Prototyping Whole Body Navigation of Musical Harmony

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ABSTRACT

We present a Wizard-of-Oz study where we explored the design requirements needed to transform an existing desktop music application to a system using whole body interaction. The desktop tool used is called Harmony Space [1,2]. It is grounded in two well-established theories of music cognition and perception [3,4] providing a parsimonious, unified, and expressive graphical representation of musical harmonic relationships [1,5,6]. This level of description focuses on objects, locations, shapes, centres, moveable 'allowed' and 'forbidden' areas, trajectories and motions in space, to be navigated while meeting rhythmically-felt, layered, time constraints. This approach makes it possible to characterise such disparate concepts as scales, chords, triads, tonal centres, chord sequences, bass lines, harmonic progressions, modes and modulations, using a single, consistent, parsimonious extended spatial metaphor.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Input devices and strategies, Interaction styles, Evaluation/methodology*; K.3 [**Computers and Education**]: Computer Uses in Education – *collaborative learning, computer-assisted instruction*; [**Computer Applications**] Arts and Humanities – *Performing arts*.

General Terms

Design, Music, Experimentation, Human Factors, Theory.

Keywords

Harmony Space, whole body interaction, embodiment, music, memorability.

INTRODUCTION

In this paper, we present a description of a Wizard-of-Oz study exploring the design requirements necessary to transform an existing desktop music application to a system that uses whole body interaction. The desktop tool used is Harmony Space [1,2]. It is grounded in two well-founded theories of music cognition and perception [3,4] and provides a parsimonious, unified, and expressive graphical representation of harmonic relationships in music [1,5,6]. The tool focuses on objects, locations, shapes, centres, moveable 'allowed' and 'forbidden' areas, trajectories and motions in space, to be navigated while meeting rhythmical time constraints. This approach makes it possible to characterise a wide range of concepts including scales, chords, triads, tonal centres, chord sequences, bass lines, harmonic progressions, modes and modulations, using a single, parsimonious spatial metaphor.

Following Papert's notion of body-syntonic learning [7], we were interested in whether participants' understanding of harmonic relationships could be effectively mapped to their knowledge of their own bodies and situated sense of space. A previous 'human-powered' pilot study [5] with no computer-based elements, using physical labels on the floor, and a large manually-moved wooden frame demonstrated the potential of whole body navigation of Harmony Space for free composition by musical experts. Here we aimed to identify any benefits that a more flexible computer-based whole-body version of Harmony Space aimed both at beginners and accomplished musicians might provide over the present desktop system. Because of its physical similarity to the popular party game, we called this system *Harmony Space Twister*.

Figure 1: left – the Harmony Space representation projected onto the floor.

Figure 2: the projector on the top floor of the atrium, with two metal arms holding a mirror for downward projection

The central aim of the described trial was to explore design requirements in adapting Harmony Space from a desktop system controlled with a mouse and keyboard to the medium of whole body interaction. This process of remediation – taking techniques and practices that work in one medium and applying them in another – can be a productive approach in dealing with the complexity of predicting the affordances of a new *medium a priori* [8]. We aimed to use a Wizard-of-Oz approach to identify and characterize some of the new opportunities that

whole body interaction presents in the context of the principled manipulation of chord sequences and bass lines.

1. WIZARD-OF-OZ STUDY

The Harmony Space Twister interface was prototyped in a large atrium, and focused on a floor display area about 6 metres by 4 metres (figure 1), illuminated via a mirror by a powerful data projector situated some 10 metres overhead (figure 2). White sheeting was taped down over the carpet tiles to provide a high contrast surface for image projection.

The engine driving the system was the 2008 desktop implementation of Harmony Space, which was designed and implemented by one of the authors. This is coded in Squeak Smalltalk and runs platform independently on Mac and Windows machines. Squeak's internal software FM synthesiser is used to drive the audio. One option under consideration was to interface this system with the ReacTIVision [9] camera-based blob tracking or fiducial tracking system via the existing Squeak implementation of the Tuio protocol [10] to track players' movements, but for this design study we chose to use Wizard-of-Oz position tracking (i.e. a human operator of the desktop version of Harmony Space tracked the position of players by eyeball). This allowed us to explore the implications and possibilities of different candidate tracking mechanisms (camera-based head tracking, camera based foot tracking, pressure mats, etc). To trial a feature needed if camera tracking were used, a hand gesture was trialed for muting the generation of sound. This involved participants putting their hands on their head as if covering a fiducial marker [9].

The desktop Harmony Space representation used in this study has a number of key features, which are described in more detail in [1] These include representing the tonal centre for a piece of music by ringing the note in red. Tonal centres were described to the participants in this study as 'home' and a good place to start and finish a song. A second feature is highlighting white 'allowed' areas and black 'forbidden' areas, which correspond in the simplest case to the white and black keys on a piano – though the areas change when the key or mode changes. It was pointed out that the terms 'allowed' and 'forbidden' only act as loose guides. Finally, there are only 12 distinguishable notes in the display. This basic pattern is repeated like wallpaper allowing the long information-rich trajectories found in tonal music to be more easily seen, played and analysed.

