Aesthetic Resources for Technology-mediated Bodily Self-reflection: The Case of Eloquent Robes

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ABSTRACT
The use of biofeedback data is becoming increasingly popular in interactive art and design, acting as a mirror of the self. It opens up interesting avenues for facilitating technology-mediated self-reflection on the body. However, it also poses challenges for interaction design, given the semi-involuntary nature of control we have over our physiological data and the personal and social implications of externalising what is normally invisible. We describe the case of Eloquent Robes, an interactive installation, aiming to elicit self-reflective engagement with personal physiological data that normally remains concealed from our everyday awareness. The study explored methods for facilitating the subjective interpretation of heartbeat data represented in an artistic form, as an aesthetic revelation of the inner self during a moment outside the quotidian. Participants were asked to compare their results with other people’s manifestations in the form of a reflective garment, revealing a mirroring of the self in the other. Heartbeat - as a physiological data - might not be an accurate tool for prediction of another person's feelings, however when shared as a metaphor of feelings, it can be an effective tool for the generation of narratives and self-revelation. We contribute a set of design strategies for interactive biofeedback artworks that aim to address some of the challenges of using physiological data as an aesthetic resource to enhance bodily self-awareness.

Author Keywords
Biofeedback, Heartbeat, Self-awareness, Self-reflection, Wearable technology

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Interactive technologies offer interesting possibilities for aesthetic reflection grounded in subjectivity. Since technology can make evident, amplify and help us to rediscover concealed aspects of our bodily selves, technology-based design exploration offers a fertile ground for artistic as well as research inquiry. Despite the broad use of biofeedback in fields such as medicine, sport, military and game design, there is an increasing interest by artists and designers in the use of physiological data as a tool for aesthetic exploration and self-reflection. Such exploration is directly related with self-awareness of the body assisted by the amplification of the senses by means of technology. However, the use of biofeedback as a mirror of the self also poses challenges for interaction design, given the semi-involuntary nature of control humans have over their physiological behaviour and the personal and social implications of externalising what is normally invisible.

We describe the case of Eloquent Robes, an interactive installation, aiming to elicit self-reflective engagement with personal physiological data that normally remains concealed from our everyday awareness. The study explored methods for facilitating the subjective interpretation of heartbeat data represented in an artistic form, as an aesthetic revelation of the inner self during a moment outside the quotidian. An answer to the phenomenological research question of how participants interpret their biofeedback data (heartbeat) facilitated through an aesthetic resource will be unraveled through participants’ narratives.

In terms of findings, we will describe how participants’ willingness to influence their bodily responses is directly related with their self-identification towards the interactive piece. Participants were asked to compare their results with other people's manifestations in the form of a reflective garment, revealing a mirroring of the self in the other. Heartbeat - as a physiological data - might not be an accurate tool for prediction of another person’s feelings, however when shared as a metaphor of feelings, it can be an effective tool for the generation of narratives and self-revelation. We applied a conceptual tool to bring out the cyclical nature of awareness in interactive experiences grounded in bodily self-observance. How the body and the displayed biofeedback data move between the background and foreground of our awareness will be illustrated by examples from participants’ accounts.

Some of the main design challenges emerging from the design research process were ensuring self-identification with the displayed biofeedback; facilitating participants’ provision of rich responses through appropriate visual imagery; and encouraging bodily self-reflection on the participant experience of interacting with visual representations of their own physiological data. We describe a range of methods for addressing these issues, drawn from existing research, including ambiguity as a reflective resource and facilitated interaction. Finding the optimal balance between tensions of ambiguity/clarity (Gaver, Beaver et al., 2003) and the unfamiliar/familiar (Todres, 2007) will be illustrated through the unpacking
of our design process. We contribute a set of design strategies for interactive biofeedback artworks that aim to address some of the challenges of using physiological data as an aesthetic resource to enhance self-reflection.

