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Mood Swings: design and evaluation of affective interactive art

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The field of affective computing is concerned with developing emphatic products, such as affective consumer products, affective games, and affective art. This paper describes Mood Swings, an affective interactive art system, which interprets and visualizes affect expressed by a person. Mood Swings consists of eight luminous orbs that react to movement. When a person experiences certain emotion, his/her movements are claimed to have certain characteristics. Based on the integration of a framework for affective movements and a color model, Mood Swings recognizes affective movement characteristics, and subsequently displays a color that matches the expressed emotion. Mood Swings was evaluated in a museum for contemporary art by 36 museum visitors. The Trajectory of Interaction (ToI) was applied to assess common phases in interacting with Mood Swings, i.e. response, control, contemplation, belonging, and disengagement. The visitors who interacted with Mood Swings were videotaped. Results showed that The ToI could be identified, although not all phases were experienced by everyone. Few participants reached the contemplation phase and none of them reached the belonging phase. All together, the introduction of the new affective interactive art system was a success.

Keywords: Mood Swings; Affect; Colors; Movement; Interactive art; Trajectory of Interaction

1. Introduction

Not only is usability important for a pleasant user experience, but other factors like emotions also play a major role. For example, we can feel great using a product that is pleasing to the eye, even if it is not user friendly. According to Norman (2004), there are three levels of processing that can be mapped to the product's characteristics: (1) visceral design, which relates to the appearance of a product; (2) behavioral design, which represents the pleasure and effectiveness of use; and (3) reflective design, which deals with

the self-image, personal satisfaction, and memories. In addition, advertisement companies have developed strategies to tap into the emotions of the consumer. They concentrate on visceral and reflective design. So we buy products because they look good, and not just because of their specifications. In addition, the esthetics should provoke a feeling that makes the consumer curious.

Products can provoke emotions and, nowadays, computers are even getting equipped with special software to assess the users' affective state (Picard 1997, Sony 2007, Van den Broek *et al.* 2009, Van den Broek and Westerink 2009). This helps them in giving the right feedback. In 2007, Sony introduced a photo camera with a smile shutter that is able to recognize whether or not the person in focus is smiling. The camera can detect a smile, but is it possible to detect happiness? In the field of affective computing, it is believed that computers need the ability to (at least) recognize and express affect to achieve natural and intelligent interaction with its users (Picard 1997, van den Broek *et al.* 2009, van den Broek and Westerink 2009). That is why systems are being designed that can recognize, interpret, and process emotions (Picard 1997, Boehner *et al.* 2007, van den Broek *et al.* 2009, van den Broek and Westerink 2009). So, interest is shifting from intelligent to emphatic products.

It is interesting to expand research on this topic, to acquire more insights in affective computing in different contexts. Therefore, Mood Swings, an affective interactive light installation, was created. The installation reacts on movement and gives feedback in colored light that matches the displayed emotional state of the user.

2. (Affective) interactive art

Art is, like emotion, a very complicated concept. In most cases, art can be characterized by the following features (Wilson 2002): it has a non-utilitarian purpose; is provocative (esthetically, intellectually, and spiritually); and values individual perspectives. This section will provide a brief review on (affective) interactive art.

16 Pillars is an interactive light and sound installation (Brinkmann 2007). When people move in front of the pillars, the pillars light up accompanied by dissonant tones; see also figure 1.

The Expressive Control allows users to use their full-body for controlling the real-time generation of expressive visual and audio feedback (Castellano *et al.* 2007). The system extracts expressive motion features from the user's full-body movements and gestures and uses these to project visuals on a screen and play audio; see also figure 2.

The Influencing Machine uses color, shapes, animation, and music to portray emotions (Höök *et al.* 2003, Ståhl *et al.* 2005). Users insert art postcards, representing different emotional inputs, into a slot that resembles a postbox. The Influencing Machine answers with child-like drawings (projected onto a screen, accompanied by music) intended to express emotional states. The Influencing Machine explores the user–computer relationship and

Figure 1. 16 Pillars by Brinkmann (photo by Theo de Rijke).

provokes reflection in the end-users as to whether computers can have emotions and express them in this artistic way. See also figure 3.

eMoto is a mobile messaging service that uses colors, shapes, and animations for expressing emotions (Ståhl *et al.* 2005, Sundström 2005). After writing a text message the user can adjust the background of the message to fit the emotional expression s/he wants to achieve. The adjustments are done through affective gestures, which are measured by an extended stylus picking up on movement and pressure.

