
Experiencing affective interactive art

Leticia S.S. Bialoskorski

User Experience Group,
Philips Research Europe,
High Tech Campus 34,
Eindhoven 5656 AE, The Netherlands
and
Center for Telematics and Information Technology (CTIT),
University of Twente,
P.O. Box 217,
Enschede 7500 AE, The Netherlands
E-mail: l.s.s.bialoskorski@alumnus.utwente.nl

Joyce H.D.M. Westerink

User Experience Group,
Philips Research Europe,
High Tech Campus 34,
Eindhoven 5656 AE, The Netherlands
E-mail: joyce.westerink@philips.com

Egon L. van den Broek

Center for Telematics and Information Technology (CTIT),
University of Twente,
P.O. Box 217,
Enschede 7500 AE, The Netherlands
E-mail: vandenbroek@acm.org

Abstract: The progress in the field of affective computing enables the realisation of affective art. This paper describes the affective interactive art system Mood Swings, which interprets and visualises affect expressed by a person. Mood Swings is founded on the integration of a framework for affective movements and a colour model. This enables Mood Swings to recognise affective movement characteristics as expressed by a person and display a colour that matches the expressed emotion. With that, a unique interactive system is introduced, which can be considered as art, a game, or a combination of both, as becomes apparent from evaluations.

Keywords: Mood Swings; affect; colours; movement; interactive art; ToI; trajectory of interaction.

Reference to this paper should be made as follows: Bialoskorski, L.S.S., Westerink, J.H.D.M. and van den Broek, E.L. (2010) 'Experiencing affective interactive art', *Int. J. Arts and Technology*, Vol. 3, No. 4, pp.341–356.

Biographical notes: Leticia S.S. Bialoskorski (1982) received a BSc in Multimedia Design and Technology and a MSc in Cognitive Ergonomics. As a trainee at Philips Research, she developed the interactive art installation Mood Swings, which recognises people's affective movement characteristics and displays a colour that matches the expressed emotion.

Joyce H.D.M. Westerink (1960) studied Physics and took her PhD in 1991 on the Human-Oriented topic of Perceived Image Quality. She joined Philips Research and specialised on human perception, emotion and cognition related to consumer products. Written output of her work can be found in some 50 articles in books and international journals and 20 patents and patent applications.

Egon L. van den Broek received his MSc (2001) in Artificial Intelligence and PhD (2005) in Image Retrieval, and will obtain a PhD (2010) in Affective Signal Processing. Currently, he is an Assistant Professor, a Research Coordinator (University of Twente and Radboud University Medical Center Nijmegen, both The Netherlands) and a Consultant with Human-Centered Computing Consultancy. He has published 100+ articles, guided 45+ students, holds 3 patent applications and various awards, and he is/has been (guest) editor, reviewer, chair and PC member of various conferences and journals. Additionally, he is editor-in-chief of the Pan Stanford Series in Artificial Intelligence, to be launched in 2011/2012.

Colours, like features, follow the changes of the emotions.

Pablo Picasso (1881–1973)

1 Introduction

In the field of affective computing, systems are being designed that can recognise, interpret and process emotions (Boehner et al., 2007; Picard, 1997). Picard (1997) states that computers need the ability to (at least) recognise and express affect to achieve natural and intelligent interaction with humans. Interest shifts from intelligent to sensitive products. Emotions indeed play a major role in judging products (Norman, 2004); for example, we can feel great using a product that is pleasing to the eye, even if it is not user friendly. In 2007, Sony introduced a photo camera with a 'smile shutter' that recognises whether or not the person in focus is smiling (Sony, 2007). The camera can detect smiles, but is it possible to detect happiness?

In (interactive) art affective technologies are also applied. An example is Cardiomorphologies by Muller et al. (2006). It is an interactive installation that uses bio-sensing and multimedia technologies to create real-time visual and sonic representations of participants' breath and heart rate. During their interaction, participants are encouraged to use the installation as a feedback system to observe and experiment with their own breath and heart-rate patterning.

Expanding research on this topic fosters the acquisition of more insights in affective computing in different contexts. Therefore Mood Swings, an interactive light installation, was created. The installation consists of eight luminous orbs that react on movement and take on certain colours with distinct movements, creating patterns of light. In this way, users are challenged to express their emotion. Figure 1 depicts a person interacting with Mood Swings.

Figure 1 Mood Swings' luminous orbs in action (see online version for colours)

2 Related work

Various papers have been written on interactive art. This is done both from a user experience point of view (e.g. Heinrich, 2008) and from a technological point of view (Trifonova et al., 2008). However, to the authors' knowledge, such surveys do not exist for interactive affective art. Hence, the various achievements that have been made in this field are disregarded to a certain extent. This section aims to correct this and will highlight some interactive affective pieces of art, in a condensed overview. Besides *Cardiomorphologies*, as mentioned in Section 1, a range of empathic interactive art works has been introduced throughout the last decade.