CHALLENGES FOR DESIGNING TECHNOLOGY-MEDIATED BODILY SELF-REFLECTION
This section will describe the challenges that face the design of interactive technologies aiming to encourage bodily self-reflection through externalization of physiological data. Some of these are related to the nature of self-observation and the difficulty of sustaining a state of self-awareness in everyday life. The technical and experiential issues of working with biofeedback technology as a mirror of the self are discussed. We describe a range of methods for addressing these issues, drawn from existing research, including ambiguity as a reflective resource and facilitated interaction.

The nature of self-observance
It is important to note that we use the term bodily self-reflection as an aesthetic approach to address the issue of bodily self-awareness in technology. Our understanding of self-reflection recognizes the body as an essential part of human cognition and feeling, and a potential source of insight, information, and creativity. The process of meaning-making is performed by the body, and it is through the body that we acquire our expertise about the surrounding world (Merleau-Ponty 1962, p.153). The experience of aesthetically appreciating physiological data connects participants with their own bodies in unfamiliar ways, leading to questions regarding whether the data representation makes sense to them. The question of “making sense” might sound like a rational process of comparing and contrasting the inner and the outer world, however the abstract representations displayed by the installation do not suggest a direct answer. In this case, the open-ended answers surpass the rational process of pure understanding, remaining in the domain of the tacit (Polanyi, 1966; Todres, 2007). In this context, stimulated by technology, participants might experience a sense of trust and self-representation that is hard to explain rationally, but that is still embodied in the self. Rooted in phenomenology, this body-mind resonance finds its practical application in the psychotherapeutic technique of Focusing (Gendlin, 1978), in which psychological or emotional issues are treated from a bodily perspective. The assumption is that the body encapsulates a tacit knowledge that is useful to encounter our daily challenges. Therefore, apart from making decisions informed by reason, we are also able to feel and sense them.

Even though we inhabit our bodies, we also take them for granted. There is an evident lack of access to our bodily self-knowledge, which remains somehow obscured due to biological and social boundaries. For instance, it is impossible to look at our outer bodies directly by using our senses (Shusterman, 2003). We would need external mediators such as mirrors or cameras to see the entire vision of ourselves from the outside. Another lack of access is represented by the unavailability of our physiology from our consciousness. In this depth, our consciousness is permanently disengaged from our viscera (Leder, 1990). On this account, technology-mediated bodily self-awareness offers new spaces for existential exploration. Inspired by Heidegger’s ideas of present-at-hand, the authors (Núñez-Pacheco and Loke, 2014) coined the term “present-at-body”, which uses the body-machine exchangeable visibility as a resource for bodily self-observance and learning. The availability of both body and machine through the interactive activity, acts as a mirror of the self, connecting participants with their self-recognition as well as with new revelations emerging from the unfamiliar experience.

Biofeedback technology as a mirror of the self
With the recent emergence of biofeedback technology in art and design contexts, the novelty and unfamiliarity of audience and users with viewing and discussing aesthetic representations of physiological data, such as heartbeat, breath, or galvanic skin response, raises challenges for designing suitable conditions conducive to self-reflection and sharing of personal data.

There are technical issues inherent in working with biofeedback and physiological data, such as the semi-involuntary control humans have over physiological behaviour and the variability amongst individuals of the range and patterning of physiological data. For artists and designers working with this kind of data, they are often reliant on third-party open-source software libraries or bespoke software for processing the signal data.

As important as the reliability of the data, is the need for participants to recognize the biofeedback data as their own, in order for the interaction to be meaningful. In this way, interactive technology acts as a mirror. In the interactive experience, participants nurture the machine with their physiological data. When this information is reflected back, participants should recognize this data as personal. This recognition or mirroring through interactive technologies allows the emergence of the sense of self (Rokey, 1995). Unreliable display of data can threaten the emergence of self-identification and interrupt the process of reflective observance. Furthermore, aside from what is distinguishable from the reflected data, the filtered and transformed interpretation displayed by the machine - the unfamiliar - challenges our preconceptions, encouraging reflection (ibid).

Methods for designing conditions for technology-mediated bodily self-reflection
In terms of designing interactive biofeedback experiences that encourage reflective self-awareness, the challenge is to find a balance between a clear set of instructions to avoid distractions from the task, and how aesthetics plays a role in the subjective meaning transmitted by the interactive piece.