SKIN: Dresses is a probe project by Philips Design, which explored the possibilities of incorporating electronics into garments to express the emotion and personality of the wearer (Philips 2007). Bubelle (the blushing dress) is a bubble shaped dress, which is illuminated by patterns that change dependent
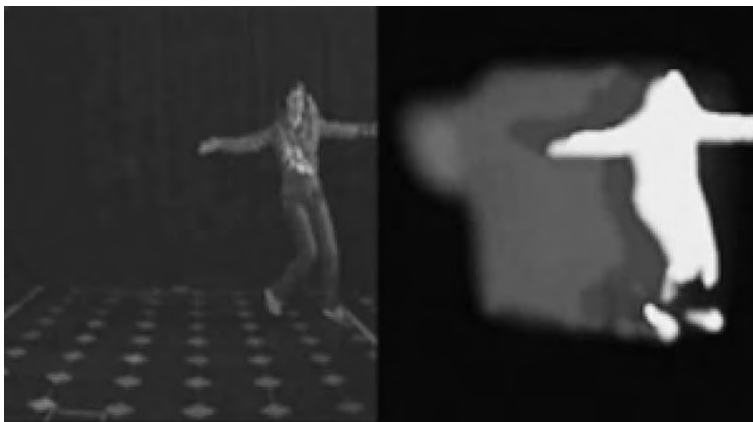

Figure 2. The Expressive Control by Castellano, Bresin, Camurri, and Volpe (Castellano 2008).
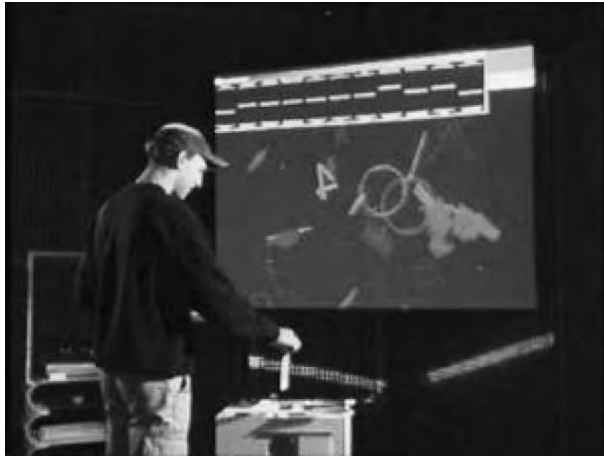
Figure 3. The Influencing Machine by Sengers, Liesendahl, Magar, and Seibert (Sengers 2004).

on skin contact. Frisson is an interactive body suit that has hundreds of tiny LEDs attached to the fabric, which react when being blown on.

Iamascope uses a video camera lens as the eye of a kaleidoscope and projects a kaleidoscopic image of the user onto a large screen (Costello *et al.* 2005). The speed and frequency of the participant's movements also trigger musical notes, which accompany the image (see figure 4). What is interesting about this artwork is that it was used for a user experience evaluation. Costello *et al.* (2005) were searching for a useful methodology to record and analyze the experience of interactive art. When examining the interaction with Iamascope, they identified "The Trajectory of Interaction" (ToI): common phases in interacting with interactive art. They labeled these phases: response, control, contemplation, belonging, and disengagement. In the response phase, the participants interact with the system and wait for a

Figure 4. Iamascope by Fels (Fels 2000).

response; they are discovering how the system works. In the control phase, the participants try to manipulate the system to feel in control. The participants reflect upon the meaning communicated by the artwork in the contemplation phase. The belonging phase is reached when the participant feels controlled by the system. The final phase in The ToI is the disengagement phase and encompasses the patterns of behavior that take place right before the participant decides to stop interacting.

The common factor in many of these installations is communication. Some installations want to enrich communication by including modalities or by letting you choose what to communicate. Most of them communicate the message one-on-one, except for the D-tower that reflects a message from a whole city. In many installations, movement is used as input, and color and sound are used as feedback modalities. As will be shown, this is also the case with Mood Swings.

3. Mood Swings' foundations

For Mood Swings, movement is used as input and colored light as output. A difference with the installations mentioned above is that Mood Swings uses a tactile interface. In the original concept, Mood Swings consisted of a room full of little orbs (see figure 5). As one walks through the room, one is followed by a trail of light that visualizes one's emotion. Because one is in a certain mood, one's movements have distinct characteristics. Sensors in the orbs measure the movements, and deduce the appropriate affective state. Feedback is given by means of different colors of light.

