An embodied cognition framework for interactive experience

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(Received 3 September 2006; in final form 4 December 2006)

Interactive art is, by its very nature, concerned with audience experience. The interaction is the essence the meaning of the work to the participant. An embodied cognition framework may be used to explore individual's cognition within a cognitive system while he or she is engaged in an interactive art experience. A cognitive system is identified as a system of interactions between the participants, the tools and the environment engaged in the experience. The aim of this paper is to characterize a person's interactive experience of different artworks using an embodied cognition framework in which bodily interaction, thought and perception of feedback are examined. The protocol analysis used to characterize participant experiences is shown to be an appropriate method for investigating interactivity in the art context. The results showed that identifying the presence of interactions between body and feedback, body and thought and thought and feedback provides an effective way to characterize each artwork experience. We discuss how these modes of interactions can be used as a measure for investigating other interactive artwork experiences in future work.

Keywords: Interactive experience; Embodied cognition; Body; Thought; Feedback; Video-cued recall

1. Introduction

Interactive art is, by its very nature, concerned with audience experience. The participant goes beyond looking or listening and we cannot describe what happens just in terms of what the see or hear. We can only describe it in terms of what they experience. The interaction is the essence the meaning of the work to the participant. Audience experience is a key issue in all art, but in the case of interactive art it becomes the overriding issue.

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One interesting question about audience experience with interactive artworks is how the human mind constructs the experience. The participant has a conscious experience of ongoing active involvement in the interaction. Pyke and West (2001) point out that this interaction includes awareness of the information exchanged itself, as well as intentional initiation and interpretation of exchanges. An example scenario for a participant’s interactive art experience would be: ‘When I walk into the interactive art environment, I start to do something to the environment; my presence is changing the environment. What is going on inside my head is situated, depending on where I walk to, how I move my body parts, where I choose to look at, what features of the environment I pay attention to and how I perceive and understand the changes in the surroundings. My body is involved in this interaction as much as my thoughts and perceptual experience’. Note that this is one view of how a participant may construct her or his experience. The description of the cognitive experience is very similar to that of Hutchins’ (1995) definition of ‘cognition in the wild’ which has been highly cited in human–computer interaction studies. This view emphasizes that conceptualization and analysis of cognition in real settings would be different than the cognition explored in experimental settings. The agent (human) is not sitting in a laboratory as in the case of psychology experiments doing the several versions or transformations of the same task in an order. The agent is in the world; his/her actions, perceptions, reflections and the circumstances are constructed on the go, which means the cognition we talk about is situated. The context where the experience takes place matters, social interactions and circumstances does matter (Clancey 1997).

When we talk about cognition, it is important to identify cognitive processes or inner representations. Nakashima et al. (2006) defined a cognitive system as a system of interactions between a human (agent) who has thoughts in mind and the surrounding environment: ‘S/he perceives something from the environment, has thoughts in mind and does something to the environment’. These processes are not sequential; rather perception, thought and action occur in coordination affecting each other as postulated by the situated cognition theory. Cognitive process refers to the interactions within the system, including the ‘thoughts’ in the mind and interactions between the human (agent) and the surrounding environment. The body is in interaction with the environment and bodily interaction involves primarily and actively constructing thoughts (mental processes). The environment is responsive: when it produces feedback, the agent perceives and interprets the feedback. Thinking governs all the interactions, selects from many possible interactions, gives meaning to the interactions and, therefore, shapes what the agent chooses to experience with the artwork.

In order to understand interactive experience we propose an embodied cognition framework that takes into account the bodily interactions, perceptual exchanges between the agent and the surrounding environment. The next section gives a brief overview of how embodied cognition was emphasized in cognitive psychology, human computer interaction and design research.

2. An embodied cognition framework

Polanyi (1967) states ‘the body is the ultimate instrument of all our external knowledge, whether intellectual or practical... experience is always in terms of the world to which we are attending from our body’ (p. 15).