D-Toren is a 12 m high sculpture in the Dutch city of Doetinchem. In cycles of six months, a changing sample group of 50 inhabitants of Doetinchem answer questions about fear, hatred, love and happiness, which are posted on a website every two days. Every evening the D-toren displays a colour based on the emotion that was most mentioned in all the answers: yellow for fear, green for hatred, red for love and blue for happiness (Serafijn and Spuybroek, 2009).

Censor Chair creates a shared experience concerning censorship. Included are self-censorship, censorship of a group upon an individual, visual and auditory censorship in digital media, and censorship in society. Censor Chair makes use of a sensor that determines electrodermal activity, live video feeds and a barcode reader to drive the presentation of a digital media library (Aley et al., 2005). For more information on electrodermal activity in applied contexts, we refer to van den Broek and Westerink (2009).

4D-Pixel is a smart surface that physically reacts to voice, music and shows high relief letters. In this way, there is a direct relation between human activity and the appearance of the surface, realising a fusion between body and machine (Roosegaard, 2009).

Skinstrument is a musical instrument that can be played by one or (preferably) more persons. It uses electrodermal activity as input to generate sound (Brinkmann, 2009).

Miro visualises 'the emotional climate' in an office. The system consists of emotional input stations and a big screen as output, portraying movements and colours of objects. Its users are supposed to learn the language of the display by having it around and,

consequently, gradually build an understanding of the relationship between their activities and the animated painting displayed on the screen (Boehner et al., 2007).

Affector is a video window between two friends. Their emotions are registered through sensors. However, the sensor data is interpreted through rules developed by the friends themselves. Subsequently, their emotions are used to render a distortion of the video (Sengers et al., 2008).

Messa di Voce is a concert performance in which the speech, shouts, and songs, produced by two abstract vocalists, are radically augmented by custom interactive visualisation software in real-time (Levin and Lieberman, 2004).

Moodwall is a low-resolution LED wall combined with a sensor system, which monitors the presence and movements of people. This input is used to transform the wall's patterns into new shapes and colours. The system is designed for public spaces, combining a futuristic effect with a feeling of safety and warmth (Oostrik, 2009).

Flexgrid is a bendable LED interactive display. Embedded into a suit, the display allows users to talk to the clothing, having it react in different ways depending on how you talk to it. This gives the clothing a 'personality' of its own (Clar, 2004).

512Pb is an interactive light installation that consists of eight matrices of 64 LEDs that can be controlled individually. The goal is to explore the use of virtual boundaries. This would help in gaining understanding on how art can influence people in public space and vice versa (Klotz, 2006).

Triptych explores a monumental site-specific LED sculpture. Three brooding presences respond to movements of people approaching them. They react through creating a visceral experience of sound and light (United Visual Artists, 2007).

4D fish (Kawaguchi, 2008) is one of the many interactive affective pieces of art of Yoichiro Kawaguchi. It is a new mixture of sculpture, computer graphics and lenticular 3D picture. It aims to trigger emotions with its users through these advanced sculpture and imaging techniques.

Iamascope uses a video camera lens as the eye of a kaleidoscope and projects a kaleidoscopic image of the user onto a large screen. The image is accompanied by musical notes, which are dependent on the speed and frequency of the participant's movements (Costello et al., 2005). Special about this artwork is that it was used for a user experience evaluation. Costello et al. (2005) wanted to find a useful methodology for recording and analysing the experience of interactive art. In examining the interaction with *Iamascope*, they discovered the trajectory of interaction (ToI): common phases in interacting with interactive art. They labelled these phases: response, control, contemplation, belonging and disengagement: in the response phase, the participants try to discover how the system works. In the control phase, the participants try to manipulate the device. In the contemplation phase, the participant reflects upon the meaning communicated by the artwork. The belonging phase is reached when a participant feels controlled by the installation itself. The disengagement phase is the final phase in the ToI and encompasses the patterns of behaviour that take place when the participant decides to stop interacting.

Evaluating this kind of interactive systems is common in human–computer interaction (HCI), but it is not common to test interaction in art. This is because HCI evaluation strives to be objective, while in art it is all about the subjective opinion of a single observer (Höök et al., 2003). Nevertheless, Mood Swings was evaluated to investigate whether the same phases as discovered by Costello et al. (2005) could be identified, thus gaining more insight in the experience of (affective) interactive art.

3 Mood Swings: foundation and development

When examining the interactive art installations as mentioned in Section 2, a common factor can be distinguished: communication. The artworks try to communicate a message; by including different modalities, or by letting the person interacting choose the manner of contact, the communication is enriched. Most installations communicate a message one-on-one, however sometimes a message from a whole city is communicated, like with the D-Tower. Not many installations communicate through physical touch and movement. Mood Swings wants to explore this relationship, while giving feedback with colour.

3.1 Emotions expressed in movement

In general, affect can be labelled in two manners; in discrete or dimensional emotions. Discrete emotions describe the affective state using basic emotions (e.g. fear, joy and sadness). A widely accepted approach of classifying emotions in a dimensional fashion is described by Russell (1980). He developed a circumplex model of affect that describes emotions in the two dimensions: valence (pleasure–displeasure) and arousal. In research by Lee et al. (2007), this model is transformed to be applicable to affective movements. They applied certain movement characteristics to the circumplex model of Russell (1980), which led to the affective dimensions: velocity and smoothness (the regularity of a movement).