Due to technical, financial, and time restrictions, it was not possible to fully execute the original concept. Mood Swings now consists of eight orbs that hang from the ceiling. Each orb consists of a motion sensor that detects movement and the LEDs inside the orbs give feedback in colored light. Figure 6 shows two people interacting with Mood Swings. The working of Mood Swings is based on two theoretical frameworks, which will be explained in the next two paragraphs.
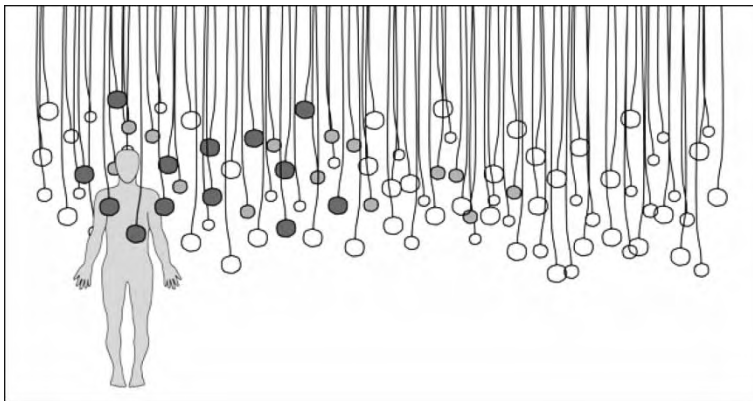

Figure 5. Original concept of Mood Swings.

Figure 6. People interacting with Mood Swings' luminous orbs.

3.1 Emotions expressed in movement

Although most of us can describe what an emotion is or how it feels, it is hard
to provide an unambiguous definition. Processes and states of emotion can be
analyzed from many perspectives, which makes it hard to come to an
encompassing whole. For example, Kleinginna Jr. and Kleinginna (1981) give
an overview of 92 definitions of emotions as mentioned in different studies.
Another confusing factor is that the term emotion is often mixed up with
terms like feeling, affect, and mood. To prevent such confusion, the following
definitions will be used in the context of this paper:

- Emotion: Automatic physiological and behavioral response to an event
  (Dolan 2002).
- Feeling: The subjective experience of an emotion (Dolan 2002).
- Affect: The combination of emotions and feelings (Frijda 1999).
- Mood: A relatively stable, longer-term affective state, not necessarily tied
  to specific objects or elicitors (Picard 1997, Frijda 1999). The precise
  duration of mood is not defined in literature.

In general, affect can be labeled by discrete or dimensional emotions.
Discrete emotions use basic emotions (e.g. fear, joy, and sadness) to describe
the affective state. A widely accepted approach of describing emotions in a
dimensional way is described by Russell (1980). He developed a circumplex
model of affect that classifies emotions in two dimensions: valence (pleasure–
displeasure) and arousal.

Emotion can be deduced from movement. The weeping willow is so named
because the shape of the tree and its movements are associated with sadness.
Posture, the movement of our body, gestures, and gait can all convey
emotions. However, not all researchers agree with this. Ekman and Friesen
(1974 cited in Wallbott 1998) say it is only possible to deduce the intensity of
an emotion from body movements and body posture. By letting actors and
actresses portray different emotions and coding their movements, Wallbott
(1998) and Bianchi-Berthouze (2008) showed that there are distinctive
patterns of movement and postural behavior associated with certain
emotions. Wallbott (1998) also states that activity accounts for some variance

of the differences between the emotions. He describes four levels of activity linked to certain emotions, with:

- Most movement activity: elated joy, hot anger, and terror.
- Less movement activity: despair, interest, and shame.
- Even lesser activity: fear, pride, disgust, and happiness.
- Least movement activity: contempt, sadness, and boredom.

Many experiments on affective movements make use of point-light displays. This means that an actor is filmed in a dark room, with lights attached to his joints. In this way point-light displays are created that give a good representation of human movement. Two advantages are that there are no other characteristics of the actor visible and that the data can be processed easily due to the small set of points. With this technique, Beardsworth and Buckner (1981 cited in Pollick 2004) as well as Cutting and Kozlowski (1977 cited in Pollick 2004) showed that movement is very personal.