Ambiguity as a reflective resource
In other words, interactive designers and artists have to master the art of managing ambiguity, which has been traditionally seen as undesirable for Human Computer Interaction (HCI) (Sengers and Gaver, 2006). However, the power of ambiguity is a valuable source for reflection,
being a property of the interpretative relationship between people and artefacts, making interactive objects more evocative than didactic and mysterious rather than explicit (Gaver, Beaver et al., 2003). The exploration of ambiguity as a resource for discussion is described through the iteration of the biofeedback public installation Cardiomorphologies, an interactive piece that functions through heartbeat and breath measurements, developed by the artist George Khut and described by Muller et al. (2006). Part of the scope of this work is situated in the visualisation and characteristics of the displayed data. After experimenting with three different sets of interactive imagery it was founded that highly complex visualisations as representations of biofeedback data may have an important aesthetic value, however such characteristics can diminish the ability to act as a reflective tool for self-knowledge due to lack of clarity.

Even though it is not simple to combine the HCI approach to evaluation with the goals of art, the inclusion of user testing in artistic contexts can refine how the message is delivered to the audience. Höök et al. (2003) explore this issue through the case study of the installation The Influencing Machine, a device intending to establish a dialogue with the audience by means of sharing metaphors of emotional responses. This study illustrates how deficient interaction design choices can be avoided by the application of user evaluation at early stages. Aspects such as lack of control of the displayed feedback and unclear communicative metaphors arising from the interaction with the machine lead to frustration of most participants. We could infer that in the case of installations that use biofeedback data, this aspect is particularly critical considering that physiological data cannot be easily controlled, but rather influenced. User evaluations even in earlier stages of development are crucial in order to establish a coherent connection between the displayed data and the sense of self-identification towards the piece. The user has to perceive there is a correlation between the displayed data and the actual bodily state. Once the user recognises the data as belonging to him or her self, self-reflection may start being achieved (Núñez-Pacheco and Loke, 2014) Considering also the ambiguity-clarity equation, the design of systems for self-observance is complex and has to be able to mirror the self by considering the intricate nature of human beings.

**Facilitated interaction**

In the case of Eloquent Robes, the main interaction goals were to keep the interaction clear and controlled, avoid faulty manipulation of the system and provide an engaging and reflective interactive experience. Facilitated interaction was selected as a method of framing the interactive experience, as guided experiences of interactions can assist somatic exploration and self-awareness.

Facilitated interactions and guided experiences fall into the category of second-person methodologies. Second-person methodologies can be defined as “an exchange between situated individuals focusing on a specific experiential content developed from a first person position” (Depraz, Varela et al., 2003). The first-person position refers to the standpoint of the subjective experiencing of the individual. In this case, the designer facilitates the exploration of the participant’s subjectivity. Loke and Khut (2014) have devised a Facilitated Interaction Framework for generating and evaluating interactive experiences, informed by Forlizzi and Battarbee’s (2004) interaction-centred framework and Benford et al.’s (2009) framework for mixed reality performance. The framework presents a model for a facilitated interactive experience, composed of four stages: Welcoming, Fitting and Induction, The Ride, Debriefing and Documentation.

One of the examples illustrating the application of the framework is The Heart Library by artist George Khut. It combines interactive heart rate controlled audio-visuals with audience participation to create a unique environment where people can reflect, explore and share experiences connected to ideas of embodiment, body-mind and presence (Loke and Khut, 2014, p.98-101). In order to assist participants in coping with their sense of unfamiliarity, the role of the facilitator was crucial to contextualize the experience and induct them in the new experiential world.