In the design of Mood Swings, the model developed by Lee et al. (2007) was incorporated. Arousal is related to the velocity of a movement, with slow movements linked to low arousal and fast movements linked to high arousal. Valence is related to the smoothness of a movement, with smooth movements being pleasant, and jerky movements being unpleasant. Because the user interacts with the system through touching the orbs and bringing them into motion (see Figure 1), the movement pattern of the orb is used to derive the emotion expressed by a user. An accelerometer was placed inside the orb to measure its movements.

3.2 Visualising emotion in colour

Mood Swings' feedback exists of coloured light. Colour is chosen because of the strong relation it has with emotion. There is a reason why we can feel blue, become red with anger, or green with envy. Meaning is given to colour due to evolution, personal experience and cultural factors (Kleinsmith et al., 2006; van den Broek et al., 2008; Zammito, 2005). Painters use their knowledge of colour to provoke emotions in the audience.

eMoto, a mobile messaging service developed by Ståhl et al. (2005), uses sub-symbolic expressions for expressing emotions. A user can adjust the background

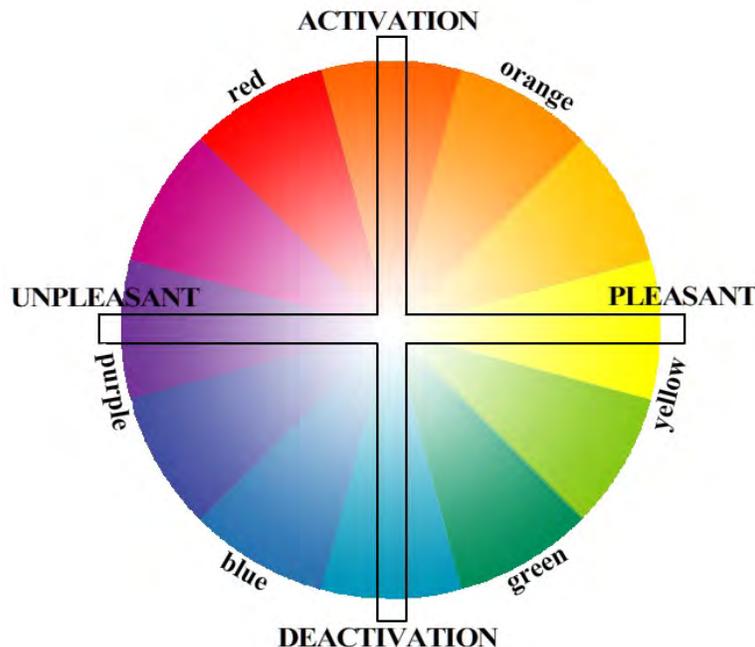
(i.e. colours, shapes and animations) of a text message to fit the emotional expression she/he wants to achieve. Emotion was linked to colour according to Ryberg's colour theory (as cited in Ståhl et al., 2005). In this theory, the most powerful and strongest emotions are represented by red, and emotions with less energy are represented by blue, the colour at the other end of the colour scale.

Ståhl et al. (2005) applied Ryberg's colour theory to Itten's circular colour model (Itten, 1961), which in its turn can be adjusted to fit Russell's circumplex model of affect, as is shown in Figure 2. The colours fade to white towards the middle of the circle, because in that point both valence and arousal are neutral.

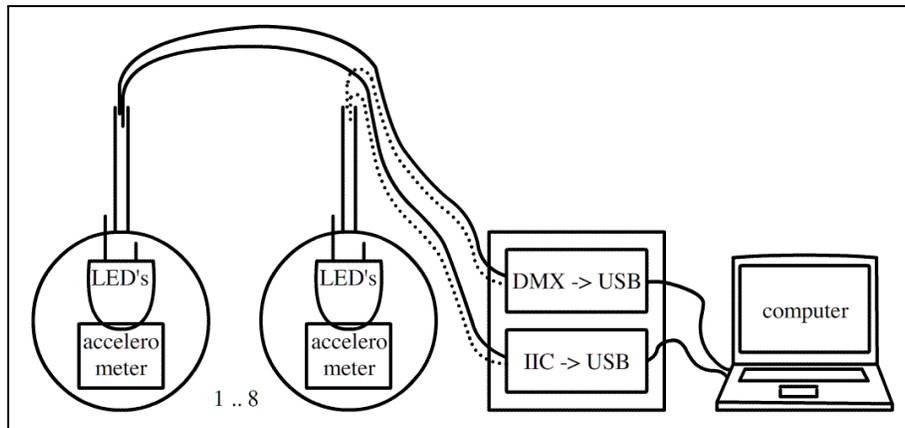
3.3 *Combining emotional movements and colours into Mood Swings*

Mood Swings was implemented as a system of eight orbs (synthetic material), each with a diameter of 10 cm. The orbs hang on wires with different lengths from a squared shaped box that can be attached to the ceiling. Each orb has an accelerometer and six RGB LEDs inside. The accelerometer has an analogue output and is mounted on a printed circuit board with an analogue-to-digital converter that makes use of an inter-integrated circuit (IIC) protocol. The acceleration sensors of all eight orbs are connected to a multiplexer that passes the signal through to an IIC/USB converter, which is connected to a laptop. The LEDs are controlled by LED drivers that make use of a DMX protocol. The LED drivers are connected to the laptop via a DMX/USB converter. Figure 3 shows a representation of the system's structure.

