Exploration and Reflection in Interactive Art: Glass Pond

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ABSTRACT

Glass Pond is an interactive artwork designed to engender exploration and reflection through an intuitive, tangible interface and a simulation agent. It is being developed using iterative methods. A study has been conducted with the aim of illuminating user experience, interface, design, and performance issues.

The paper describes the study methodology and process of data analysis including coding schemes for cognitive states and movements. Analysis reveals that exploration and reflection occurred as well as composing behaviours (unexpected). Results also show that participants interacted to varying degrees. Design discussion includes the artwork's (novel) interface and configuration.

Author Keywords

Evaluation, coding scheme, pilot study, exploration, reflection, Glass Pond, interactive art, composing, modelling, gesture, sand, tangible user interface.

ACM Classification Keywords

H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems--- Artificial, augmented and virtual realities, Evaluation methodology; H.5.2 [Information Interfaces and Presentation]: User Interfaces---Evaluation/methodology, Haptic I/O, Input Devices and Strategies, Interaction styles. I.3.6 [Computer Graphics]: Methodology and Techniques--- Interaction Techniques. I.3.8 [Computer Graphics]: Applications. J.5 [Arts and Humanities]: Fine Arts.

INTRODUCTION

The interactive artwork Glass Pond, by the first author, is designed to encourage certain behaviours in its participants as informed by the aesthetic intent of the work. A study of interaction with the work has been conducted to inform subsequent iterations and analysis.

The creation of a series of interactive artworks using iterative methods is exemplified by Edmonds' *Absolute_4.5* and *Absolute_5* (Edmonds et al., 2005; Edmonds, 2006). In this development, the work was first shown to the public in a 'beta test' mode and evaluated before final completion. Technology's role in creating interactive artwork and the relations between artwork,

artist and participant are pursued in (Candy et al., 2002; Edmonds et al., 2004).

Glass Pond Origins and Aims

Glass Pond comes out of site studies at an artist-in-residency program in the U.S.A. Here the primary formative activities were exploration and reflection: traversing the landscape and pausing by a pond to reflect and explore on a smaller scale. The artwork is designed to elicit a similar experience and behaviour from participants i.e. slow, reflective exploration. Two design features support this: the interfacing method and a simulation component which adds environmental complexity, helping to maintain participant interest. Lastly, the work's visual elements are informed by an interpretation of the site's natural environment.

Research Aims

A study was conducted with the aim of illuminating the aesthetic intent of the work. Of particular interest is any occurrence of reflection and exploration in the user's experience. System configuration, design and interface issues were also investigated as they support user experience. As stated, outcomes from this study will inform future iterations and analysis of the artwork.

Figure 1 Glass Pond detects regularities in past gestures in the sand to render mimicking patterns, such as at left

GLASS POND

Set-up and Technology

A sand tray, approximately 100cm long x 70cm wide and 15cm deep has a blue bottom and is filled with wet brown

river sand, of medium coarseness. It is located at table height in front of a projection screen on which computer generated and video imagery is displayed. The system also has a non-interactive sound component. Video sensing registers any clearings in the sand. The projection screen image renders a plan view of the sand tray: i.e. clearing sand on the left side of the tray will affect imagery on the left side of the screen. The participant is free to move the sand around on the table and, through this mechanism, interact with the work. Sand has been used in non-computer mediated ways as 'sand therapy' in psychology. As a passive haptic interface, it has also been used in topographical applications such as the tangible computing research of (Ishii et al., 2004). Here the application of art to drive an exploratory and visually expressive experience distinguishes this work.

Glass Pond Interaction Experience
Sand is used as an interface for the participant with which to interact with the work. This work is unlike many other video sensor artworks and artificial reality research such as *Shadow Garden* (Simpson, 2002), *Text Rain* (Utterback et al., 2000) and *Videoplace* (Krueger et al., 1985) in that within Glass Pond the participant has a tangible, haptic interface and leaves trails of their movements; described as "*pushing pixels*" by one study participant (participant 6).

The participant can be said to interact with an abstracted history of their actions, rendered as two types of visual imagery: 'dappled light' and 'pattern'.