The second example, Speechless is an artistic interactive installation that emulated the journey through a whale’s body as a metaphor of personal exploration (Loke and Khut, 2014, p.102-105; Loke et al., 2012). This work borrowed techniques from ritual and the performative arts, such as the Live Art model in which the artists’ participation is a fundamental part of the aesthetic experience. One of the positive features about introducing ritual and scripted experiences is the diminishment of possible issues such as disengaged or passive observation. It is also useful to restrict certain behaviours that could lead to undesirable ways of dealing towards artefacts or scenarios (ibid). These constraints also allow participants to be aware of their bodily experience, without being distracted by the lack of familiarity with the experience itself.

In the context of second-person methodologies, Schiphorst (2011) describes the importance of somatic facilitation in enriching the design in a multidisciplinary context by bridging somatic connoisseurship with HCI. By means of facilitating the interactive experience, the artist is also connecting his or her experiences with others. In that sense, somatic facilitation requires the ability to engage in empathic mediation and interpret subtle aspects of participant’s shared experiences.

By exploring concepts such as guided experiences or intimacy as existential milestones, the purpose of this approach to technology is to generate impact in participants through the emergence of unique experiences and memorable messages. Wearable biofeedback technologies can do so by extending and enhancing the aesthetic phenomena that surrounds the body, including making evident internal physiological data via visualisation and sonification as elements for new dimensions of self-understanding.
THE INSTALLATION: ELOQUENT ROBES

Eloquent Robes is an interactive art installation that uses visualisations of heartbeat data to communicate and make evident intimate physiological information. The nomenclature Eloquent Robes refers to a garment that decodes a user’s internal data by utilising abstract representations in order to enhance the creation of personal narratives. Such garments aim to induce reflection and self-recognition by mirroring the self in the artefact.

Figure 1. Setup and equipment of Eloquent Robes

The person participating in the installation is dressed with a fabric undergarment containing a large pocket positioned between the shoulder blades. This pocket holds electronic components such as an Arduino UNO, wireless communication devices (XBee), a pulse sensor and batteries. A red LED positioned on the upper front of the garment continuously blinks as a real-time indicator of the user’s heartbeat. A personal white crepe paper garment covers the undergarment and the participant’s actual clothing. Pulse data in the shape of coloured circles is projected on the garment (Figure 2). The mapping between the colour and heartbeat was divided into six ranges. The colour selection is designed to be easy to grasp through the use of metaphoric associations common in design, where the warmer the colour, the faster the heartbeat. Participants are invited to observe the accumulative emergence of these coloured circles and pay attention to their body signals and changes.

Figure 2. View under the projection

At the end of the 8 minutes of interaction, the paper garment is displayed on a mannequin, over which an image captured from the last moment of the interaction is projected. Then the participant is asked to stick coloured circles onto them, manifesting and matching the most memorable spots projected over their bodies. After the generation of what we called a “reflective garment”, they compare their results with another reflective garment randomly selected from previous participants. At the end of the experience, participants have become part of the creation of the piece, by customising a unique and personal garment.

Garment Construction

The crafting of garments was directed towards the concept of generation of a unique experience outside the quotidian. The paper garment design is inspired by some principles of Japanese design, in which traditional dress was conceived as a genderless piece that flattens the body (Fukai, 1996). Following this same trend, 20th century's Japanese fashion design tended to modify the perception of the body rather than highlighting its natural shape. By using this principle, the concept is enclosing and altering the shape of the body in a subtle manner, in order to guide participants to pay attention particularly to their lap, the part of the body that the projected images can be most easily visualised at the moment of interacting. The secondary objective of employing this principle is to increase participants’ sense of aura or vital space. According to Fukai (1996) the concept of the space (ma) generated between the body and the garment is the main difference between Japanese fashion design and Western concept of clothing.

Figure 3. Paper garment

Body Fitting

The design was conceived to enclose the body and fit in different sizes and body shapes, aspects that were tested as part of the technical issues of this installation. The robe's design is placed open over the body without any sewing, joined by pieces of ribbon. Moreover, the garment's fishtail or folded part of the design allows the wearer to place part of it in front of their sight, capturing the images that are projected over their lap, functioning as body extension and distorting part of the visualisation as an artistic resource for ambiguity.