Figure 2 Itten's colour system (see online version for colours)



Source: Ståhl et al. (2005) and Itten (1961) fitted to Russell's circumplex model of affect Russell (1980).

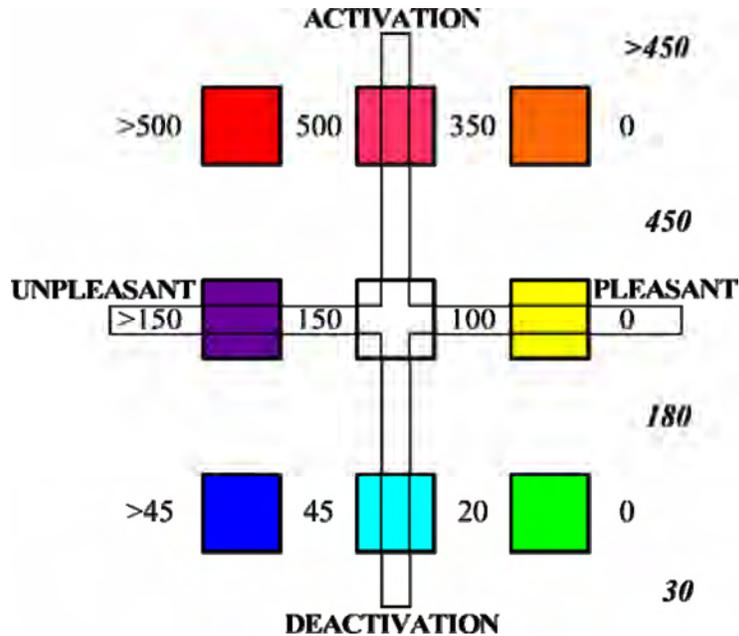
Figure 3 Mood Swings' architecture

National Instruments' LabVIEW was used for the programming of Mood Swings. Every 50 ms the program reads the value of acceleration from the three axes (x , y and z) in each accelerometer. The magnitude of the acceleration is calculated by taking the square root of the sum of the squares of the components, mathematically expressed by $\sqrt{x^2+y^2+z^2}$.

The measuring of affect starts with calibrating the device at rest. This is necessary because the accelerometer also measures static forces like gravity. This is different for each orb and each accelerometer axis due to the random orientation of the orbs. The acceleration signal is corrected with the mean of the first 20 measurements. Next, the velocity and smoothness (the regularity of the movement) are determined on a continuous basis.

- When creating fast movements, acceleration is high. To determine the three levels of velocity the mean acceleration data of five measurements was used.
- Irregular movements lead to more changes in the signal and thus the steepness of the accelerometer signal (second derivative, d^2a/dt^2) is larger for jerky movements than for smooth movements. The mean second derivative of the signal was calculated over a period of 40 measurements.

Figure 4 shows how Itten's transformed colour circle, as used in (Ståhl et al., 2005), is applied in Mood Swings. Nine colours are used in combination with the emotion-movement relation framework of (Höök et al., 2003) as measured by the accelerometers. When a value (as averaged over 10 measurements) falls inside the thresholds of a quadrant, the corresponding orb will light up in the matching colour. When an orb has to take on a new colour, it changes immediately, without a fade. When not touched for a certain while, the system can twinkle colours slowly to attract attention.

Figure 4 Itten's colour model applied to the movement categories (see online version for colours)

Note: Thresholds of the velocity axis (calculated by the mean acceleration (mV)) are depicted between the coloured squares; thresholds of the Smoothness axis (calculated by the second derivative (mV/s²)) are depicted in bold/italic numbers.

3.4 User test on emotion interpretation

A small user test was set up to determine whether the system can interpret user emotions correctly, and whether the user understands the feedback given by Mood Swings. Twelve males and eight females participated voluntarily in the study. The mean age of the participants was 27.5 years (SD = 5.01). The participants were asked to sign an informed consent form. The light installation hung in an obscured room. Only the participant and the experiment leader were present. Without further information, the participants were asked to interact with the light installation, explore the possibilities. They were informed that they could stop interacting whenever they liked.

The experimenter observed the actions of the participant and made notes. When the participants were done interacting they were asked whether they saw a link with emotion. If not, the link was explained to them. Then, they were asked if they could communicate four emotions to the installation: anger, delight, sadness and relaxation. These are the four extreme emotions from Russell's circumplex model of affect. They were also asked which colour they would prefer for these emotions. The session was ended by a small informal talk about what they thought about the installation.