Furthermore, a distinction can be made between propositional and non-propositional gestures. Propositional gestures are specific movements of certain body parts or postures corresponding to stereotypical emotions; e.g. head and body held erect show pride. Non-propositional gestures are not specific movements, but different qualities of body movement; e.g. speed and fluidity of movement (Gunes and Piccardi 2005).

Laban, a famous dancer and choreographer who studied movement in a non-propositional way, developed a system to describe movement called "effort and shape." Effort refers to the features that are used to express movement, and is described by weight, time, flow, and space. Shape refers to the path of a movement (Camurri *et al.* 2003, Ståhl *et al.* 2005). Understanding motion expression of performance art can be helpful in applying movement as a design element (Vaughan 1997). Camurri *et al.* (2003) operationalized Laban's dimensions into measurable elements, to analyze and classify expressive gesture in full-body movements in dance performances. They asked five dancers to perform the same dance four times, every time with a different emotion: anger, fear, grief, and joy. The performances were videotaped and then judged on perceived emotion by 32 observers. Results showed that the observers were able to detect expressed emotions. Grief was recognized best, followed by anger, and joy. They also developed an open software platform, EyesWeb, which can recognize movement cues on video automatically. With this program, they analyzed the taped performances, and found a significant difference in duration of time, which was longer for grief performances in contrast to other emotions. In addition, the level of contraction was higher for fear and grief, in contrast to joy. The performances of anger and joy had a higher quantity of movement than grief.

Vaughan (1997) wanted to reach a better understanding of the characteristics of movement. Therefore, she applied information gathered in research from the performing arts (theater and dance) to movement of objects on a computer screen. Four movement characteristics were found: path, area, direction, and speed.

Lee *et al.* (2007) developed Emotion Palpus; a physical device that can generate movements to express various emotions. This device was used to study the improvement of emotional user experiences and functional value for products through physical movements. They used the movement characteristics as named by Vaughan (1997) as a starting point, and applied them to the circumplex model developed by Russell (1980). This led to the affective dimensions: velocity (related to arousal) and smoothness, which stands for the regularity of a movement (related to valence).

When interacting with Mood Swings, the user moves the orbs, therefore, the movement pattern of the orb is used to derive the emotion expressed by a user. The model by Lee *et al.* (2007) was incorporated into the design of Mood Swings. 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.

3.2 *Visualizing emotion in color*

Mood Swings gives feedback in colored light. Color was chosen because of the strong relation it is claimed to have with emotion, as indicated by well-known expressions such as that we can feel blue, become red with anger, or green with envy. We give meaning to color based on a mixture of evolution, personal experience, and cultural factors (Zammitto 2005). Painters provoke emotions in the audience by using their color knowledge. Itten (1961) states it is even possible to derive feelings from subjective preferences of color arrangement, as well as character and way of thinking. He also states that color characteristics in skin complexion are linked to this preference of arrangement colors.

In the digital world, color is also linked to emotion, and used as a means to provide input to a system. For example, Guitarati (http://guitarati.com) is a website that uses this principle to recommend a suitable song to fit one's mood. One picks a color that represents one's mood, and then the program will search for a matching song.

The mobile messaging service eMoto, as mentioned earlier, uses colors for emotional expressions. For this system, emotion was linked to color according to Ryberg's color theory (1991 cited in Ståhl *et al.* 2005). In this theory, red represents the most powerful and strong emotions and blue, the color at the other end of the color scale, represents emotions with less energy. Ståhl *et al.* (2005) applied Ryberg's color theory to a circular color model, as devised by Itten (1961). This, on its turn, can be adjusted to fit Russell's circumplex model of affect, as is shown in figure 7. Toward the middle of the circle the colors fade to white, because in that point valence is neutral and arousal is average.

Mood Swings also applied Itten's transformed color circle, as used in Ståhl *et al.* (2005), using six colors in combination with the emotion–movement relation framework of Lee *et al.* (2007). Six colors are used because the results
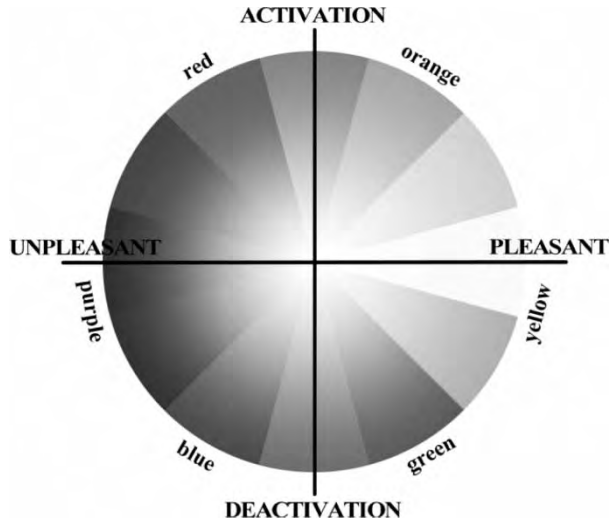
Figure 7. Itten's color circle (Itten 1961, Ståhl *et al.* 2005) adjusted to Russell's circumplex model of affect (Russell 1980).