Glass Pond Visual Elements
The 'dappled light' imagery corresponds to clearings of blue in the sand while black (shadowy) screen areas correlate to those areas covered in sand. It renders the 'plan' view described above, locating the participant in relation to the screen. Marks in the sand correspond to areas on the screen, rendered as 'dappled light', in real time.

The second type of imagery is generated by a simulation component which discerns regularities in previously detected gestures to create three-dimensional forms or 'patterns'. These patterns are based on the previously rendered dappled light imagery. This pattern imagery is a more abstract and delayed form of system response. It is not immediately predictable nor does it always correspond directly to a gesture. It can, however, stabilise and exhibit patterns of continuity over time. It is rendered in two ways. Firstly, they are rendered transparently as a series of 'ghosting' forms or potential solutions that flicker across the screen as they are replaced by other potential solutions. The flickering solution detection occurs immediately after a gesture is detected. It extends for 6 six seconds when it is replaced by a dominant solution or pattern that is rendered opaquely. The flickering is absent until a new gesture occurs, at which time a new dominant pattern will once again be computed to eventually replace the current one. Thus the opaque, dominant pattern renders every 6 seconds or 6 seconds after a gesture, in a repeating and overlapping cycle.

THE STUDY
Three experimental methods were used: video recording of participant interaction (later analysed), an open-ended interview, and a paper based questionnaire.

Protocol
Prior to commencement of the study the participants were asked to sign consent forms. The study took place at an art studio with only the participant and the interviewer present. The total session length averaged 30 minutes.

Interaction
Each participant commenced with the work in a set 'starting condition' and without any guidance or introduction[1]. A participant interacted with the work for up to 20 minutes. A video camera recorded the interaction so that the interviewer did not need to observe directly and could instead remain at a table across the room. This limited observer influence on participant behaviour.

Interview
The open-ended discussion which ensued provided the opportunity to make comments about the work as well as asking questions of the artist/interviewer. The interviewer made notes during this discussion which was also recorded with a microphone. The paper based questionnaire followed last.

Questionnaire
Openly framed, the questionnaire's 6 questions solicited information on participant observations, interpretations and experiences of the work. Feedback on set-up and materials was also requested.

Participants
The study comprised seven participants, male and female, between the ages of 25 and 50.
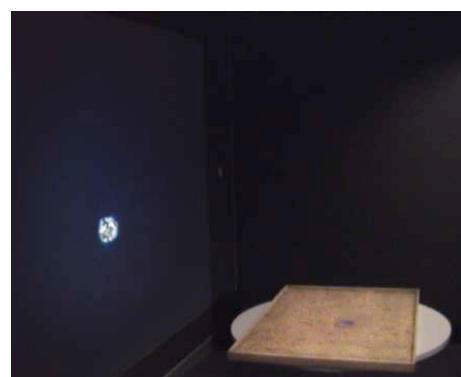
Starting Condition

Figure 2 The starting condition

A screen displays a projected image behind a table with a tray of evenly spread, wet sand. In the centre of the sand a

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[1] Except for participant 5 who knew the interface was sand and participant 6 who had experience with an early prototype of the work.

small circle reveals the blue bottom surface of the tray. The image on the screen is black except for a small, central circle of dappled light imagery. It is intended that a participant correlates the circular parting in the sand to the circle of dappled light in the centre of the screen.

Data Analysis

The aim was to find a set of high-level categories common to all profiles, i.e. a coding scheme; which would illuminate the research aims.

Video recordings of the participant interaction and audio recordings of any comments were transcribed. Descriptions of movements and screen images resulted. Questionnaire and interviewer notes were added to these transcriptions to compile a profile for each participant. For each participant their actions and any events were summarized, in chronological order. Other items such as comments and visual responses were located alongside these. Further analysis decomposed participant actions and comments into movements, gestures and intentions. Patterns of interaction and system response started to emerge.

Coding Schemes

Analysis led to the distillation of two coding schemes: Movements and Cognitive States. This follows the work by (Costello et al., 2005) in their analysis of the interactive art work *Iamascope*.