Following Polanyi, we aim to understand the nature of the interactive art experience by adopting an embodied cognition perspective. When we talk about embodied cognition,
we suggest that the body plays an essential part in constructing perceptual and mental processes and the interactions within the environment itself. Experimental psychology and cognitive science have traditionally viewed the mind as an abstract information processor where the connections to the surrounding environment are of little importance. Perceptual and motor systems were considered to serve as peripheral input or output devices that are not relevant to understanding the central cognitive processes. Consequently, experimental psychology neglected cognitive processes altogether. An embodied cognition viewpoint commits to the idea that ‘the mind must be understood in the context of its relationship to a physical body that interacts with the world’ (Wilson, 2002, p. 625). This means that our cognitive activity consists of immediate on-line interaction with the environment. Wilson also states that, ‘human cognition rather than being centralized, abstract and sharply distinct from peripheral input and output modules, may instead have deep roots in sensorimotor processing’ Wilson (2002, p. 625). Therefore our physical bodies play a central role in shaping the mind which involves human experience in the world, understanding the world and interactions in the world.

The connection between thinking and doing is an important issue in design research where a similar view of bodily activity as essential to understanding human cognition is recognized. The concept of reflective practice (Schön 1987) points to a reflective conversation between the designer and the design medium, which emphasizes thinking through doing. For example, during a sketching session, a designer sees what is in a representation, draws something in relation to it, sees what has been drawn there and further constructs new meanings; in this way the design is developed (Schön and Wiggins 1992). The view of designing as a ‘reflective conversation’ as described in the paper of Schön and Wiggins has been appropriated as a term to refer to the interactive nature of the design process. Design researchers further explored cognitive mechanisms that are related to this dialogue (Goldschmidt 1991, Goel 1995, Suwa and Tversky 1997). Suwa et al. (1998) developed a coding scheme to represent the ‘reflective conversation’ in terms of micro-level action codes which may be dependent on each other. According to this model, physical actions demonstrated by a designer are parallel to perceptual actions and they both are dependent on each other as emphasized in the situated cognition theory and in Schön’s ‘seeing – moving – seeing cycle’ (Schön 1987). During this cycle, the designer attaches a meaning to the drawn elements which is referred to as the function of the element (functional actions). The construction of meaning through drawing is assumed to be supported by two other classes of cognitive activities: conceptual and recall activities. Conceptual actions include planning of actions (setting up goals) and appreciative judgements of quality; while recall actions include recollecting previous knowledge and experience.

Klemmer et al. (2006) discuss how the body matters in interaction design. Two of the themes they discuss are relevant to this paper: first, the concept of thinking through doing as in Schön’s reflective conversation argument (Schön 1987), and second, how human performance is influenced by how our bodies learn to do things. They argue that ‘designers are capable of incorporate an artefact into bodily practice, to the point where people perceive that artefact is an extension of themselves, they act through it rather than on it’ (Klemmer et al. 2006). For example, expert architects acquire action-centred skills, such as the ability to design via sketching, which is a learned bodily practice. This suggests that sketching becomes unconscious expert behaviour, such that these experts can act via simulating the knowledge learned by their bodily practice. When expert architects were forced to only think/imagaine, rather than thinking by doing, they were able to re-recreate a reflective conversation with the situation as if they were thinking by...
doing (Bilda et al. 2006). Similarly we are able to sense, recall our bodily positions and
movements through the motor/kinaesthetic memory that is involved in how to ride a
bicycle or how to navigate spaces we have never seen (Franklin and Tversky 1994).

In this paper, we analyse the experiences of interactive artworks by participants by
coding their interactions within the embodied cognition framework. Next section
describes a series of studies to evaluate audience experience with interactive artworks.
This includes overview of interaction, where each interactive experience took place, the
participants involved in the studies, as well as how the data are collected and analysed.

3. Method

3.1 Interactive artworks and participants

Studies of the three interactive artworks were conducted at Beta-Space between
November 2004 and February 2006 (Beta-Space 2006). Beta-Space is an experimental
exhibition space for interactive art situated within a large science and technology museum
in Australia. The space is curated by members of the Creativity and Cognition Studios
(CCS), a multi-disciplinary practice-led research group in digital media and the arts.
Beta-Space provides a public context for artists and technologists to conduct research
into artworks prior to final completion.

Each study was conducted on a single interactive artwork, each of which was produced
by a different artist. Three studies which are in the scope of this paper are based on the
works: Cardiomorphologies, Iamascope and Absolute 4.5 (see figures A1–A3 in the
Appendix).