The mean duration of participants interacting with Mood Swings was 230 sec, ranging from 90 to 460, with a SD of 110 sec. Seventy-five percent of the participants discovered a link between movement and colour. Generally, all participants were very

cautious when they started playing with the installation. In general, there were two types of interaction visible:

- after the first step some participants tried out different movements, hence creating many different colours
- the other group remained cautious in their touch and sometimes only discovered two colours.

The orbs afford different types of handling. Techniques used were: swinging, squeezing, touching, ticking, stroking, hitting and braiding. For almost all users, it was hard to figure out the different kinds of movements to elicit the different colours. In many cases, this was experienced as frustrating.

When directly asked about the relation with emotion, 35% of the participants stated they saw a link between the installation and emotion. They could explain that relaxed movements and angry movements caused the orbs to turn green and red, respectively; other colours were not as easily classified. Participants often found it hard to discriminate between yellow and orange.

When asked to act out certain emotions, Mood Swings interpreted the expressed emotion correctly in 30% (anger)–60% (delight) of the cases. There were some participants who found it hard to transfer their emotions to the installation, in particular expressing sadness. The colours the participants preferred for each emotion were mostly in line with those expressed by the system: 55% (sadness)–75% (anger), which confirms the method used in Ståhl et al. (2005). There was no consensus between participants when the preferred colour differed from the colour established from the model. For example, the participants who would like to see a different colour linked to sadness named: dark purple, lilac, ochre yellow and grey.

The above results were used to improve the installation. In particular, it should be a little less mysterious and easier to understand. Hence, fewer colours should be used and the orbs should stay lit longer when they have reached a certain state. In the new version, the colour that corresponds to the highest value is held for 5 sec, instead of changing to a new colour immediately. When bringing down the colours from nine to six, yellow is replaced by white to be more easily distinguished from orange. Table 1 shows this new colour mapping. This improved Mood Swings system was now evaluated in its intended context, a museum, as will be described in Section 4.

Table 1 Mood Swings interprets the input (movement) as emotion in terms of valence and arousal, and subsequently gives feedback through colours

<i>Arousal</i>	<i>Valence</i>	<i>Colour</i>
High	Negative	Red
High	Positive	Orange
Neutral	Negative	Purple
Neutral	Positive	White
Low	Negative	Blue
Low	Positive	Green

Note: This table shows the relation among valence, arousal and colour aspects.

4 Evaluation of Mood Swings as an art installation

4.1 Description of the evaluation

The complexity and key experiences of interactive art lie in the interactivity. Since that is not material, it is hard to determine just what is interesting in interactive experiences (Edmonds et al., 2006). As stated before, Costello et al. (2005) discovered that in interaction with interactive art it is possible to identify five phases: response, control, contemplation, belonging and disengagement. The goal of the system evaluation is to investigate whether these phases also exist in Mood Swings.

In line with Mood Swings' character of an interactive art installation, the evaluation was conducted in a museum. The codiscovery method (Höök et al., 2003) was considered a suitable way to evaluate interactive art, especially for a museum setting, where in many cases visitors – though not always – come in pairs or in trios.

Out of the 46 people invited to participate in the experiment, 36 accepted. In total 11 individuals (6♂, 5♀) and 11 groups (10♂, 15♀) participated. In nine of the 11 groups, the persons knew each other. All participants signed an informed consent form. Both individuals and groups were asked to examine the installation like they would have done otherwise. They were told to explain (to each other) what they were thinking and doing during the interactions and to just stop when they got bored with the installation. Afterwards, they were asked to fill out a questionnaire with open questions. All interactions were videotaped.

4.2 Results on interaction with Mood Swings

The mean duration of interaction in the individual condition was 220 sec, with a SD of 160 sec. In the group condition the mean duration was 320 sec, with a SD of 190 sec. No significant difference in duration of interaction between the two conditions was found. However, the participants in the group condition (mean = 5.4 colours) saw significantly more different colours than participants in the individual condition (mean = 3.8 colours) ($t(18) = -2.638, p = 0.009$).

All events recorded on the videotapes were coded according to a simplified coding scheme (Table 2) based on the one used in Bilda et al. (2006). Important (sub)categories were chosen such that the phases of the ToI (Costello et al., 2005) could be linked to the different elements of interaction. The coding scheme, thus, consisted of three main categories: Purpose, State, and Conceptual. Every physical action has an intention (Purpose). This information is revealed by the participants' remarks. Remarks of feelings and realisations are coded in the State category. The Conceptual category is related to contemplation of the artwork itself.

Most phases of the ToI (Costello et al., 2005) could be identified. In the *response* phase, most participants figured out that the installation works on movement. An important moment in this phase was seeing multiple colours. Usually, this was accompanied by a change in movement behaviour. When the participants saw it was possible to create multiple colours they would start to form theories about how the installation worked (45% of the individuals and 67% of the groups).

In the *control* phase, the participants tried to manipulate the device. A common behaviour is making it into a game. The most popular game was trying to light all the orbs in the same colour, usually green or red.

In the *contemplation* phase, the participant reflects upon the meaning communicated by the artwork. However, few participants reached this phase (9% of the individuals and 17% of the participants in the group condition).

