requirements of the system. When taken in conjunction with the encouraging results of Hurtienne and Blessing's (2007) experiments, their conclusion lends further weight to the claim that Image Schema and Conceptual Metaphor Theories hold promise as a foundation for a methodology for Music Interaction design.

2.3 Sound Interaction Design Using Embodied Concepts

Investigating the advantages of a system that employed the principles of embodiment to facilitate user interactions with the system, Antle, Corness, and Droumeva (2009) and Antle, Droumeva, and Corness (2008) designed an interactive system that enabled users to manipulate basic musical parameters such as pitch, tempo and volume simply by moving their bodies. The interactions were based on mapping specific movements with changes in sound parameters, for example equating fast movements with fast tempo. The results of their experiments indicated that an interaction layer employing embodied metaphors led to a system that was easier to learn. This result adds further weight to the claim that the application of embodied theories to interaction designs results in more intuitive interactions. However, the results were inconclusive with respect to enhancing the ability of children to learn musical concepts (Antle et al. 2008).

2.4 Using Conceptual Metaphors to Evaluate Music Interaction Designs

Earlier research has demonstrated how conceptual metaphors can be used to evaluate the designs of various interactions within music software, illuminated by two case studies (Wilkie et al. 2009, 2010). Through analysing the transcript of a dialog between experienced musicians discussing the melodic, harmonic and rhythmic structure of a short excerpt of music, we were able to identify a number of conceptual metaphors the musicians used to form their understanding of the musical properties of the excerpt. By comparing the conceptual

metaphors with the layout, configuration and behaviour of the Music Interaction designs within two examples of music software, Harmony Space (Holland 1992, 1994; Holland et al. 2009) and GarageBand (Apple 2009), we were able to identify instances where the designs either fully or partially supported the conceptual metaphors or, conversely, contradicted them. In many cases, areas of design tension or contradiction arose due to the desire to enhance support for specific tasks or musical parameters, reducing the support for other tasks or concepts. For example, in Harmony Space, the desire to support tasks associated with harmonic analysis led to less emphasis on the support for voice leading. The results of the evaluation of Harmony Space led to improvements in the design of the tracing functionality to increase support for the conceptual metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH.

The success of these evaluations provides supportive evidence to the claim that Conceptual Metaphor Theory can be used as a foundation for a methodology for Music Interaction design. The following sections explore how such a methodology can be extended to deal with participative design.

3. Developing a Participatory Approach to Music Interaction Design

A participatory approach to design generally involves the prospective users of the system in the design process (Kensing and Blomberg 1998; Preece et al. 1994). In our case, we are designing for novices who lack knowledge of the terminology, notations and processes in the domain. Such prospective users have a very limited foundation upon which to base their design decisions. Consequently, although novices are an important target for our interaction designs, our approach focuses primarily on conducting participatory design sessions with experienced musicians. We posit that by encouraging experienced musicians to formulate their design decisions based on conceptual metaphors underpinning their musical knowledge, this will help in the framing of relevant design structures and relationships in ways that afford wider accessibility. In this way, we hope to capitalize on

musicians' domain knowledge and thus develop interaction designs for music software that are intuitively usable to novice users.

Despite the use of Conceptual Metaphor Theory as a technique to inform new and redesign existing interactions (Antle et al. 2008, 2009; Hurtienne and Blessing 2007; Hurtienne et al. 2008; Treglown 1999; Wilkie et al. 2009, 2010), to the best of our knowledge, no studies have used this theory to drive the development of new interaction designs in collaboration with domain experts through the use of participatory design sessions. In the following sections we propose a methodology for such a task with respect to Music Interaction design.

3.1 Identifying and Validating Task Specific Conceptual Metaphors

A valuable initial step in such a methodology is to validate any relevant domain-specific conceptual metaphors provisionally identified in previous research (such as those noted in section 2.1) that the design must address. It is also useful to identify and validate any previously overlooked applications of conceptual metaphors in the domain that may be relevant to the design. All such conceptual metaphors can then be used to develop materials such as functional requirements and scenarios for participatory design sessions and to evaluate any resulting design decisions.

To this end, and following on from the previous study mentioned in section 2.4 and discussed in more detail in Wilkie et al. (2009, 2010), two further studies were carried out with a number of groups of musicians as follows. All of the musicians involved in the two studies played at least one instrument regularly and many also had at least some experience of teaching, arranging, conducting or composition.

In the first study, pairs of participants were provided initially with a set of words and subsequently a set of images and asked to use the words or images to describe and discuss short excerpts of music. The set of provided words included pairs of polar opposites, for example "moving" and "static", "up" and "down" and "attracting" and "repelling" and some additional standalone words such as "journey". The words were chosen specifically to encourage the participants to de-

scribe aspects of the excerpts in such a way that they might reveal their structural understanding of musical concepts in terms of conceptual metaphors. The images chosen for the second part of the first study were simple ClipArt drawings, again in some cases representing polar opposites such as a full glass and an empty box, as well as some additional standalone images such as balanced scales. Again, the aim was to encourage participants to discuss aspects of the excerpts, eliciting conceptual metaphors.