- Interacting with Cardiomorphologies creates dynamic visuals that are triggered by
  heart-rate monitor connected to the body. Participants are encouraged to use the
  work as a feedback system to observe and experiment with their own breath and
  heart-rate patterning.
- Interacting with Iamascope creates kaleidoscopic images that are triggered by
  movement in front of a video camera. The kaleidoscope reflects back an abstract
  portrait of the participant and the speed and frequency of the participant’s move-
  ment produces a varying range of musical notes to accompany this changing
  image.
- Interacting with Absolute 4.5 creates a change in the grid of colours on a large
  screen accompanied by a complex sound track and controlled by a generative set
  of rules carried out by a computer. As the audience approaches the screen Absolute
  4.5 detects their presence through sensors in the floor. Aspects of the system’s
  behaviour, such as its rate of change, are influenced by audience behaviour in the
  space.

In the first study, five participants took part in the Cardiomorphologies experience: a
female who is in equipment business, a clinical psychologist (male), a curator (female), a
social worker (female) and a support worker (male). In the second study, three
participants were engaged in the Iamascope experience: an English/history schoolteacher
(female), an actor (male), and a part-time student (female). In the third study, four
participants were engaged in the Absolute 4.5 experience: a drummer/web designer who
teaches at a university (female), a video artist who teaches at a university (male), a cellist
who teaches music (female), and an animator/double bassist (male).
3.2 Methods of data collection and analysis

The method of data collection employed in these studies was video-cued recall, a technique which involved collecting participants' reports of their thoughts about their primary experience of the interactive artwork. The video-recording of each participant's behaviour in the interactive artwork environment was shown to them immediately after their experience as visual cues for recalling their experience. This method has been used and proved to be useful for understanding situated experience of interactive art and how meaning is generated in situated experience (Bilda et al. 2006; Costello et al. 2005; Muller et al. 2006).

Protocol analysis is used as a method to analyse verbal and behavioural data. Interactive art experience protocols involve both types of information: the behaviour of the individual interacting with the artwork and her retrospective report (verbalizations) of what was on her mind during the primary experience. Interactive experience protocols were coded and analysed with the use of a single coding scheme (Bilda et al. 2006) in order to maintain a rigorous and replicable analysis process. The generic coding scheme (Bilda et al. 2006) represented codes under seven different categories which are: observed actions of body parts, purpose of the actions, self states, object of attention, perception, concepts/goals/evaluations and recall. All interactive experience protocols were coded with the coding scheme described in Bilda et al. (2006). The following sections describe the use of video analysis software for coding data and the procedures for the protocol coding process.

3.3 Software support for video analysis

The video-cued recall method of data collection produced a large amount of data for analysis. The analysis software, INTERACT, was used because it allowed video data to be analysed together with transcribed documents (INTERACT 2006). It also supported a collaborative analysis process by giving each analyst access to the segmented protocol, its associated video piece and any associated text within the one interface (figure 1). In our research into interactive art experience, we were particularly interested in observing any behavioural patterns that occurred across the whole timeline of an experience. With INTERACT it was easy to either obtain a mapping of the behavioural patterns along a timeline of the activity or to view the percentage of time spent in each coding category.

3.4 Coding process

Each video showing the retrospective reporting of the interactive art experience was coded by two different coders. During the individual coding process, the analyst validates the segments in numerical order by both listening-viewing the audio-video recorded data as well as reading the transcripts of the segments. Based on his or her understanding of the content of the segments and the coding scheme, each segment is assigned with a code from the coding categories. After both analysts finish the individual coding, they combine their results in a joint arbitration process.

Comparing different coding is essential in order to handle the congruence in data analysis. In the protocol analysis literature, this is referred to as 'inter-coder reliability'. After each analyst codes the protocol, two sets of coded lists are produced (see figure 2). In order to achieve the final protocol, a process of arbitration is used. In the arbitration
Figure 1. Coding with INTERACT.

Figure 2. Using INTERACT for arbitrating the codes.
process, the two analysts meet face-to-face to compare their protocols. The analysts consult the transcriptions and refer to the audio-video data when it is necessary in order to clarify the subject's actions and intentions as well as to reach an agreement on each other's coded lists. When there is a disagreement, each coder will offer reasons for his/her results and by a consensus approach the arbitrated results will be achieved. A description of the process in detail may be found in Bilda et al. (2006). The practical outcome of arbitration is the final protocol agreed by both coding analysts. Beyond this practical outcome, arbitration is also a negotiation and learning process for all analysts. Through this process, a coder gains the opportunity to see other analysts' approaches to understanding and analysing the protocols and the coding schemes.