from a user test about the functioning of Mood Swings showed that using more colors made the installation's feedback harder to understand. The actual colors expressed by Mood Swings are generated by six LEDs that are placed inside each orb. The colors change depending on the measurements of the accelerometer inside the orb. In this way, they display the color that reflects the emotional state of the user, based on the user's movements. The emotions and their accompanying colors are presented in table 1. When comparing table 1 to Itten's color circle, one would expect to see the color yellow as a result of neutral arousal and positive valence. However, the user test about the functioning of Mood Swings showed that the participants found it hard to discriminate between yellow and orange. Therefore, yellow was replaced by white.

4. Evaluation

Evaluation is an important factor in interaction design. In Human Computer Interaction (HCI), effective evaluation methods are developed to understand and improve (digital) systems. However these techniques are not used in evaluating interactive art; in most cases, there is no evaluation at all (Höök *et al.* 2003). 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).

Various studies, however, have shown that evaluation of interactive art can help artists to get their message across (e.g. see Höök *et al.* 2003, Costello *et al.* 2005, Bilda *et al.* 2006, 2007, Muller *et al.* 2006). For example, Höök *et al.* (2003) showed how user-testing strategies should be adapted to be appropriate to the concerns of artists. They used the co-discovery method to evaluate group reactions and dynamics to The Influencing Machine. The

Table 1. Mood Swings' input (movement) is interpreted as emotion in terms of valence and arousal, and subsequently feedback is given through colors. The relation between these aspects is shown in the table.

Velocity/arousal	Smoothness/valence	Color
Fast/high	Jerky/negative	Red
Fast/high	Smooth/positive	Orange
Intermediate/neutral	Jerky/negative	Purple
Intermediate/neutral	Smooth/positive	White
Slow/low	Jerky/negative	Blue
Slow/low	Smooth/positive	Green

laboratory evaluations helped uncover problems in the interaction, thereby indicating possible points of improvement in the design (Höök *et al.* 2003).

The complexity and key experiences of interactive art lie in the interactivity. It is difficult to measure experiences, which makes it 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; together termed The ToI. The goal of this study is evaluating Mood Swings using The ToI. Many studies about evaluating interactive art are conducted in a laboratory setting. This is not ideal, because context is very important in user experiences. Therefore, for this evaluation, the experiment is conducted in a museum.

4.1 Method

4.1.1 Participants. Out of the 46 people invited to participate in the experiment, 36 accepted (16♂ and 20♀). The participants had a mean age of 32.6 years (14–61 years, SD = 13.11), with one missing value. Twenty-eight of the participants were Dutch and six participants were non-European.

4.1.2 Procedure. Mood Swings was hanging in an open space at MU (http://www.mu.nl), a contemporary art museum in Eindhoven, The Netherlands. Simultaneously, an exhibition was held that showed work that was strictly *no* touching. In order to invite users to *do* touch Mood Swings, a sign was placed next to the installation, which said: Mood Swings, touching obligatory. Figure 8 shows the area where Mood Swings was shown. Museum visitors, both individuals and groups, were invited to take part in the experiment. They were told they would be participating in an experiment about the evaluation of an interactive light installation and that the session would be videotaped for research purposes. Afterwards, they were asked to fill out an open-ended questionnaire. If they agreed and signed the informed consent, they received the following instruction:

> I would like you to examine the installation like you would have done as if I had not asked you to participate in this experiment. If you get bored with the installation just stop interacting. When you indicate that you are done, I will

Figure 8. Experiment area in MU museum, which shows Mood Swings on the right, the sign on the left, and the camera used to tape the participants on the table.

> turn off the camera. Afterwards you will be asked to fill out a questionnaire with open questions. During the experiment you have to think-aloud. Explain (to each other) what you are doing and/or thinking. During the test you cannot talk to me. If necessary, I will remind you that you have to think-aloud.