Master Code	Sub-Codes	Includes
Assessing System	Working out how to work it.	Visually inspecting; Probing; Tapping.
	Identify limitation.	Testing resolution, 3D input, and real-time performance.
	Completed interactive possibilities.	Gestures as image; Engaged with patterns in a feedback loop.
Refer to self	Identity reference.	Correlate body space to screen space; Recognised hand or arm.
	Self Conscious	Discomfort.
Response	Positive.	
	Negative.	
Described behaviour	Play.	
	Goal or Aim.	Looking for something; composing.
	Feel in control.	Reveal image; Understand what makes the patterns appear; predict them.
	Decide to leave.	
	Clearing	Revealing
	Covering	Obscuring; resetting
	Feeling	Touching

Table 1 Cognitive State Coding Scheme

Cognitive State Coding Scheme

Relevant master and sub-codes from the Cognitive States Coding Scheme of (Costello et al., 2005) were combined with additional sub-codes *clearing, covering, feeling* and *self-conscious*. These captured this study's aims and the interaction behaviour unique to the interface and system of Glass Pond. Table 1 lists the Cognitive States Coding Scheme alongside occurrences observed during the study.

Movement Coding Scheme

Positioning, modelling (sand interaction), non-modelling and interaction postures are master codes within this coding scheme. Table 2 lists the Movement Coding Scheme along with examples of what they include.

A modelling movement is defined here as an elastic, deforming movement where the shape of the objects changes. This follows (Bowman et al., 2004) in distinguishing manipulation that is spatially non-rigid from that which is rigid. Intention behind the movement is not defined within the movement coding scheme (e.g. it could be assessing, exploring or composing an image.)

Master Code	Sub-Codes	Includes
Positioning	Walk around	
	Lean	
	Kneel	
Postures	Look	
	Pause	
Non-modelling	Wave	Raise arms in front of screen.
	Touch surface lightly	Palm glide on sand; palm flat in clearing; still or moving.
	Shake dust off hands	Clap hands; remove jewellery mid-interaction.
Modelling	Stroke	Hand or finger/s strokes; sweeping arm motion; brushing with fingers; trailing fingers.
	Cup	Mound; scoop
	Pick up	Grab; scoop
	Drop	Throw; sprinkle; pour
	Pat	
	Push/pull	
	Dig	
	Mound	
	Repeat a movement	

Table 2 Movement Coding Scheme

RESULTS

Questionnaire responses on the set-up and the sand were illuminating of themselves but also shed light on some behaviour.

Set-up

The set-up was observed to affect the interaction behaviours of the participants: most exhibited a tendency

to interact with the sand while looking down and then stop to look up and view the result/for feedback. The angular distance between the projected image and the sand tray was also commented on as being uncomfortable for the neck. Kneeling and stepping back from the tray were two movements that were observed and later explained to improve field of view since they permitted taking both sand tray and screen in with one glance, something deemed desirable.

A set up which reduces the gap between participant action and system response, as well as the correlating gap between interface and screen image may promote a seamless tactile and visual exploration of the work. Furthermore alleviating discomfort may increase a sense of presence.

Sand

All participants understood that modelling the sand resulted in changes in the system. There was no hesitation in modelling it to clear, reveal or obscure. This is likely due to both the affordance of sand (Gibson, 1979) and the communication of potential relationships between sand and screen image, by the starting condition.

The use of sand was predominantly positive though the tactile sensation afforded by wet sand was debated.

"*I think the sand is great. I'm not sure I like it being wet. I think I might prefer it dry. Because it has much more of a silky feeling then … I think wet sand is something you associate with discomfort, whereas dry sand is something which is sensuous.*" (P2[2])

One participant said she "*didn't really enjoy the feel of the sand*" (P5). Another thought it was "fine" and he liked that it held its form and was "*cool to the touch...though perhaps a bit coarse.*"(P7). Participant 1 described it as "earthy". Participant 4 confided a preference for wet sand given its malleability and resonance with personal experience but said she thought dry sand would be preferable to most people. While favouring the use of sand, the remaining participants also articulated a preference for dry, white sand over the wet, brown river sand. As participant 6 stated: "*Hate wet sand, love dry sand. Don't like to get dirty*". Since participant 5 also stated that she did not like to get dirty this may be why she did not enjoy the feel of the sand.