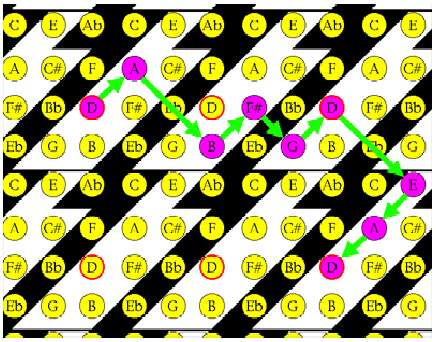
In general terms, each task or game focused on a specific song (e.g. Pachelbel's Canon, Michael Jackson's 'Beat It', Fats Domino's 'Blueberry Hill'). The player's task was to navigate through space across the grid in time to the playback of a recording of the song in question in such a way as to generate the bass line (or chord sequence). The songs used for the trial were chosen to exhibit a variety of clearly distinguishable but thematically related trajectories in Harmony Space. For example, Pachelbel's Canon moves harmonically in a regular zig zag (avoiding the 'forbidden' black area outside of the current key) followed by a straight-line trajectory to home (see figure 3).

1.1 Participants

The study focused principally on a single participant (participant A) for a two-hour period. However, two watchers of the study (which was in a public atrium space) spontaneously joined in to demonstrate by example alternative paths for some songs to the paths suggested by the coach (one of the authors) or worked out by the participant, so that in effect there were two secondary participants (participants B and C). Participant A did not have any experience in playing a musical instrument, but had done some sol-fa singing at school, and knew the Greek notes names. Participants B and C had some experience of playing guitar and electric bass respectively.

Figure 3: Path of chord roots of Pachelbel's Canon in Harmony Space

2. OBSERVATIONS FROM TRIAL



From the Wizard-of-Oz study, we were able to draw out a number of themes that have implications for the development of our planned high-tech version of Whole Body Harmony Space.

2.1 Individual differences between participants

There were a number of differences between the four different players (three participants plus coach) who used Whole Body Harmony Space during the two-hour session. Firstly, they differed in their style of moving through the space. The principal female participant used a fluid, dance- based, highly rhythmic form of movement in the faster songs while walking and leaping during the slower numbers. Two male participants used relatively minimal precise planned movements to try to hit the targets at the right times. One male participant used a very exuberant dancing style. In order to not alienate one group of users, the high-tech version of Whole Body Harmony Space should therefore allow for both precise and more exuberant or dance-like forms of interaction.

The participants' stride length was also observed to vary considerably. This was no problem for any participant making single steps in any of the eight compass directions, but for two particular musical intervals (the whole tone and the tritone) steps of size two are required. Steps of size two on the diagonal in particular required some agility from the somewhat petite principal female participant. This did not create any real problems in the trials, but clearly there is a trade-off between engaged physicality vs. challenges for older, smaller or younger participants. One design possibility might be to calibrate the size of the Harmony Space Representation to the physical capabilities of users.

Finally, different participants had markedly different strategies for constructing trajectories for playing the same bass lines. For example, in playing Michael Jackson's "Billie Jean", the coach had envisaged the path which demonstrates the harmonic structure clearly from a music- theoretic point of view. However, one of the steps proved to be physically difficult, so participant A used a physically more convenient alternative path. Participant B intervened spontaneously to suggest a third alternative on the grounds that that this would minimize physical inconvenience. We suggest that the discussion stimulated by these differences of opinion is one of the benefits in translating Harmony Space from a desktop system, to a

whole body system, encouraging participation and experimentation by bystanders and others (cf. [11]).

Figure 4: Participant A following a path in Harmony Space

2.2 Memorability of different harmonic structures

Different songs can have very different paths in harmony space. When songs were learned in preview mode or social mode, where the songs, or parts thereof, were learned in advance, there were clear differences between the physical memorability of different paths. Those songs that were found to be easiest to memorise during the trial were those based principally on a simple straight-line trajectory. Those ostensibly simpler patterns where the participants had to move away from home by single steps in repeated patterns were found to be hard to remember, with participants often forgetting when to move up and when to move down the harmonic axis. Songs with more than one straight-line trajectory, such as Stevie Wonder's "Isn't she lovely" were found to be of intermediate difficulty. This suggests that when introducing beginners to Whole Body Harmony Space, it makes sense to take advantage of the embodied cognitive economies of straight line trajectories before moving onto more complex paths.

