Springboard: Exploring Embodiment, Balance and Social Justice

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Abstract
In this paper we describe the theory and design of a prototype interactive environment called Springboard. Springboard supports users to explore concepts in social justice through embodied interaction. We present the foundational theory of embodied conceptual metaphor, focusing on the *twin-pan balance schema*. We describe the application of balance metaphors in the design of the interaction model for our interactive environment. We conclude with a discussion of design choices and describe future research based on our prototype.

Keywords
Embodied interaction, metaphor, embodied schema, social justice, interactive environments.

ACM Classification Keywords
H.5 [Information interfaces and presentation]: Multimedia Information Systems--*Artificial, augmented, and virtual realities;* User Interfaces--*Theory and methods.*

Introduction
As computing becomes embedded in the physical environment, understanding how metaphors may be used to support users to enact appropriate input actions and understand the relationship to resulting computational representations requires investigation [1,3,5]. Most of the research to date on metaphor in human computer interaction has focused on the use of metaphor in the design of the visual communication elements of the graphical user interface or in

understanding user's mental models of such interfaces. We focus on the ways in which metaphors may be used in the interactional mappings between input actions and output responses.

In previous work we explored the idea that conceptual metaphors, derived from embodied schemata and operating outside of conscious awareness, could be used to create systematic and predictable relationships between specific human actions and specific system responses [1, 2]. We call these *embodied interactional models* and claimed that they constitute a design principle which has several benefits. Based on our investigation of an interactive audio environment called SoundMaker we found evidence that an embodied interactional model made the system easier to learn to use and resulted in a more enjoyable experience.

In order to validate our initial findings and extend our work to visual as well as auditory modalities, we have created another interactive environment, called Springboard. Springboard is a room-sized interactive environment where users can explore issues in social justice through balancing their bodies in space. This paper briefly describes the theoretical foundation, the design rationale and the system implementation. Springboard is a research instrument which will allow us to continue to empirically investigate the details and benefits of embodied interaction in embedded computational systems. We ask questions including: Does incorporating an embodied metaphor in the interaction model make the system easier to use? Easier to learn? Easier to understand? Are users consciously aware of the embodied knowledge instantiated in the system? Does using embodied metaphor promote a shift attention and awareness away from input mechanism and towards to representational content? Does this make the experience more engaging? More immersive?

Theoretical Underpinning

Embodied Conceptual Metaphor

A metaphor is the interaction between a target domain and a source domain that involves an interaction of schemas or concepts. Johnson claims that metaphors arise unconsciously from experiential gestalts relating to the body's movements, orientation in space, and its interaction with objects [4]. He called these fundamental gestalts *embodied schemata,* also called image schemata. Conceptual metaphors extend embodied schemata to structure and organize abstract concepts. For a more detail discussion of the role of embodied metaphors in interaction models, see Antle et al [1].

The Meanings of Balance

Johnson presents an analysis of the meaning of balance as both an experience and a concept [4]. He states that our experience of balance is so pervasive and basic that we are seldom aware of its existence. The structure of balance is a key element that pulls our physical experience together as a coherent whole. For example, a toddler learning to walk immediately experiences various states of bodily balance and imbalance. We learn about balance with our bodies. Thus the meaning of balance emerges through acts of balancing. Long before we have grasped the meaning of the word we develop several embodied schemata for balance based on our experiences.

As we develop, embodied schemata related to balance begin to structure, and thus give coherent meaning to, our perceptions. In the realm of visual perception, we soon learn to interpret visual imagery as balanced or

imbalanced. An image with black circle placed at the interior edge of a square is interpreted as less balanced than an image where the circle is in the middle of the square. The embodied schema for bodily balance (around a point) structures this interpretation. Balance or imbalance does not objectively exist in the images. Balance comes through our act of perception and our interpretation which utilizes an embodied balance schema.

Balance schemata are also used to give meaning to balance in several abstract domains including: psychological states, legal systems, mathematics, and social justice. Through metaphorical elaboration, we interpret an abstract concept of balance based on similarities with our embodied schema for balance. For example, when we speak of social justice, we infer that justice involves a balance of factors such as rights, privileges, damages, and duties. Our understanding and judgments arise from the twin-pan balance schema (figure 1) [4]. We treat factors metaphorically like forces or weights in the pans of a scale. The scale can be imbalanced by either side of the fulcrum having too much or too little metaphorical weight or force. For a detailed discussion of balance schemata and their metaphorical extensions, see Johnson ([4], Chapter 4).

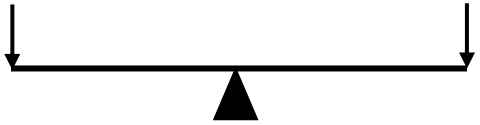

figure 1. Twin-pan balance schema.

System Design and Implementation

Why Social Justice?

In our earlier work we explore the benefits of an embodied metaphorical interaction model in an acoustic environment. As pointed out by several reviewers, changes in sound parameters are more perceptual than conceptual, and more physical than abstract. Johnson's work explores balance schemata and its metaphorical extension in a variety of domains including visual art, mathematics, law and justice [4]. The concept of balance in social justice is very abstract. It also lends itself well to visual representation. As such, it was chosen as a suitable domain to explore using in this next stage of our investigations.

We chose to represent three issues in social justice so that we could create three versions of the system for our future experimental work. Each version will have the same input space and similar interaction model but focuses on balance in a different social issue. Each issue must be conceptualized based on metaphorical extension of the twin-pan balance schema. Each issue should be able to be represented through visual media and each must have multiple aspects or themes to it which will support the creation of a rich display that will sustain user interest for our future investigations. Based on these criteria, issues related to food allocation, conflict resolution and the economics of production were chosen.