In addition the wetness of the sand may be discouraging interaction. As participant 6 further states, "*[I] didn't want to keep touching it.*" Generally, dislike of the wet sand was more strongly expressed than preference for it.

All participants exhibited self conscious behaviour, such as shaking the sand from their hands. By returning focus to their hands and away from the artwork, this awareness that their hands are covered by wet sand may be diminishing their sense of presence.

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[2] Participant 2. For brevity, 'P' denotes 'participant'.

Control

Although the participants had no difficulty interacting with the system in terms of modelling the sand to interact with the dappled light imagery, many wished for greater control of the patterns, as well as understanding of what causes them.

"*I think I want a little bit more feeling of controlling them... Obviously I can control the part where the kind of light [dappled light imagery] is. [Gestures] this time I think I can control it, I have a feeling I am controlling this object. But sometimes, I don't know why they appear.*" (P3)

"*I'm not quite sure what makes these red shapes come up. Or what they are.*" (P6)

"*[I do not]... understand why this shape in the sand makes that interesting shape [pattern]?*"(P7)

The inability to directly control, predict or understand the patterns sometimes led to frustration.

"*Just now I have a beautiful thing [pattern] like a 'J', but sometimes it does not really follow my movement. Like I tried to do a – [gestures] – I moved the sand around and I think it was supposed to show a thing like this... but actually it was not so probably I was wrong... And sometimes it's not really pleasant because I try to make something, a beautiful thing with my sand and suddenly this thing pops up on top of my picture and I can't really see the thing that I made...*"(P4)

And "*... sometimes the colour objects [patterns] disturbed me. I couldn't read my name on the screen because of the obstacles, I mean objects [laughter], but that's fine. I kept trying to control those objects – how they appeared on the screen and how I can stop them to appear on the screen. But I think I failed. I still can't control them.*" (P3)

Reflection

Participants were observed to pause frequently and watch the system; or watch intently while making some small movement (e.g. waving their hand slightly).

Participant comments and responses during interaction, interview and questionnaire describe their reflections. Reflections were on the artwork in general, on seeing themselves in the work and on their interaction with the work. Participant 6 commented out loud during initially clearing the sand to uncover the dappled light imagery "*I feel like it's a pool and its revealing...*" Participants 1 and 5 also described their actions as 'revealing'; that of "secret things" according to participant 5. Participants 6 and 4 made comparisons to previous experience. The latter is quite personal and locates dappled light and pattern imagery in the pond metaphor.

"*...It's almost like...you're looking up into a forest canopy and there's something in your way and you clear it to see the view... very satisfying, that big clearing.*"(P6)

"*When I was little I really enjoyed sitting at the side of a pond and there are some leaves on the top of the water*

and you stir the water... yes I just realised it's all shiny, actually... I would I disturb the water, disturb the leaves, maybe this is the thick leaves and this is some pretty thing under the water. The water comes back again and I disturb it again." (P4)

Participants enjoyed seeing their hands as shadows in the dappled light and would place them in cleared blue areas of the sand tray or, more often, wave hands and arms around while watching the screen. Some saw this as an extension of a pond metaphor, with shadowy reflections in the water. Participant 4, for example, commented:

"*... when there is air without any sand and I put my hand on the top of the empty board I can see the shadow of my hand. And it's really pretty. It's not really the shadow it's kind of shiny, it's twisted like really like you see the reflections on the water. So I think that's really enjoyable. Its like the real time you went to the lake and you put your hands there and then you see your shadow of your hand and it's moving.*"

Contemplation of the patterns varied greatly among the participants. Some were able to relate to them and some were not. Participants 5 and 6 expressed dislike and subsequent to a brief initial exploration, ignored them:

"*...they didn't really do much for me...*" (P5)

Participant interaction with the patterns was also explicitly positive and playful, as in the case with participant 2 who created several compositions in both the sand and pattern images. He was observed to interact with the sand while closely watching the screen; vary the tempo of his gestures; pause and watch for pattern imagery and on one occasion burst into surprised laughter. This participant interacted (modelled) by shifting lines of sand with sweeping arm gestures (Figure 3(a)-(c)). He was arguably deeply immersed in his interaction with the system because a gesture in clearing the sand was, at one point, unnecessarily forceful and resulted in nearly pushing the sand tray off the table (Figure 3(d)-(e)). His comments on exiting the work and in the questionnaire included "*Yeah its fun!*" and "*Very engaging – encouraged play behaviour usually reserved for the beach!*" (P2)