Inter-rater reliability was measured by Kappa (Cohen 1960), a measure where 1 refers to total agreement for all codes, 0 refers to no agreement. INTERACT software calculates Kappa values by comparing the first and second analysts' coded lists, or comparing the arbitrated coding list with either of the analysts' coded list. Table 1 presents the average reliability Kappa values for each coded experience within the three cases (artworks). Table 1 shows that Kappa values for all coded data were between 0.6 and 0.8, which are acceptable values for agreement of the coded data.

The arbitrated coding list represents the interpretations of the analysts as codes, wherein these codes are converted to numbers. From this point on, the qualitative enquiry is converted to a quantitative one. INTERACT calculates and documents how much time is spent on each action. This gives us duration of each action, thought, state or perception observed and reported in the interactive art experience videos. The following analysis of the coded data is based on exploring duration percentages of codes and searching for patterns of how actions/behaviours occur together.

4. Analysis of the coded data

An embodied cognition framework provided us with three important indicators to search for in an interactive art experience. In this framework, a system of interactions was identified between a human (agent) who has thoughts in mind and the surrounding environment. From this definition, we postulated that there are three types of interactions between the three components. The components are:

1. Body—agent’s bodily interactions with the environment,
2. Thought—agent’s thoughts,
3. Feedback—agent’s perception of the feedback from the environment.

Accordingly, we identify three types of interactions which are between Body and Thought, Body and Feedback, Thought and Feedback.

<table>
<thead>
<tr>
<th>Table 1. Inter-rater reliability (Kappa values) of coding.</th>
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<tbody>
<tr>
<td></td>
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<tr>
<td>P1</td>
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<td>P2</td>
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<td>P3</td>
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<tr>
<td>P4</td>
</tr>
<tr>
<td>P5</td>
</tr>
</tbody>
</table>
Table 2 shows how body, feedback and thought components relate to our previous
coding scheme (presented in Bilda et al. 2006). These three indicators are re-coded based
on the arbitrated coding lists. ‘Body’ refers to observed moves and the sensation/awareness of body parts in the generic coding scheme. ‘Thoughts’ refer to concepts/goals/evaluations and recall categories. ‘Feedback’ refers to perceptions (of image, sound or both) in the generic coding scheme (Bilda et al. 2006).

### 4.1 Body, Thought, Feedback

1. **Body**: Body contributor shows that the participant’s focus has been on her or his body during the interactive experience. Body also refers to the body awareness of the participants, in terms of sensing changes in the body, sensing parts of the body. Body is an integral part of the cognitive system, and it becomes the input to the interactive art system during this experience. ‘Body’ is re-coded when the sensors of the interactive art system are activated by the body (parts) or when body awareness is reported by the participants.

2. **Thought** refers to participant’s thinking. We refer to all mental processes as thought, including:
   1. Production of meaning, metaphor, concepts, abstract relationships
   2. Planning
   3. Learning
   4. Recalling images and knowledge
   5. Explicit thoughts about relations between the movement and usage of body parts
   6. Evaluation of perceptual information

   The ‘Thought’ component shows that a participant’s focus is on her/his thoughts during the interactive experience, identified above as the six types of thoughts.

3. **Feedback** refers to participant’s understanding and perception of the visual and auditory changes within the interactive artwork environment. Feedback contributor shows that the participant’s focus is on the feedback coming from the system as a result of her/his interaction. When a change is reported in the visualization or sound (or other feedback) components of the system by the participant, this contributor is coded.

Figure 3 shows an example of how the Body, Thought and Feedback components of interactive art experience are represented. The left of the chart represents the start of the session; the right of the chart represents the end of the experience. Each horizontal bar of Body, Thought and Feedback shows the duration of each component along the timeline of the session.

<table>
<thead>
<tr>
<th>Components</th>
<th>Related categories in the generic coding scheme (Bilda et al. 2006)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body</td>
<td>Observed movements/actions of body parts + Sense (when it is body awareness)</td>
</tr>
<tr>
<td>Thought</td>
<td>Concepts/goals/evaluations + Recall</td>
</tr>
<tr>
<td>Feedback</td>
<td>Perceptions (of image, sound or both)</td>
</tr>
</tbody>
</table>
4.2 Interactions of body, thought and feedback

Interactions between Body, Thought and Feedback have been identified as concurrency of these components in the coded data. For example, when body and feedback co-occurs in the same period, then this indicates body-feedback interaction, the rectangular shades in figure 3 shows co-occurrence of body and feedback.