The *belonging* phase is reached when a participant feels controlled by the installation itself. At this point, the artwork truly affects its viewers, constituting a closed loop of emotional interaction. It is a difficult phase to achieve. In this experiment, none of the participants reached this phase. However, sometimes it appeared that participants got much immersed in the interaction.

The *disengagement* phase encompasses the final phase in the ToI. Costello et al. (2005) describe that all their participants ended the interaction in a state of control, and that they repeated a previous action sequence from the most intense control state, just before this occurred. In our evaluation, 50% of all participants ended in a state of control, and most of them indeed repeated a previous action.

All participants reached the response phase. One individual and one group (two participants) did not reach the control phase. In a session, the response phase was reached 2.8 times on average. The control stage was reached on average 2.8 times per session. In general, the interaction pattern for individuals and groups corresponded. In both conditions, the discovery and control codes interchanged multiple times. However, 55% of the individuals and 44% of the participants in the group condition only had a maximum of two changes between discovery and control codes.

Table 2 The coding scheme according to which the video data was coded

<i>Code</i>	<i>Content</i>	<i>Phase in ToI</i>
Purpose	Stated purpose of action	
Discover	Trying to discover or explore	Response
Control	Trying to control	Control
State	Self states	
General	Described general state	Contemplation/belonging
Notice	Realising, noticing recognising	Response
Conceptual	Concepts, goals, and evaluations	
Goal	Set up a goal	Control
Wonder	Wondering or questioning	Response
Explain	Explanatory statements about how the system works	Control
Selfw	Mention of the interactive relationship between the self and the work	Contemplation/belonging

Note: Each code is explained and its relation to the phases in the ToI is indicated.

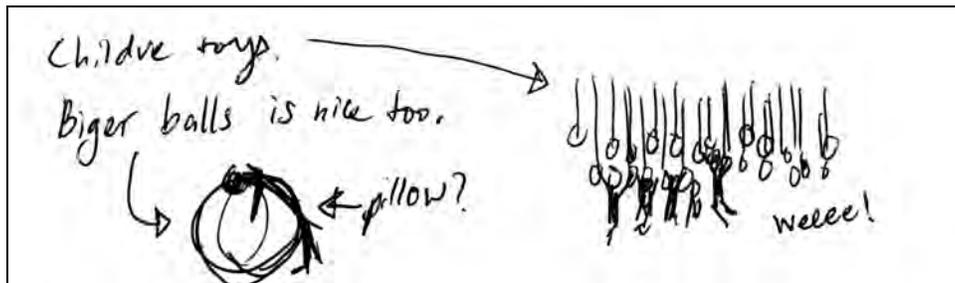
4.3 Results on Mood Swings as a concept

When asking the participants how they would define Mood Swings, most of the participants in the group condition indicated they saw it as a game. In the individual condition, the major part of the participants saw Mood Swings as either art or as a game. Because it was possible to make up different games, in many cases the installation remained fun, even after the participants discovered how it worked. Twenty-five percent of the participants mentioned words linked to emotion in relation to the installation during interacting and/or in the questionnaire before they were explicitly mentioned. They used expressions like ‘the spheres express themselves’, ‘calm’, ‘aggression’ and ‘soothing’. When explicitly asking about a link between emotion and Mood Swings, 47% of the respondent answered they saw a link, 22% did not see a link, and 25% were in doubt or did not know.

If participants could change something about the installation, 19% indicated that they would like to expand the installation (see Figure 5 for an illustrative drawing by one of the participants). This is similar to the original concept. Applications that were suggested for Mood Swings were, among others: living room lighting, communication device for a public space or waiting rooms, and applications for children, in school, on a playground, or in a therapy room.

When asked what they would do if they saw Mood Swings three years from now, all answers were positive. The participants indicated that they would play with the installation again, demonstrate it to others, and that they would be curious to see if changes were made. This concurs with the research by Edmonds et al. (2006), who indicate that an important facet of an artwork is its power to build up a relationship with the audience.

Figure 5 Explanatory drawing by one of the participants



5 Discussion and conclusions

5.1 Discussion

Mood Swings combines movement and colour to achieve an affective experience. A minor success is achieved concerning the meaning Mood Swings tries to communicate; given the fact that 25% of the participants mentioned words linked to emotion in relation to the installation, while interacting with the system.

The participants had no problem comprehending how colour was related to emotion. Linking movement to emotion proved to be more difficult. Discriminating between the effects of slow and fast movements was clear; however, to most participants it remained unclear how the different movements related to the different colours. An explanation can be found in the way participants were interacting. They had to think about what they were doing, instead of acting more natural.

Interaction with Mood Swings was investigated according to the ToI. The ToI proved to be very useful, although 1 phase was not observed. None of the participants reached the belonging phase; as judged from the fact that no explicit comments were made about feeling immersed. In general, participants mostly commented about the functioning of the installation, and not about their thoughts and feelings. This made it hard to code remarks in 'general' and 'selfw' (see Table 2) linked to the belonging phase. One could interpret the phase of belonging as the most important phase of the ToI, in the sense that it is the phase in which the art installation truly impacts the viewer to the extent that she/he feels affected by it. Under this interpretation, Mood Swings did not reach this final level for the participants of our test, maybe quite comparable to many other works in an average museum. If so, however, it only underlines the usefulness of the ToI for the evaluation of the interactive art works.