Similarly participant 7 was highly engaged and reflected deeply on the patterns. Here he reflects on the meaning of the flickering, ghosting of the patterns as well as their final, more solid form:

"*My reading of these flickering shapes is that they are like reflections on the surface of the water and these things [patterns] are captive or captured like a photograph.*"

Participant 7 also described how reflection on the work informed his actions:

"*[I]...started off just doing anything to just work out what the parameters would be and then started thinking about what was important about the shapes that I made like if it was the size of the shape or the complexity of the shape or wether I could join two shapes together...*"

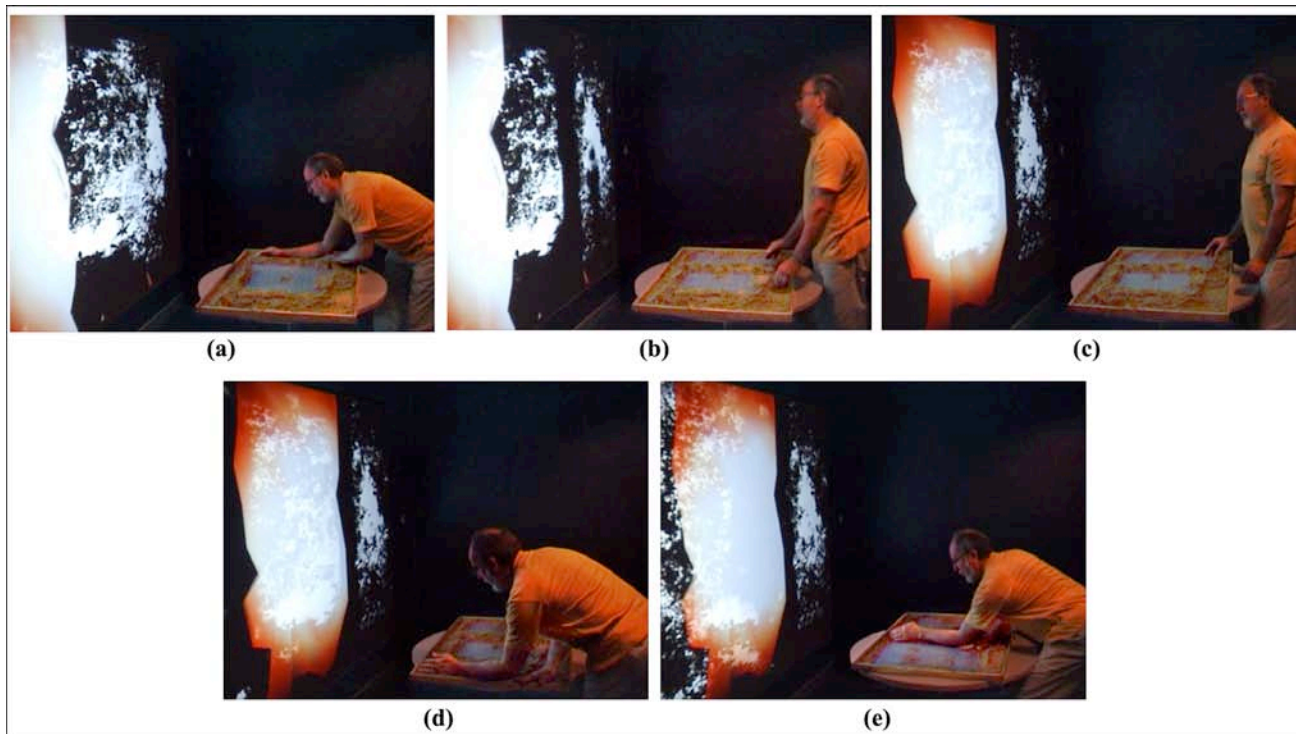And, in reference to a flickering ghosting: "*Here comes a good one!*" (P7)

Figure 3 depicts a series of gestures. (a) P2 sweeps a clearing in the sand with a broad stroke of his forearm (7 mins 33 secs); (b) P2 watches the dappled light imagery update and waits for the pattern solution to update (7 mins 34 secs); (c) The final pattern updates to sit across the newly created clearing (7 mins 37 secs); (d) P2 responds to the new pattern with a new gesture (7 mins 40 secs); (e) 7 mins 42 secs, P2 drags the tray across the table.