The concurrency of components is interpreted as the following.

- Concurrency of Thought and Feedback: thinking is involved in creating/understanding the feedback or feedback is involved in shaping/triggering the thinking. For example, in some cases, if what the audience inputs for a change in the system is NOT what the audience directly perceives as feedback, then this would trigger concurrence of feedback and thought.
- Concurrency of Body and Feedback: if what the audience inputs for a change in the system is what audience perceives as feedback, there is a strong dependency between the two.
- Concurrency of Body and Thought: thinking is involved in order to create and understand the bodily input and bodily input triggers further thinking. For example, in some cases, if participants have a chance to choose their input to the system and therefore thinking may be involved for creating this input, then we observe a concurrence of body and thought.

5. Results

This section provides a summary of the results of analysing the three interactive works under consideration: Cardiomorphologies, Iamascope and Absolute 4.5.

5.1 Body, Thought and Feedback components

**Body**: for the Cardiomorphologies (Muller et al. 2006) experience, the heart rate sensors were connected to participant’s body in which physiological changes, such as breathing in/out faster or slower, being in excited or clam states etc., were the input to the system. For this specific interaction, a participant’s body awareness and perception of somatic responses were the indicators for understanding what they input to the system. For the Iamascope work (Costello et al. 2005, Fels and Mase 1999), an overhead camera captured a participant’s images during his or her movements in the space as input to the system. For the Absolute 4.5 work (Edmonds 2006) pressure sensitive floor pads in the room were activated through participant’s body movements. Although the three artworks were concerned with a bodily interaction as input to the system, in Absolute 4.5, there was no direct interaction with body.

**Thought**: for the Cardiomorphologies experience, the thoughts were dominantly in the form of recalled scenes/images related to past experience or construction of future
experience via imagination. The participants were aware of the fact that their thoughts could make a difference in their physiological states; therefore they were using their thoughts to generate states. For the Iamascope experience, participants’ thoughts were mostly in terms of evaluating the perceptual information, they heard and saw. For the Absolute experience, participants’ thinking was more about goals and evaluations.

**Feedback:** for the Cardiomorphologies experience, the feedback was in terms of dynamic changes in visualization and sound. The role of the artist here was to explain different types of feedback to the participant as they occur along the timeline of the experience. The participant constructively learned about how the feedback can be interpreted as s/he interacted with the artwork. In the case of Iamascope, the feedback was in terms of changing kaleidoscopic image on the screen as well as the musical notes creating a sonic accompaniment to the flow of images. For Absolute 4.5, the feedback was speed of the change of two-dimensional coloured bars specified as co-ordinates, along with synthetic sounds that occupied temporal positions.

### 5.2 Interactions between Body, Thought and Feedback

Finding commonalities or differences across the cases may help us to characterize the interactive experience in each case. In order to this, we have analysed the instances where Body, Thought and Feedback components co-occur with each other along the timeline of each experience.

Table 3 shows the co-occurrence percentages of input, thought and feedback contributors for the three interactive artwork experiences. Table 3 shows percentages of Thought & Feedback, Body & Feedback and Body & Thought concurrency percentages.

For Cardiomorphologies, it can be observed that the instances of Thought & Feedback co-occurrences existed for all participants. This indicated that Thought-Feedback

<table>
<thead>
<tr>
<th>Cardiomorphologies</th>
<th>Thought &amp; Feedback (%)</th>
<th>Body &amp; Feedback (%)</th>
<th>Body &amp; Thought (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>2.3</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>P2</td>
<td>3.8</td>
<td>n/a</td>
<td>1.2</td>
</tr>
<tr>
<td>P3</td>
<td>2.4</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>P4</td>
<td>7.6</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>P5</td>
<td>18.4</td>
<td>18.9</td>
<td>3.0</td>
</tr>
<tr>
<td>av</td>
<td>6.9</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Iamascope</th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>n/a</td>
<td>25.0</td>
<td>n/a</td>
</tr>
<tr>
<td>P2</td>
<td>10.2</td>
<td>16.1</td>
<td>n/a</td>
</tr>
<tr>
<td>P3</td>
<td>n/a</td>
<td>29.7</td>
<td>n/a</td>
</tr>
<tr>
<td>av</td>
<td>–</td>
<td>23.6</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Absolute 4.5</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>21.8</td>
<td>11.8</td>
<td>3.3</td>
</tr>
<tr>
<td>P2</td>
<td>37.3</td>
<td>25.7</td>
<td>37.0</td>
</tr>
<tr>
<td>P3</td>
<td>18.0</td>
<td>23.9</td>
<td>4.0</td>
</tr>
<tr>
<td>P4</td>
<td>2.3</td>
<td>6.6</td>
<td>1.1</td>
</tr>
<tr>
<td>av</td>
<td>19.8</td>
<td>17.0</td>
<td>11.4</td>
</tr>
</tbody>
</table>