Design Goals

Our main objective was to create a system that we could use as a research instrument to look for evidence that we can leverage embodied knowledge of balance to support users to explore abstract concepts of balance related to social justice in an interactive environment. One design goal was to create a single interaction model that would support all three content sets. The interaction model is the mapping layer that relates body-based input actions to changes in

displayed images and sounds. Each interaction model uses the balance metaphor to map input body positions, reflecting different states of bodily balance, to changes in output imagery and sounds, depicting various degrees of balance in each social justice issue.

A second design goal was that the environment should support the user to both move and think without privileging one modality more than the other. For example, input movements should not be too difficult or to trivial to enact. Similarly, changes in output images and sounds should be fairly easy to perceive and interpret (while moving). A related design goal was that the environment should support both imbalanced and balanced bodily states without causing physical harm to participants.

Values

Concepts of balance in social justice are value laden and subjective. We have chosen issues and related themes that can be conceptualized along a continuum using the twin-pan balance schema. We designated the position on the balance spectrum for each image through a collaborative triangulation process involving image sorting by three researchers working on the project. Our design objective is to support users to explore these issues visually in order to evaluate usability and experiential factors through comparative experiments (as in [1]) and phenomenological reports. It is not necessary that users agree with us on what a balanced solution to a particular issue is.

The Springboard Interactive Environment

The Springboard environment supports users to interactively explore representations and sounds related to three social justice issues. The active input space is a small raised platform (132 x 71 x 20 cm) made from a crib mattress spring, board and black cloth (figure 2). Since standing in a balanced way is a normal state for most adults we required an input space that upset this balance but not so much as to focus the user away from the display space. When a user steps onto the platform, their centre of gravity becomes immediately, slightly out of balance since they will likely wobble on the platform. The rectangular design of the platform also supports lateral movement. By moving left or right, the user can also be out of balance spatially and the design of the platform ensures that it is even more wobbly at the edges than in the centre. States of bodily balance are determined as users move their body's centre of gravity and spatial position on the springboard input platform.

figure 2. Springboard input platform.

The bodily balance of the user is determined using a blob tracking and analysis computer vision system developed in the Max/Jitter programming environment. The participant stands in front of a black background on the black platform. This setup allows a simple background subtract process to be used to isolate to participant's image. The total balance of the participant is calculated using a body centre of gravity balance

figure 3. Springboard input and image display space.

index and a positional balance index. The two indices are combined using a scaled addition process, producing the total balance index that ranges from -10 to +10 where 0 reflects a completely balanced body state. The total balance index is used to control the image and sound reasoning and display engines.

A description of the image engine follows. Each of the social issues is divided into three themes. For example the food allocation issue has themes: agricultural production, health and nutrition, and culinary aesthetics. Each theme is represented on one of three vertical screens as shown in figure 3. For each theme, a set of images depicting different aspects of that issue were sourced and tagged through a collaborative sorting process, and placed in five numbered bins. Bins range from too much (1) to too little (5) with a central bin (3) for balanced. Each bin contains several images to support variation and multiple interpretations. The display engine uses the current value of the total balance index in a random process controlled by a bell distribution curve to select images from the five bins. The center of the curve is determined by scaling the data from the total balance index to a floating point index from 1 to 5. The deviation of the bell curve is set so that when the control index is at x.0 the engine presents images only from that bin. So if the index is at 3.5, the engine will display images from bin 3 and bin 4 with equal probability. Images in all three screens synchronously fade in and out as the user's body position changes. Users' movements in and out of balance trigger metaphorically related changes in the image and sound displays.

The sound feedback for Springboard utilizes several approaches to representing the concept of balance through sonic aspects. It provides constant ambient information, responding to and guiding user actions. The obvious choice of a left-right channel panning was discarded. Panning is a representation of balance based on a cultural invention associated specifically with the technology of headphones. It is not based on a metaphorical extension of bodily or perceptual sonic balance. In addition, panning does not provide a clear resolution of change. We focus on more primary perceptually-based sound parameter changes such as pitch, timbre and phase, in order to achieve a sense of sonic balance.

Discussion

Designing an interaction model and implementing the sensing and reasoning system based on an embodied metaphor is difficult and relies on several simplifying decisions. The choice to use the twin-pan balance schema was driven by the focus on justice in which the scales (twin-pan) are a dominant concept. The choice of sensing user's centre of gravity and spatial location on the platform in order to determine states of bodily balance was largely driven by body-storming exercises and exploration of different structures that would cause users to move in balanced and unbalanced ways. The classification of images into five bins (rather than three or seven) was chosen to ensure that the environment is interesting and yet not difficult to understand and interpret. Similarly, the decision to have three themes depicted on vertical screens was a compromise between promoting engagement and supporting ease of interpretation. The screens were placed vertically to avoid any overt reference to the horizontal arms of a scale since images represent a single balance state at each point in time. All of these decisions have implications for use and interpretation of the environment and the strength of knowledge claims made in future experimental work.

Future Work

Future user studies will be required to test and tune the prototype before experimental work can be undertaken. For example, we are currently conducting workshops to finalize the sound parameter design. The goal of our future research is to use Springboard as a research instrument for comparative experimental and phenomenological user studies where we investigate the benefits of using embodied metaphors in an embedded computational system that is accessed using full body movement and represents abstract concepts.

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