Both informed consent and questionnaire were provided in Dutch to the Dutch participants and in English to the foreign participants.

4.1.3 Processing of the data. The events recorded on video were coded afterwards, according to a simplified coding scheme (table 2), based on the one used in Bilda *et al.* (2006). Due to time restrictions, it was not possible to use their original coding scheme. Important (sub)categories were chosen that could be linked to the different phases of The ToI.

The coding scheme used consisted of three main categories: purpose, state, and conceptual. Every physical action has an intention (Purpose). This intention may be expressed by the participants' remarks. Trying to discover signifies an exploratory state, where the participant investigates what the object can do (the "discover" code in the coding scheme). When trying to control, the participant is examining what s/he can do with the object (the "control" code in the coding scheme). Remarks of feelings and realizations are coded in the State category. There is a code for general state descriptions ("general") and a code for noticing something about the artwork ("notice"). The Conceptual category consists of four codes. Setting goals ("goal") is linked to the "control" code and the questioning of ideas ("wonder") is linked to the "discover" code. Furthermore, explanatory statements about how the system works ("explain") are also coded in this category. The final conceptual code ("selfw") is used when participants make remarks about the relationship between themselves and the artwork (Costello *et al.* 2005).

Each phase of The ToI has its own defining actions and remarks. In the response phase, the participants try to understand how their input influences the feedback of the system. Many remarks will be about the installation and

Table 2. The coding scheme, consisting of three main categories. Related to phase indicates to which phase of The ToI the code applies.

Codes	Content	Related to phase
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	Realizing, noticing recognizing	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

start with "Why ..." or "What ..." This phase is, therefore, linked to the "discover," "notice," and "wonder" codes from the coding scheme. In the control phase, the participants have theories about how they can influence the system. The participants focus more on their own actions, characterized in their statements by phrases like "It reacts to ..." and "I'm trying ..." The "control," "goal," and "explain" codes from the coding scheme are linked to the control phase. In the contemplation phase, the participants think about what the artwork is communicating. In this phase, participants are highly engaged, which encourages contemplation. They comment on thoughts passing through their heads, rather than stating opinions, e.g. "I was thinking ..." The "general" and "selfw" codes are linked to this phase. In the belonging phase, the participants feel controlled by the artwork. A difficult state to achieve and to measure, because the participants explicitly need to state they are not as conscious about what they are doing. The "general" and "selfw" codes are linked to this phase. The disengagement phase focuses on the behavior the participants display just before they stop interacting. They feel like there is nothing left to discover. This phase is not coded, because it encompasses actions and not explicit comments. The coder evaluates if a previous action sequence did occur at the end of the interaction.

The program HCS Timeline, developed at Philips, was used to code the recorded material. With this program it is possible to link certain behaviors to periods in time. Behavior was coded according to the comments the participants made, which means that only the starting point of a certain state could be coded. The state ended when a new code in the same category began. In the purpose category, a state could also end when a participant stepped back and stopped interacting. This period is then coded as undefined. It is possible that multiple codes from different main categories occur at the same time. Afterwards the data could be exported to a spreadsheet.

4.2 Results

The mean duration of interaction was 262 seconds, ranging from 75 to 655 seconds, with a SD of 177 seconds. Forty-five percentage of the participants saw all possible colors the installation could make. Only one person just saw one color. On an average the participants saw 4.6 (SD = 1.6) colors.

When asking the participants how they would define Mood Swings, most of them indicated they saw it as either art or a game. Other characterizations that were given were: living creature, computer application, living room lighting, and a communication device for a public space. Many participants saw Mood Swings as an application for children, in school, on a playground, or in a therapy room. Others could see the installation in a public space like a waiting room, so people can get into contact with each other. One participant commented he would like to see Mood Swings in an airplane, to see aggressive colors during heavy turbulence.

Twenty-five percentage of the participants mentioned emotion words in relation to the installation during interacting and/or in the questionnaire before they were explicitly mentioned. When asking about a link between emotion and Mood Swings, 47% of the respondent answered they saw a link. Most of the participants in this group stated their movements triggered certain emotions in the installation that became clear by the different colors Mood Swings showed. Others commented on the emotions Mood Swings caused in themselves. Twenty-two percentage did not see a link, and 25% were in doubt or did not know (the remaining percentage consists of missing values).