In the second study, groups of participants were asked to bring along an excerpt of a piece of music they knew well and to discuss aspects of that music such as the melody, harmony and rhythm with the other participants in the group. The participants were given the opportunity to play or sing the musical excerpt to aid their discussion if they so wished. Following the discussion, a score and an audio recording of a short piece of music was provided to the participants. Again the participants were asked to discuss the structural aspects of the piece with each other. As with the previous study, the aim was to encourage the participants to discuss musical concepts in a manner that would elicit conceptual metaphors associated with the structural aspects of the excerpts they were discussing.

The analysis of the results of the two studies is still being completed. However, a preliminary review of the first study, together with the results of the initial analysis of the transcriptions of the second study indicate that several image schemas and their related conceptual metaphors can be validated, supporting their provisional identification by previous studies (Brower 2000; Eitan and Granot 2006; Eitan and Timmers 2010; Saslaw 1996, 1997; Zbikowski 1997a, 1997b). For example, the image schemas most frequently used by the participants in the second study were SOURCE-PATH-GOAL, PART-WHOLE, CONTAINER, MATCHING, MOMENTUM, UP-DOWN and SCALE in descending order of frequency. Interestingly, despite the BALANCE image schema being identified by Brower (2000) as part of a set of image schemas central to our understanding of harmonic relationships, analysis of the transcriptions did not reveal any instances of this image schema. Subject to further analysis, this could indicate either that the tasks the musicians were asked to carry out did not lend themselves to discussing aspects of the excerpts in terms of balance, or that the musicians did not conceptualise the

structural properties of the excerpts in terms of balance. This finding highlights two factors:

- The importance of engaging with participants with appropriate levels of expertise in the topics being discussed in order to ensure conceptual metaphors of a suitable conceptual depth are elicited.
- The importance of designing tasks in such a way as to elicit as wide a coverage of relevant domain-specific conceptual metaphors as possible.

These considerations are important to ensure adequate coverage of conceptual metaphors to support the design of more complex interactions.

3.2 Participatory Music Interaction Design

Following the identification of relevant image schema and conceptual metaphors as outlined above, the next step will be to establish the extent to which experienced musicians can collaborate to develop music interaction designs based on musical conceptual metaphors. To this end, a participatory design study involving musicians will be carried out. The participants chosen for the study should have knowledge of the principles of harmonic theory and at least some experience of conducting, arranging or composing. During the study, the participants will be asked to work in groups to design a wearable instrumented jumpsuit that would allow wearers with limited knowledge of harmonic theory to create, explore and manipulate simple chord progressions. The participants will be provided with a set of materials to provide input into the design discussions:

- A list of functionality that the jumpsuit will support, for example detecting if the wearer places an object in the pocket or moves their feet.
- A list of musical tasks that the jumpsuit can support, for example playing a chord sequence or adding a chord to an existing chord sequence.
- A series of simple pencil sketches based on validated musical conceptual metaphors. For example a sketch based on the conceptual

metaphor HARMONIC PROGRESSION IS MOVEMENT ALONG A PATH, may involve chord objects moving along a road and fading into the distance.

- A list of mappings between the functionality that the jumpsuit supports and the associated image schema, for example mapping movement of the arms to movement along a path (SOURCE-PATH-GOAL).

The lists of functionality and musical tasks list the functional requirements that the jumpsuit must support, while the sketches and mappings will encourage the participants to link the requirements to the relevant musical conceptual metaphors. We posit that such an approach will not only provide a framework for testing whether conceptual metaphors can be used to drive participatory design discussions but also enable us to determine which musical conceptual metaphors can be mapped to physical gestures in practice.

3.3 Validating Design Decisions

In order to validate the designs produced during the participatory design sessions, we propose to develop a prototype of the instrumented jumpsuit based on aspects of the design outputs of all of the study sessions. We will evaluate the prototype to determine the degree to which participatory approach based on the principles of Conceptual Metaphor Theory was able to produce a useful design that is usable by novices.

4. Conclusion

Previous studies have established that using conceptual or embodied metaphors have at least two clear applications in HCI. Firstly to guide user interaction design (Antle et al. 2008, 2009; Hurtienne and Blessing 2007; Hurtienne et al. 2008; Treglown 1999) and secondly to evaluate, critique and improve existing designs (Wilkie et al. 2009, 2010).

To the best of our knowledge, the present work is the first application of Conceptual Metaphor Theory to drive participatory design discussions in any domain. In interaction design for domains such as music, where it can be particularly hard for novices to articulate concepts, this approach appears particularly well suited to promote the framing of expert knowledge in an accessible form.

While, as already noted, conceptual and embodied metaphors have been used in previous studies to aid user interaction design, to the best of our knowledge, this work is the first attempt, irrespective of domain, to develop an end-to-end methodology for user interaction design based on conceptual metaphors.

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