Materiality was also important as a metaphor in the design of the external garment (Figure 3). One of the challenges was to find a fragile material to represent the idea of temporary suspension from the outside world as well as an access to the ephemeral and strange. Paper is generally regarded as not wearable or durable, but rather
as a single-use material, suggesting the temporary nature of the experience. However, the introduction of ribbon as wearable material aimed to generate certain ambiguity regarding the nature of the garments as disposable.

Imagery
One of the objectives behind the creation of imagery was the design of simple visualisations able to elicit open-ended responses. The chosen pattern consisted of coloured circles emerging at a relatively random pace, in a range between one and three seconds. The image size varied slightly, also following a randomly generated pattern. In terms of metaphor, the imagery was inspired by the creative interpretation of blood cells arising from the human-machine interaction – that is, the machine cannot function autonomously without being nurtured by a human body.

Development of Script for Facilitating Interaction
Some elements of ritual interaction were included in the user testing session. Even though sessions were run in an environment similar to a design laboratory, the space was reconditioned and cleaned up. The facilitator invited the participant to take off their shoes before being introduced to the protocol. Apart from guiding the experience by following a script - which ensured the provision of the same instructions to all the participants - the facilitator was in charge to dress up the participants, as part of the ritual. These simple steps had as an objective the suspension of the participant’s natural attitude or ritual. These simple steps had as an objective the suspension of the participant’s natural attitude or immersion in his or her quotidian mode of living. This approach to suspension is influenced by phenomenological research methods (Moustakas, 1994; Todres, 2007) and particularly applied in psychological research. It is also found in ritual performance (Turner, 1982; Schechner, 2003) and more recently in the crossover between interactive art and ritual performance (Loke et al., 2012; Loke and Khut, 2014).

Having chosen guiding the interactive experience as a mode of fostering self-exploration, some considerations arise from the use of the script designed for such end. Explorations through pilot studies demonstrated the importance of delivering a neutral set of instructions in order to minimise unwanted bias apart from participants’ focus on themselves. It was observed that a poor phrasing of such instructions could heavily influence the way the installation is perceived, compromising the validity of the study. This issue led to the exploration of methods that could assist in the enhancement of self-awareness and reflection, by minimising such problems. Part of the draft script was delivered as below:

(Showing the device to the participant) “This is a pulse sensor, that will detect your heartbeat, and according to your internal data different colours in a shape of dots will be displayed. The warmer the colour, the faster your heart beat. You can see the details of every numeric value in (pointing at the projection) this image at the top right corner (Figure 1)”

![Figure 4. Ranges of heartbeat represented by colours and displayed in the projection.](image)

As a result of this apparently minor change of wording in the script, participants expanded their range of responses during the installation’s final version as seen in Table 1.

<table>
<thead>
<tr>
<th>Active</th>
<th>Contemplative</th>
<th>Green</th>
<th>Outgoing</th>
<th>Rude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beautiful</td>
<td>Detailed</td>
<td>Ignorant</td>
<td>Peaceful</td>
<td>Showy</td>
</tr>
<tr>
<td>Calm</td>
<td>Excited</td>
<td>Intimate</td>
<td>Relaxed</td>
<td>Subtle</td>
</tr>
<tr>
<td>Cautious</td>
<td>Fragile</td>
<td>Lazy</td>
<td>Reserved</td>
<td>Vibrant</td>
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</tbody>
</table>

This approach shows how a certain degree of controlled ambiguity is relevant in order to elicit participant’s variety of responses. Sengers and Gaver (2006) elaborate a set of design strategies that describe the importance of clearly specifying aspects of usability without constraining the use of systems. In our case, even though the interaction is guided by means of a pre-defined set of instructions and actions designed to reduce bias in participants’ responses, instructions regarding their approach to data remain open to exploration and interpretation. In that sense, participants were free to explore the possibilities of the interactive artwork by trying to influence their heartbeat as well as remain as witnesses to their own internal process. More details about this topic will be addressed in the Findings section.