Exploration

Explorative behaviours are supported by the occurrences of several cognitive states and movements. These include assessing the system, feeling the sand, revealing dappled light imagery and probing, prodding or otherwise engaging with the patterns to solicit a reaction.

Participants comment on trying to work out how to interact with the system and what its limitations are:

"... I didn't know what the thing was for so I tried to explore by myself and I realised that where there is [no] sand I can actually see the picture on the screen like here [gestures]" (P4)

"Tried at first to discover the 'edges' of the work (image and behaviour)...." (P2)

"To explore the resolution... I tried to figure out what was the resolution of this [gestures]." (P3)

Clearing movements were used to 'reveal', as described by participant 5:

"Making/clearing holes in the sand... Cause parts of (screen image) to be revealed. It was like there were secrets that could be revealed." She also used non-modelling movements such as the wave of her hand to 'reveal secret things'.

All participants created mounds at some point, and some described this as being with the intent of seeing if three dimensional input affects the system. However, next to assessing the system, clearing the sand to reveal dappled light imagery was the most common method of exploring.

Participant 7 initially explored in an assessing way but his goals changed while interacting with the system. His actions were based on response from the system and his reflections on it, his own ideas. He utilised a range of modelling behaviours and cognitive states, including clearing and covering to alter the patterns.

"...started off just doing anything to just work out what the parameters would be and then started thinking about what was important about the shapes that I made like if it was the size of the shape or the complexity of the shape or wether I could join two shapes together..."

He explicitly states his interest in following the system and how his goals emerged interactively: "I really get that feeling... of just aimless investigation... I'm quite happy just to be here and go with it... like before I was trying to see what the biggest shape I could make was... [but upon realising that the]... large shapes were not necessarily as rewarding as the more complex ones..., [I tried to find what was]... the prettiest thing... [that could be made]." (P7)

Thus, exploration behaviours vary in their degree of interactivity with the system, reflecting a range in the degree to which explorative goals are formulated in collaboration with the system.

Composing

Composing behaviours were observed when recognisable figures were created in the sand and/or on the screen. A variety of modelling movements, as described in Table 2, were observed. Participants also commented on their attempts to create compositions.

"I tried to arrange the sand to form an image." (P1)

"I have been trying to write characters, like my name." (P3)

"I tried to create a composition that I liked." (P5)

"So there was the small spot exposed at the beginning and I was trying to make a composition that I liked. So trying to reveal patches and make it look how I liked..." (P5)

Participant modelling efforts can, in most cases, be understood in terms of clearing and covering. Clearing was utilised as a form of mark making or drawing. For example, stroking, sweeping, or digging movements were used to create images. Covering cleared areas also facilitated drawing and was described as 'erasing' by participant 4:

"...Like you use the rubber to erase all of your drawing and I do it again. So I assume this is a paper like now [gestures] and I cover it all with sand so it's basically black now and so I start to draw again."

Several other participants would also recover the surface. Participant 3 frequently covered his compositions with the intention of re-starting: spreading the sand out and patting it down to recreate the smooth surface of the start condition. He also suggested a 'reset' feature in lieu of having to do this every time:

"If I can, reset it like this with one motion – that would be great. [He gestures a sweeping motion across the surface of the tray, as though a long brush might move across it right to left, sweeping it clean]" (P3)

Compositions were created in 3 ways:

Firstly, compositions in the sand could be created with no regard for the system response. This occurred very rarely and during an initial period while the participant is still assessing the limitations of the system (e.g. compositions with mounds will only register as their footprint).

Secondly, participants created compositions by clearing areas in the sand and the system responded by rendering directly corresponding areas on screen, as dappled light imagery. Participants were thus able to view their composition directly, predictably, as it was being created. This was the most common method of composing.