When asking the participants what they would change or if they could think of any application for Mood Swings, 19% indicated that they would like to expand the installation. This is similar to the original concept. Seventeen percent of the participants wanted to change the appearance of the installation, most comments were about the appearance of the orbs that appeared unattractive, and 11% wanted to add sound. Some participants even made drawings, which are depicted in figure 9.

4.2.1 The Trajectory of Interaction (TOI). In total, 22 sessions were videotaped. However, due to technical difficulties, in one case only part of a session was recorded. In another case, the session started with an invited duo, but after one minute three other people joined in. Because both situations were not comparable to the rest, they were omitted, which left 20 sessions that were coded. From the coding of the video images, the phases (response, control, contemplation, and disengagement) became visible, but not the belonging phase.

In many cases, the participants first read the sign before they started interacting. The response phase usually began with very carefully touching the orb, softly pushing it or holding it in the palm of the hand. This phase is overall characterized by gentle movements. Furthermore, because the participants are trying to figure out how the installation works, many questions are asked; e.g. "Why is that one blue?" and "What does it react to?" Most participants figure out that the installation reacts to movement.
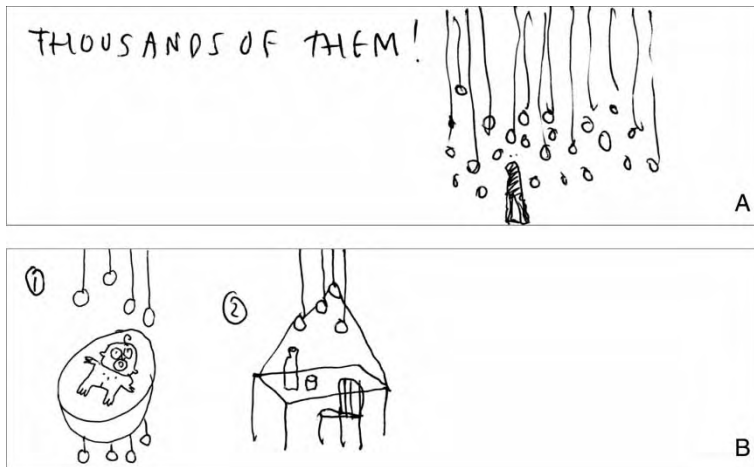
Figure 9. (A) Answer of participant 33 on the question how to improve Mood Swings. (B) Answer of participant 33 on the question to think of a purpose for Mood Swings.

However, in developing theories, participants try all kinds of different strategies. Some start talking to the orbs to see if they react to sound, while others try squeezing the orbs. Some participants were convinced that the number of times you tap the orbs make them light up in different colors. Although they did not understand how it worked, they understood how to work it. Like Costello *et al.* (2005, 53) describe it: "it is not actually correctly understanding how the system works that is key for the experience of this phase, but how it is perceived to work." An important moment in this phase was seeing multiple colors. Usually this was accompanied by a change in movement behavior. When the participants saw it was possible to create multiple colors they, would start to form theories about how the installation worked. Remarkable was that two participants stated they would like to see a red color before they even knew it was possible to make this color. One of the two mostly saw green orbs and stated that it was not possible to make the orbs red, because they were relaxing.

After forming theories about how the system might work, the participants started to test the theories. They wanted to be in control. Three participants did not reach the control phase. Grabbing an orb and making more strong movements is a common behavior in the control phase. Another common behavior (in 55% of the sessions) is making it into a game. The most popular game was trying to light all the orbs in the same color, usually green or red.

Few participants reached the contemplation phase (14%), in which the participant reflects upon the meaning communicated by the artwork. One participant commented: "Green is the normal touching, the normal state of the installation. Well maybe it is my state." Later on she stated: "Now it's blue. Maybe, I've changed." A second participant commented: "We're just like children in a playpen, who haven't grasped their toy yet." Another participant wanted to create red and stated: "I'm going to get really cross."

One of the participants who saw the installation as a living creature states: "You can provoke it, it gets angrier." In the questionnaire, he wrote: "The purpose is to show how irritating I am when I shake and disturb it. It's an animal with no function to fight back." Yet another participant described another experiment, he once participated in. He then stated that he was looking for the cause of things, so he could manipulate them consciously. Moreover, many participants commented that they would like the installation in their home as a lighting ornament.

