

Sensory augmentation for abstract, conceptual relationships: whole body interaction and musical harmony

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Sensory augmentation for abstract, conceptual domains

The majority of sensory augmentation systems, though not all, augment the sensing of *physical* objects, phenomena and events (looming obstacles, the physical environment, oncoming projectiles, etc). In this position paper, we consider research issues which concern the use of sensory augmentation for exploring *abstract, conceptual* objects, phenomena and events.

One domain that is particularly rich with abstract, conceptual objects, phenomena and events is *musical harmony*. Harmony, considered to be one of the most abstract and technically difficult parts of music, is replete with abstract entities, phenomena and occurrences. This area is typically taught *symbolically* via abstract, domain-specific concepts, principles, rules and heuristics. At first sight, this does not appear to be a domain readily amendable to systematic, in-depth sensory augmentation.

However, when musical harmony is visualised, analysed, manipulated and created using metaphors embodied in the existing interactive desktop tool Harmony Space, a new, parsimonious, but expressive level of description emerges. This metaphorical level of description focuses on moving objects; locations; centres, trajectories; and moveable ‘allowed’ and ‘forbidden’ areas. Harmony Space is grounded in two theories of music cognition and perception, and relates strongly to recent findings on embodied cognition in music. By facilitating the interactive exploration of harmony using a single unified spatial metaphor, the tool affords new ways of perceiving, analysing and manipulating the relevant domain concepts.



Figure 1: left – a player throwing shapes in the Harmony Space representation projected onto the floor; middle – a projector on the top floor of the atrium, with two metal arms holding a mirror for downward projection; right – the path of the chord roots of Pachelbel's Canon in Harmony Space.

To transform the desktop version of Harmony Space into a sensory augmentation system, our initial designs focussed on a vibrotactile array, worn on the chest or back, to allow the wearer to sense spatial patterns generated using the appropriate cognitive theories. in response to the playing of music.

Conditions for *enactive* sensory augmentation

This satisfied the conditions for an enactive sensory augmentation system for musical *experts*, since expert players could enact musical actions (using the musical instrument of their choice) while receiving systematic vibrotactile feedback. This constituted a sensory motor feedback

loop, creating the necessary conditions to allow expert players to perceive new abstract relationships in the domain, or to discover new views on those relationships.

However, this early design was *not*, in general, enactive for beginners. The problem is that beginners with no skill in playing a musical instrument have *no systematic direct means of manipulating* the elements of tonal harmony. Even those who can sing reliably can only sing *one* note at a time, whereas the basic elements of harmony typically involve manipulating *three* notes at once – an activity which requires skill with a musical instrument. Thus, vibrotactile feedback alone is insufficient to provide a sensory augmentation system for harmony for beginners. Beginners have no ready means to carry out meaningful actions in the domain, whose effects they could experience fed back to them via sensory augmentation.

Fortunately, a *whole body interaction* system for Harmony Space, which we have constructed and trialled in prototype, appears far better suited as an enactive sensory augmentation system for music both for experts and beginners, for reasons we will now explain.

A whole body system for sensory augmentation

In the basic system, players physically navigate over the terrain of a projected surface (about 6m x 4m) illuminated via a mirror by a powerful data projector situated some 10 metres overhead. The projected image includes various graphically distinguished areas and dynamically moving features representing phenomena in the domain. The task of the player is to walk, run or dance an appropriate path in time to play back of a song, such that the tracking of their whole body in real time generates an appropriate bass line or chord sequence to that song.

The current prototype simply uses the player's position and path, tracked in time (in more complex cases, over a moving background elements) to generate chord sequences and bass lines, via a systematic, principled, theoretically well-grounded mapping. A later prototype will extend the tracking to pay attention to elements of body posture and orientation, building on the same spatial metaphor, so as to bring more finely detailed aspects of tonal harmony into the ambit of integrated motor control and sensory augmentation.

Implications for memorability

Our preliminary trials suggest that the whole body mode of presentation may have some implications for the memorability of knowledge derived from sensory augmentation systems. In particular, memory for walked paths, integrated with instantaneous auditory feedback of the effects of walking those paths, may in some circumstances be more vivid and perhaps longer lasting than similar knowledge obtained from less physical forms of presentation. This is analogous to the differences between planning a route using a map and physically walking the route.

Anecdotally, knowledge about music gained from using whole body harmony space appears to be qualitatively different in some interesting respects from knowledge gained by conventional symbolic routes.

Further work

1/ Whole Body Harmony Space throws up various technical issues in whole body tracking – for example in reliably tracking the location of footfalls in a large space. Trade-offs between alternative potential technological solutions need evaluation.

2/ I am interested to learn how empirical experiments with whole body Harmony Space or related systems could be used to further philosophical and psychological enquiry into such issues as:

- Sensory augmentation for exploring *abstract, conceptual* domains.
- Strategies for designing fully expressive enaction in such domains.
- The effects of whole body interaction, as a mode of presentation for sensory augmentation systems, on the memorability, or quality of memory, of knowledge gained.