5.2 Further explorations

In research by Pasch et al. (2009) on physical activity as interaction mode in video game consoles, is stated there is a link between physical activity and engagement. If a game technology is able to interpret the affective state of the gamer and adapt the game to steer the gamer's movements, this will lead to a more enjoyable interaction.

In the current system, all the orbs work individually. This means that the emotion expressed by the user is visible in each orb individually. An example, if a user wants to express anger, she/he will move quickly and randomly. In doing so, not all orbs will be touched equally. Maybe some orbs will move barely and light up in a colour appropriate for relaxation. A nicer solution would be to let the orbs learn from each other. A first step is letting the installation calculate a mean from all the orbs and adjust the feedback more appropriately. The installation will work more cohesive and it would be easier to include other feedback modalities like audio. Another advantage is that it would be possible to create more suitable games for Mood Swings, which will lead to a more natural and richer experience as discussed by Pasch et al. (2009). An idea for further improvement would be creating a learning system that can adapt to specific users.

The core of Mood Swings is the triangulation between motion, colour and emotion. This triangulation should receive much more attention in science and engineering since it influences us all continuously in our lives. However, each of these three issues on its own is already complex. For example, human perception of colour is investigated for more

than a century and is still a topic of debate (Bianchi-Berthouze, 2003). Constantly, new approaches are introduced to enhance the understanding; for example, van den Broek et al. (2008). The same holds for both human motions (Bianchi-Berthouze et al., 2007) and emotions (van den Broek and Westerink, 2009), which are hard to tackle, in particular in applied contexts.

An issue that should be explored in depth, but was beyond the scope of this research, is that of effects of culture. Within the context of embodied agents, Kleinsmith et al. (2006) showed both the importance and the complexity of cultural influences on emotions. They conclude with stating: ‘emotions are both universal and culturally specific. In evaluating cultural dimensions, some cultures are more similar than others’. This emphasises the need for a vast amount of research on this topic.

5.3 Conclusions

Mood Swings was designed to be an affective interactive art installation, with no specific function and its main goal to be fun. The working of Mood Swings is founded on a theoretical framework to facilitate the recognition of emotions as expressed in movements and reflecting them by displaying corresponding colours.

Mood Swings was evaluated in a museum. Overall Mood Swings was received rather positively: on average attracting continuous interest for more than 3 min. Interaction with Mood Swings was investigated according to the ToI. All but one of its phases were observed, underlining the generally applicability of the ToI to interactive art. Mood Swings may be considered to have many of the qualities of an interactive art installation, and clearly demonstrated to allow for interesting affective gaming applications.

Acknowledgements

The authors thank Jos Bax, Rene Verberne, Albert Geven, Frank Vossen, Tom Bergman, Albert Hoevenaars, Martin Ouwerkerk and Paul-Christiaan Spruijtenburg for their contribution in the development of Mood Swings. Additionally, we thank Evert van Loenen and the three anonymous reviewers, who provided valuable comments on a previous version of this manuscript.

References

- Aley, E., Cooper, T., Graeber, R., Kerne, A., Overby, K. and Touns, Z.O. (2005) ‘Censor chair: exploring censorship and social presence through psychophysiological sensing’, In H. Zhang, T-S. Chua, R. Steinmetz, M. Kankanhalli and L. Wilcox (Eds.), *Proceedings of the 13th ACM International Conference on Multimedia*. New York, NY, USA: ACM Press, pp.922–929.
- Bianchi-Berthouze, N. (2003) ‘Subjective perception of natural scenes: The role of color’, *Proceedings of SPIE (Color Imaging VIII: Processing, Hardcopy, and Applications)*, Vol. 5008, pp.1–13.
- Bianchi-Berthouze, N., Kim, W.W. and Patel, D. (2007) ‘Does body movement engage you more in digital game play? and why?’, *Lecture Notes in Computer Science (Affective Computing and Intelligent Interaction)*, Vol. 4738, pp.102–113.
- Bilda, Z., Costello, B. and Amitani, S. (2006) ‘Collaborative analysis framework for evaluating interactive art experience’, *CoDesign*, Vol. 2, No. 4, pp.225–238.