A variation in the extent to which the participant consults with the system while working was observed when participants composed in this way: they would either glance intermittently at the screen while working or else they would just look up at the end of an effort. This latter action is supported by the high degree of predictability afforded by clearing the sand to create compositions in the dappled light imagery. It can also suggest the

execution of a planned composition or discomfort from looking while working.

Thirdly, some participants created compositions using the patterns. As before, this was also accomplished by modelling clearings in the sand and the same feedback of dappled light was visible; but here the composition emerges when the participant's actions are informed by the system's response.

Examples include P7's attempts to create types of patterns that are increasingly "complex" or "pretty" (refer to the previous section). Similarly, watching the 'ghosting' to anticipate the next pattern exemplifies how subsequent actions are informed by previous action and system response.

Participant 2 was observed to create several compositions including a 'cross' image; interactively in sand and patterns. He used a series of bold gestures while intermittently glancing at the screen. He would also pause, watching, to brush sand in the corners, further interacting with the agent to amend the image. His comment in the questionnaire on a relationship between his interaction and the imagery indicates that he felt an awareness of the range of interaction the system affords: "*Encouraged me to push it further than initial impressions...*" (P2)

Due to the lack of control and predictability of the patterns, compositions cannot be planned and rather emerge through participant response to system response i.e. with a high degree of interaction.

Like exploratory behaviours, composing behaviours also varied in their degree of interactivity with the system. The degree of interactivity corresponded to the degree of predictability of the component engaged with (dappled light, patterns); and the formation of the compositional goal (ranging from that which is planned to that which is collaborative or has emerged between participant and system).

Degrees of interaction
Compositional and explorative behaviours can be analysed to illuminate degrees of involvement or interaction.

As previously stated, exploratory behaviours range from trying to work out the system to seeing what it has to offer, the latter being an inherently contextual, collaborative activity. Compositional behaviours have also been shown to range in the degree of interaction in the activity and the formation of goals.

A continuum of the degree of interactivity with the system becomes apparent. Here the execution of a preconceived plan is at one end and the emergence of a goal due to sensitivity to context or situation, is at the other end. This is similar to Suchman's differentiation of plans from 'situated actions' where preconceived ideas of action can be superseded by the context (here system response, artwork, sand and its affordances, etc.) to inform action dynamically. Furthermore, participant 7's

determination of action based on the situation is an example of Suchman's 'intelligent action' (Suchman, 1987).

The emergence of the goal within either exploration or composition has been shown to have occurred with participants 2 and 7. Both were highly involved in their interaction: participant 7 anticipated the patterns when watching the ghosting "*Here comes a good one!*" and participant 2 burst out in laughter and nearly pushed the sand-tray off the table while working. These participants interacted with the system for longer than average periods of time. They continually watched the screen while working. Their interaction can be characterised as executing broad, sweeping gestures that worked across the whole sand tray, at a pace that was relatively slow and punctuated by reflective pauses. It was observed that during their interaction there was a relationship between subsequent actions. Similarly, a relationship between subsequent images was observed. Continuity between subsequent historical snapshots was thus able to emerge.

Simulation Agent Performance
The continuity observed in participants 2 and 7 was also due to the slow, steady rate of their interaction. Since the agent processes a preceding period of time, decreasing the rate of interaction reduces the range of input, resulting in a more stable simulation that tends to be more predictable.

Ghosting was commented on and observed to have been noticed by only one person: participant 7. It was also observed as not being very visible, due partly to the location's lighting. Since the flickering imagery presents possible forms for the upcoming solid shape (pattern) it creates anticipation. Were the other participants to respond to this form it may increase their reflection and system interaction.

Shadows, such as from hands reaching or waving above the sand were occasionally detected as input by the simulation agent in the creation of the patterns. Participants would not necessarily expect to be affecting the patterns when they are not directly interacting with the sand and this occurrence is likely to have affected their perception of the meaning and the predictability of the agent system. It is a performance issue that results from the sensor's sensitivity being too high.

CONCLUSION AND FUTURE WORK
The aim of this study was to illuminate any occurrences of explorative and reflective behaviour during interaction with this version of the artwork, Glass Pond. As has been shown, this has been achieved.