None of the participants reached the belonging phase, in which one should feel controlled by the installation itself. The study by Costello *et al.* (2005) already showed this is a difficult phase to achieve. However, sometimes it appeared that participants became much immersed in the interaction. For example, one participant started laughing when the color red appeared and later said: "Wow!"; however, no explicit comments about being immersed in the artwork were made. This can be explained by the fact that few participants reported about their feelings. They mostly commented about how they thought the installation worked mechanically.

The final phase in The ToI is the disengagement phase. Costello *et al.* (2005) describe that all their participants ended the interaction in the control phase and that they repeated a previous action sequence from the most intense control state, just before this occurred. In this case, 50% of all participants ended in the control state. Most of them indeed repeated a previous action. When they completed their goal (e.g. winning the game), they also stopped interacting in some cases. When not stopping in the control state, participants were still discovering what exactly happened. Usually, these cases ended in stepping back, and looking at the changes. They waited until the installation was back to the start position. In some cases, the participants touched one orb softly to make it green. It is possible that the first interaction, the changing of color, was the most powerful impression.

5. Discussion and conclusions

5.1 Discussion

In our research, The ToI showed to be very useful. All phases except belonging were observed, which illustrates the generic applicability of The ToI. The results also illustrated that besides being in control during the disengagement phase, participants could also end their interaction while discovering. This difference can be explained by the fact that 36 participants were used in this study in contrast to the three participants that were used in Costello *et al.* (2005).

The think-aloud method was used for the evaluation. A disadvantage of this method was that participants mostly commented about the functioning of the installation, and not about thoughts and feelings. It is possible that more self-related responses are collected with the video-cued recall method. However, this method is more time consuming, which makes it harder to recruit participants. In addition, only one coder was used, which means that

the reliability of the results is lower than when using more coders. In a future experiment, more information about the installation could be given before the experiment starts. This could increase the personal comments, because then the working of the installation is already clear.

The mapping of movement and color to emotion was based on models from literature. The results showed a minor success concerning the meaning Mood Swings tries to communicate, because 25% of the participants mentioned emotion words or emotion related concepts, while interacting with the artwork. These participants also seemed to me more engaged during their interaction, in contrast to those who did not mention emotion words. Present research cannot explain this difference; it is probable that personality plays a role.

The participants were able to link color to emotion. Making the connection between movement and emotion proved to be more difficult. Some participants linked different colors to different states of the installation. Two participants even expected the color red before they knew it was possible to make more colors. Participants were able to discriminate between slow and fast movement. However, it remained unclear to them how the different movements relate to the different colors. This could be explained by the fact that the participants had to think about what they were doing, instead of acting more natural. When playing with the installation, they wanted to discover how it worked and were not occupied with expressing themselves.

Future research is needed to further explore the influence of different contexts on the experience of interactive art. It is also important to develop a good testing methodology. Video-cued recall seems a good start, but the drawback is that it takes a lot of time to implement.

5.2 *Further explorations*

In research about physical activity as interaction mode in video game consoles, Pasch *et al.* (2008) state there is a link between physical activity and engagement. To achieve a more enjoyable interaction, the game technology should be able to interpret the affective state of the gamer and adapt the game to steer the gamer's movements.

Currently, Mood Swings' orbs all work individually. For example, if a user wants to express joy, s/he will move quick and regular. In doing so, not all orbs will be touched in the same manner. It is possible that some orbs will move barely and light up in a color appropriate for relaxation. Mood Swings could be improved by letting the orbs learn from each other. In this fashion, the installation can calculate a mean from all the orbs and adjust the feedback more appropriately. The feedback of the system will be more cohesive, and it would be easier to include other feedback modalities like audio. Another advantage is that creating suitable games for Mood Swings will be possible, which will lead to a more natural and richer experience as discussed in Pasch *et al.* (2008). In this way, it might even be possible for a person to reach the belonging phase of The ToI.

Mood Swings was originally designed as an affective interactive art installation, with no apparent function and the goal to be fun. While observing people interacting with the system, and asking their opinion, it became clear that Mood Swings indeed has the qualities of an interactive art installation. Additionally, it can be used as a game and a communication device. By adding more functionality, Mood Swings can be more effective and even more suitable as a game or communication device.

5.3 Conclusions

Founded on a theoretical framework, Mood Swings senses movements and maps them onto emotions, which are expressed through displaying corresponding colors. Mood Swings was evaluated in a museum for contemporary art to investigate The ToI. All The ToI's phases, except one, were observed. Hence, more evidence for The ToI was collected, illustrating its generic applicability.

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