n/a: co-occurrence does not exist
interaction was a major phenomenon during the Cardiomorphologies experience. For two of the five participants, we observed input and thought concurrences (P2 and P5) and for P5 all three concurrences were observed. P5's experience can be characterized to be different than the other four participants, since interactions between Thought & Feedback, Body & Feedback and Body & Thought were emphasized. Based on the observation that Thought–Feedback interaction existed for all participants, the Cardiomorphologies experience can be interpreted as one where thinking and imagination created most of the feedback, and feedback created more thinking/imagination. Participants also had to understand and plan how their body would influence the system; in Cardiomorphologies, it was through heartbeat and body awareness.

For the Iamascope experience, Body–Feedback interaction was emphasized the most, i.e. all participants' experiences involved Body & Feedback concurrency (table 3). Only P2 showed Thought & Feedback concurrency additionally. During the Iamascope experience, what the participant input for a change in the system was directly what the participant perceived as feedback. As in the creation of the kaleidoscope, participants realized their bodies and partial bodies were a part of the image and, therefore, there was a strong dependency between the Body and the perception of the image as Feedback.

For the Absolute 4.5 experience, we observed co-occurrences for all participants in the three different categories: Thought & Feedback, Input & Feedback, and Input & Thought. This can be interpreted as:

1. Participants either had to think about how to interpret the feedback or their understanding of the feedback triggered other thoughts.
2. Participants either understood how the input affected the feedback, or they did not understand how the feedback was created.
3. Participants either had to think about how to configure the input for interaction or the way they configured the input triggered more thoughts.

The Absolute 4.5 experience can be characterized as the richest of all three cases, in terms of how different modes of interaction occurred to construct the experience.

6. Discussion

This study shows that an embodied cognition framework applied to investigating the interactive art experience can provide a means to analyse, explore and understand cognitive interactions of participants during an artwork experience. Using an embodied cognition framework, a model for a cognitive system has been derived, whereby cognitive interactions occur between the participant and the surrounding interactive art system. We have identified three components which are Body, Thought and Feedback and three types of interactions between these components: Thought–Feedback, Body–Feedback and Body–Thought.

6.1 On methodology

Protocol analysis methodology proved to be an effective means of exploring and describing the audience experience of interactive art using an embodied cognition analysis framework. The exploration of video-cued recall was achieved by the use of a coding scheme that allows us to interpret verbal and non-verbal behaviour during participant
interactive art experience. Bilda et al. (2006) describes the development of this coding scheme and the potential for generating results. Using this coding scheme, we finalized the coding-arbitration process and then we explored several ways to understand and structure the coded data. We came to the conclusion that 7 categories and 29 codes were a large number for a single coding scheme. The advantage of having an elaborate coding scheme is that the activity is coded on a microscopic level, resulting in a detailed representation. The disadvantage of it is that the represented codes are often highly diffused along the timeline of the experience. The resulting representation in this case does not allow the analyst to see the emerging patterns between the codes. If there were 3 codes instead of 29, it becomes more likely that the codes would be aggregated to demonstrate overlaps and sequential patterns. This was one of the reasons why we aimed to simplify our coding approach and re-code all interactive experience protocols with Body, Thought and Feedback components. This meant that searching for concurrency and understanding the interactions between these components was easier, compared to understanding the relationships between a large number of codes.

On the other hand, the process of coding the interactive experience protocols with an elaborate coding scheme, provided us with a detailed view and understanding of the experience: in particular, it made clear what behaviours, states, thoughts and perceptions occur most frequently. These analyses showed that individual differences, the characteristics of the interactive artwork, the artist’s goals as well as the context in which the artwork is exhibited are all factors to take into consideration for a more comprehensive understanding of audience experience.