The results from this study also indicate how they might be amplified for future versions of this work. As analysis has shown there exist degrees of explorative and compositional interaction with the system. Participants P2 and P7 exemplify the highest degree of interactive exploration and composition of this continuum. The study's results indicate that, in order to extend the experience for more participants toward this high degree

of interaction, the consideration of the following research issues is required: sand quality, set-up, agent performance, predictability and control (for the patterns) and visual imagery.

Sand
The self-conscious behaviour attributed to the discomfort of wet sand may have impacted on the degrees of participant involvement or interaction. Thus, increased satisfaction with the feeling of the sand such as by replacing wet river sand with fine, dry sand is a major issue for future versions of the work.

Setup
Changing the setup to locate sand and screen in the same field of view will improve participant comfort. Reducing the gap between an action and system response may also enhance interaction with the work. Several possibilities, such as providing a chair for the participant or an augmented reality interface, can be pursued.

Patterns: Agent Performance, Predictability, Control
Another issue for future research is participant desire for control of the patterns. Complete control, as in the control of an instrument or tool, is not of interest in this artwork which is more oriented towards a complex environment to support an explorative and reflective interaction experience. However, the ability to detect the occurrence of patterns (and perhaps predict them) affects the ability to interact meaningfully with the artwork and thus requires consideration.

The pilot study has illuminated two areas of redress: firstly, the appearance of the ghosting patterns needs to be revised. These can provide a sense of anticipation but were not perceived by the majority of the participants due to a set-up problem. Adjusting the lighting conditions and increasing their rendered opacity are two solutions. Secondly, the sensor's detection of shadows as (false) input informed the construction of the patterns. This performance issue affected the user's (perceived) control of the system and its predictability. The subsequent iteration of the artwork will address this issue by, for example, improving the calibration to reduce the sensor sensitivity.

Visual Imagery
Analysis revealed that the nature (e.g. continuity, scale) and rate of participant interaction affects the pattern imagery. Investigation of what imagery is being generated and how, relative to the interaction, is a research issue that will be addressed in the future work. Furthermore, how the visual imagery from different interaction methods (e.g. waving and stroking) and of different qualities (dappled light and pattern imagery) combine to an aesthetic whole also remains a research issue.

REFERENCES
Bowman, D.A., Kruijff, E., LaViola, J.J., JR. and Poupyrev, I. 3D User Interfaces Theory and Practice. Boston, Addison-Wesley, (2004).

Candy, L. and Edmonds, E.A. Research. Explorations in Art and Technology. London, Springer (2002), 39-53.

Costello, B., Muller, L., Amitani, S. and Edmonds, E.A. Understanding the Experience of Interactive Art: Iamascope in Beta_space. Proc. of Interactive Entertainment 2005, ACM Press (2005), 49-56.

Edmonds, E. Abstraction and Interaction: An Art System for White Noise. Computer Graphics, Imaging and Visualisation - Techniques and Applications, IEEE Computer Society Conference Publishing Services (2006), 423-427.

Edmonds, E.A. and Fell, M. Absolute_5. White Noise Exhibition at Australian Centre for the Moving Image (ACMI), (2005), Interactive Artwork.

Edmonds, E.A., Turner, G. and Candy, L. Approaches to Interactive Art Systems. Proc. 2nd International Conference on Computer Graphics and Interactive Techniques, ACM Press (2004), 113-117.

Gibson, J.J. The Ecological Approach to Visual Perception. London, Houghton Mifflin, (1979).

Ishii, H., Ratti, C., Piper, B. and Wang, Y. "Bringing clay and sand into digital design – continuous tangible user interfaces." BT Technology Journal 22, 4 (2004), 287-299.

Krueger, M., Gionfriddo, T. and Hinrichsen, K. VIDEOPLACE - an Artificial Reality. Proc. SIGCHI Human Factors in Computing Systems, ACM Press (1985), 35-40.

Simpson, Z.B. Shadow Garden. ACM Siggraph (2002), Interactive Artwork.

Suchman, L.A. Situated Actions. Plans and situated actions The problem of human-machine communication, Cambridge University Press (1987).

Utterback, C. and Archituv, R. Text Rain. ACM Siggraph, (2000), Interactive artwork.