- Boehner, K., DePaula, R., Dourish, P. and Sengers, P. (2007) 'How emotion is made and measured', *Int. J. Human-Computer Studies*, Vol. 65, No. 4, pp.275–291.
- Brinkmann, D. (2009) *Skininstrument*. Retrieved on 15 July 2009. Available at: <http://www.daanbrinkmann.com>.
- Clar, J. (2004) *Flexgrid*. Retrieved on 15 July 2009. Available at: <http://www.jamesclar.com/product/2004/flexgrid>.
- Costello, B., Muller, L., Amitani, S. and Edmonds, E. (2005) 'Understanding the experience of interactive art: iamascope in beta_space', *2nd Australasian Conference on Interactive Entertainment*. Sydney, Australia: CCS Press, pp.49–56.
- Edmonds, E., Muller, L. and Connell, M. (2006) 'On creative engagement', *Visual Communication*, Vol. 5, No. 3, pp.307–322.
- Heinrich, F. (2008) 'On the beauty of interactive art', *Int. J. Arts and Technology*, Vol. 1, No. 2, pp.159–172.
- Höök, K., Sengers, P. and Andersson, G. (2003) 'Sense and sensibility: evaluation and interactive art', *SIGCHI Conference on Human Factors in Computing Systems*. New York: ACM Press, pp.241–248.
- Itten, J. (1961) *Kunst der Farbe*. Ravensburg: Otto Maier Verlag.
- Kawaguchi, Y. (2008) 'Infinite 4D fish', *Proceedings of the International Conference on Computer Graphics and Interactive Techniques*, article No. 20. New York: ACM Press.
- Kleinsmith, A., Ravindra De Silva, R. and Bianchi-Berthouze, N. (2006) 'Cross-cultural differences in recognizing affect from body posture', *Interacting with Computers*, Vol. 18, No. 6, pp.1371–1389.
- Klotz, P. (2006) *512Pb*. Retrieved on 15 July 2009. Available at: <http://www.led-art.nl>.
- Lee, J.-H., Park, J.-Y. and Nam, T.-J. (2007) 'Emotional interaction through physical movement', In J. Jacko (Ed.) *Human-Computer Interaction. HCI Intelligent Multimodal Interaction Environments*. Vol. 4552. Heidelberg, Germany: Springer, pp.401–410.
- Levin, G. and Lieberman, Z. (2004) 'In-situ speech visualization in real-time interactive installation and performance', *Proceedings of the 3rd international symposium on Non-photorealistic animation and rendering*. New York, NY, USA: ACM Press, pp.7–14.
- Muller, L., Turner, G., Khut G. and Edmonds, E. (2006) 'Creating affective visualisations for a physiologically interactive artwork', In E. Banissi, R.A. Burkhard, A. Ursyn, J.J. Zhang, M.W.McK. Bannatyne, C. Maple, A.J. Cowell, G.Y. Tian and M. Hou (Eds), *Information Visualization*. Vol. 10, Los Alamitos, CA, USA: IEEE Computer Society, pp.651–657.
- Norman, D.A. (2004) *Emotional Design: Why We Love (or Hate) Everyday Things*. New York: Basic Books.
- Oostrik, M. (2009) *Moodwall*. Retrieved on 15 July 2009. Available at: <http://www.magdatt.nl>.
- Pasch, M., Berthouze, N., van Dijk, E.M.A.G. and Nijholt, A. (2009) 'Movement-based sports video games: investigating motivation and gaming experience', *Entertainment Computing*, Vol. 1, No. 2, pp.49–61.
- Picard, R.W. (1997) *Affective Computing*. Cambridge, MA: The MIT Press.
- Roosegaarde, D. (2009) *4D-Pixel and Flow 5.0*. Retrieved on 15 July 2009. Available at: <http://www.studioroosegaarde.net>.
- Russell, J.A. (1980) 'A circumplex model of affect', *Journal of Personality and Social Psychology*, Vol. 39, No. 6, pp.1161–1178.
- Sengers, P., Boehner, K., Mateas, M. and Gay, G. (2008) 'The disenchantment of affect', *Journal of Personal and Ubiquitous Computing*, Vol. 12, No. 5, pp.347–358.
- Serafijn, Q.S. and Spuybroek, L. (2009) *D-Toren*. Retrieved on 15 July 2009. Available at: <http://www.d-toren.info>.
- Sony (2007) *Latest Sony Cyber-shot T-series Cameras Bring New Focus – and Smiles – to Point-and-Shoot Users*. Retrieved on 20 July 2009. Available at: http://news.sel.sony.com/en/press_room/consumer/digital_imaging/digital_cameras/cyber-shot/release/31103.html.

- Ståhl, A., Sundström, P. and Höök, K. (2005) 'A foundation for emotional expressivity', *Conference on Designing for User Experience*. San Francisco, California. Designing For User Experiences. Vol. 135, New York: American Institute of Graphic Arts.
- Trifonova, A., Jaccheri, L. and Bergaust, K. (2008) 'Software engineering issues in interactive installation art', *Int. J. Arts and Technology*, Vol. 1, No. 1, pp.43–65.
- United Visual Artists (2007) *Triptych*. Retrieved on 15 July 2009. Available at: <http://www.uva.co.uk/archives/70>.
- van den Broek, E.L., Schouten, Th.E. and Kisters, P.M.F. (2008) 'Modeling human color categorization', *Pattern Recognition Letters*, Vol. 29, No. 8, pp.1136–1144.
- van den Broek, E.L. and Westerink, J.H.D.M. (2009) 'Considerations for emotion-aware consumer products', *Applied Ergonomics*, Vol. 40, No. 6, pp.1055–1064.
- Zammito, V.L. (2005) 'The expressions of colours', *Digital Games Research Conference, Changing Views: Worlds in Play*. Vancouver: University of Vancouver, pp.1–15.