6.2 Characteristics of interactive artworks

During the Iamascope experience, the participants’ perception of themselves in the kaleidoscopic visualization was the primary characteristic. That is why Body–Feedback interaction was emphasized the most (table 3). In accordance with this finding, the Iamascope artist, Sid Fels, is said to be primarily concerned with the development of intimacy between a person and an interactive system and that he links the intensity of this intimacy to the different types of pleasures that these object relations can stimulate (Costello et al. 2005).

Iamascope and Cardiomorphologies might be considered to have an emphasis on Body–Feedback interaction in common. On the other hand, the difference between the two interactive systems was that, in Cardiomorphologies, the feedback was to be created through physiological changes in the body rather than a one to one correspondence of body-image relationship as created in the Iamascope. Absolute 4.5 was different from the other two works, in that it does not provide a one to one mapping for body input and feedback. The feedback is initially continuous, and when the participant begins interacting with the system, s/he perceives the changes and then tries to understand how the change was created.

6.3 Individual differences

As stated in section 2.1, the participants who were engaged with the different interactive experiences had quite different profiles. All Absolute 4.5 participants are musicians and have various talents/interests who actively take part in pursuing those interests. We classify these participants as experts. They may have a better understanding of the artistic context or a strong motivation to find out about an artist’s intentions. We can speculate
that these factors might have encouraged these experts to be engaged with the artwork experience in a different way to that of other participants. This may be one of the reasons why the Absolute 4.5 experience characterized as the richest in terms of modes of interactions. Similar richness in modes of interaction was observed for P5 in Cardiomorphologies (i.e. all three types of interactions between Body, Thought and Feedback were observed). P5 is a curator and can be classified as an expert, who could be expected to have a strong motivation to understand and to engage more actively with the artwork.

7. Conclusions

The three case studies analysed so far have provided some interesting indicators of the nature of audience’s interactive experience. The issues that have been identified from the analysis of the interactive experience have generated more specific research questions that will be addressed in the ongoing research. From the discussion above, for example, we can ask:

- How do we better identify the emerging patterns of experience in time? How do we see the emerging patterns between the codes?
- Can the differences between the concerns of interactive artworks be more fully articulated? Can we identify a more complete taxonomy of feedback and audience interaction concerns?
- There are different kinds of audience that different artists seem to address. Can we understand this better and target future research to study the experiences of different audiences?

The analysis of the interactive art experience for the three different cases shaped our understanding of each of the individual interactive experience. These three cases of interactive experiences can be characterized as follows.

1. The Cardiomorphologies experience is primarily based on co-occurrence of Thought and Feedback. This finding is in accord with the desired/expected state of the artwork: that the thoughts will create a change in the physiological state and this will affect the feedback in return.

2. The Iamascope experience is primarily based on co-occurrence of Input and Feedback. This finding is in accord with the desired/expected state of the artwork; that the artwork system (feedback) and body will create different types of embodiments between the two.

3. The Absolute 4.5 experience is primarily based on co-occurrence of three different combinations of the three contributors: Input, Thought and Feedback, which means the artwork stimulates different modes of interactivity. The Absolute experience can be characterized as the richest of all three cases, in terms of how different modes of interaction occurred to construct the experience.

Acknowledgements

The authors are grateful to the other artists whose work was studied, Sid Fels and George Khut, and to the audiences that cooperated with the studies. Beta-Space is a collaboration between the Creativity and Cognition Studios (CCS) and the Powerhouse Museum, Sydney. We are most appreciative of the support from the Powerhouse and, in
particular, for the tireless enthusiasm of curator, Matthew Connell. Lizzie Muller is the CCS curator for the space and has been largely responsible for successful mounting of the artworks in it. She has also made significant contributions to data collection and analysis. Brigid Costello and Shigeki Amitani also contributed to the evaluation studies. The research work was partly conducted within the Australasian CRC for Interaction Design, which is established and supported under the Australian Government’s Research Centres Programme. Related work was reported by many of the researchers and artists involved with Beta-Space in CoDesign 2(4).

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Appendix

Figure A1. Cardiomorphologies experience.

Figure A2. Iamascope experience.
Figure A3. Absolute 4.5 experience.