2.3 Keeping bearings during modulation and changes of trajectory

When the key window moves (which occurs whenever the key is explicitly changed) it is relatively straightforward to visually grasp what has happened when using the desktop version of Harmony Space. Subjectively, it is at first more disorienting in the whole body version when the key changes, even when it is anticipated. However, participant A noted that having experienced this, it was possible to come up with strategy for avoiding confusion. She reported that she simply fixed her eyes on the note names, and ignored key shifts when working out where to step next. One design change that might reduce the disorienting effects of key changes is by animating rather than jumping the key window to the new location, giving the user more opportunity to work out what is going on. Similarly, while in the desktop version of Harmony Space, movements in any direction are equally straightforward to perform through the interface, in the Whole Body prototype, the ease of a particular movement depended upon the current orientation of the participant. In particular, most mistakes were made when the next chord or bass note to be played was located behind the participant. This finding demonstrates the trade-offs inherent in moving between different media. While the whole body version of Harmony Space may support better memorization of songs and hands free interaction, it also potentially makes movement in the space more demanding. This is analogous to the differences inherent in planning a route using a map and physically walking the route in the real space.

2.4 Playability

The speed of bass lines and chord sequences that could be played was limited partly by the speed with which players could move. For example, a fully accurate version of the bass line to "Hey Joe" would nest rapid sideways chromatic trajectories (Figure 5, middle) into the fundamental upwards straight-line subdominant-powered trajectory (figure 5, left). Figure 5, middle shows this overall path laid out for maximum clarity of the harmonic structure, but this version of the path is physically impractical for a single player due to the speed required for the silent moves to the start of each chromatic trajectory. However this could be achieved by "relay players" collaborating. Alternatively,extended sections of the musically equivalent path (fig 5, right) (which stresses the melodic aspects of the bass line while de-emphasising its harmonic aspects) are physically workable for a single player, but they would "run out of road" before finishing the pattern. Again, two or more players could execute this path working as a relay. In the trial, the simple path shown in figure 5, left was used.

Another possibility for studying and playing pieces otherwise too fast to play faithfully would be to slow the tempo digitally without the altering pitch or harmonic structure.

For purposes of simplicity during the trial, moving to each note circle generally sounded the relevant bass note or chord without adornment – or in some cases adorned with a simple repeated rhythmic figure. There are many other possibilities to give the user more control over rhythm or produce a more pleasing result – for example hand slaps on sensors on the body or repeated foot strikes could be used to control rhythm, or a collaborator could use body movement to modulate the notes produced with different rhythmic figures or melodic figures or accompaniment patterns at different points in the song – or purely automatic accompaniment patterns could be used.

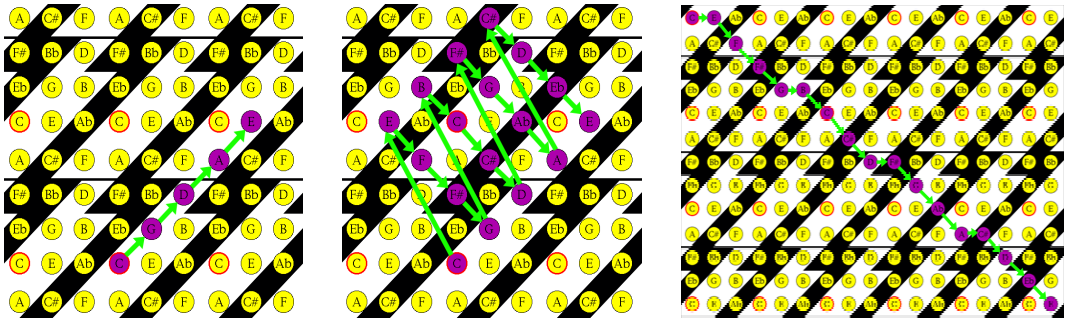


Figure 6: "Hey Joe". Left – underlying trajectory; Middle – with nested chromatic trajectories; Right – 'melodic' path.

2.5 Tracking Issues

Experience in the trial suggests that tracking footfalls, e.g. by pressure mats, may reflect players' intentions better than tracking head position (e.g. via a fiducial marker on a hat). In some cases, where head position remained intermediate between two note circles, players clearly used footfalls in time with the rhythm to indicate note transitions correctly. On the other hand, it was clear that foot position would often be occluded relative to a ceiling-based camera. A related problem with using a single overhead projector was that players' shadows sometimes occluded the labeling of nearby features. Three possible design changes to address this problem include: larger note labels; multiple projectors - although this would come at the cost of greater complexity and calibration issues; and labels fixed to the floor – though this would rule out the use of dynamic labeling essential for dealing with more complex harmonic material.

3. DISCUSSION

The purpose of this trial was primarily to explore design requirements in adapting Harmony Space to whole body interaction, and also to gather preliminary evidence on any benefits and key differences compared with the present desktop system. The trial suggested interesting contrasts with the desktop version. All subjects unanimously reported finding the whole-body interface and tasks absorbing, attractive, demanding, and fun. The desktop version attracts broadly similar reactions, but the reaction appeared more marked in the whole body case. The trial suggests that the whole-body version of Harmony Space offers several new opportunities compared with the desktop version. Key differences appear to be deeper engagement and directness, qualitatively different opportunities for collaboration, stronger memorability (in turn affording new opportunities for reflection), hands which are free for other simultaneous activities (such as playing an instrument), and deeper integration with rhythmically-felt, layered, time constraints. The Wizard-of-Oz study elicited a issues that shall feed in to the next iteration of the prototype.

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