USER TESTING RESULTS AND FINDINGS
Nine participants took part in individual user testing sessions of 50 minutes duration. Each participant was guided through the process of interaction, elaborated above. The sessions were videotaped for later analysis. The analysis resulted in the following set of insights into the relationships between the designed interactive piece, participant’s levels of self-identification with the representations of their heartbeat data and their levels of bodily self-reflection. Even though results cannot be generalisable due to the small sample of participants, they offer interesting insights that open up new inquiries and

![Image of colour spectrum with numbers]
design opportunities for interactive installations that utilise self-observance as a tool for reflection.

**Aesthetics of garments and self-identification:**
Aesthetics is one of the aspects that might have influenced the mirroring of the self in the reflective garment. One of the aesthetic aims behind the creation of *Eloquent Robes* was the design of gender-neutral garments. Design itself can be efficient for the purposes that it was created, in this case, to enclose the body and display the projected images in a proper manner. However, it has to be considered that the design of apparel for ritual is certainly different from everyday clothing. The main difference between the two is that everyday clothing may embody aspects such as individuality and change more related with fashion, ritual clothing is strictly tied with tradition, or anti-fashion values (Barnard, 1996). It raised concerns regarding the reception of the paper garments by some male participants due to its similarities with apparel generally considered as feminine. For that reason, garments were presented to male participants as "samurai robes" in order to diminish any possible discomfort and consequently distraction.

As a consequence, when asked about the aesthetics of the installation, the total of 5 male and 4 female participants showed slightly relative differences. The totality of male participants evaluated aesthetics as “satisfactory”, whereas all female participants identified themselves as “very satisfied” with the aesthetic aspects of the experience. In addition, perceptions of general experience matched with opinion regarding aesthetics. During the interviews, all female participants spontaneously referred to the beauty of the garment and the projection as a fundamental aspect of their general experience. In that sense, the perception of feminine clothing might have played an important role in this study, even though only one male participant directly manifested his opinion about this particular characteristic.

Nevertheless, even though some aesthetic aspects of the installation might have influence in self-identification with the experience, it was observed that this aspect was not the most relevant factor for reaching such a state of ownership towards the displayed data.

**Ownership and self-identification - Differences between active and passive participants:**
In terms of how participants approached the displayed data, they can be divided into two groups: active and passive. Such categories emerged spontaneously and participants were never asked to situate themselves within them. Active participants are those who tried to influence the interactive possibilities of the installation, even though heartbeat is a physiological function evidently difficult to control.

"I was focusing on being calm, so then my heartbeat would go down and it was really interesting to see where the next dot would come up, and which colour it would have (...) I tried to be calm and relaxed. Actually it works; the dots got between green and yellow."

On the other hand, passive participants are those who remained inactive, waiting for changes in the visuals, mostly without any conscious attempt to influence the displayed imagery during this process. They tended to interpret the interactive experience as a possibility for contemplation, aiming to be lured and engaged by the artwork. As one participant expressed:

"The part I enjoyed the most? Just sit and wait until the dots come up."

In terms of how this difference impacted on how the installation was perceived, all of the active participants (6 out of 9) assessed their self-identification to the artistic piece with the highest qualification. On the other hand, even though passive participants evaluated positively the aspect of “self-identification”, they did not reach the highest qualification. As a result, there is a possible correlation between self-attribute of the displayed data and willingness to control it. It means that the level of involvement with the experience as well as the sense of ownership comes with the will to influence the data somehow.

**Mirroring the self in the other:**
In addition, except for one subject, participants who expressed the highest levels of self-identification towards the experience were more open to verbalise their theories about others through comparisons. By comparing reflective garments it was possible to mirror participant's feeling and self-attributions, obtaining more personal responses than by means of direct questions such as: "How did you experience interacting with this installation?" or "Do you believe that this representation interprets your mood in some sense?" The common answers to such questions were based on judgement in terms of aesthetics, as well as some brief descriptions of feelings arising from the interactive experience. In addition, most participants tended to unconsciously situate themselves as active or passive during early stages of the interview. Nevertheless, after being consulted about others’ feelings by comparing reflective garments, most participants revealed new information related to themselves. Unintendedly, the installation functioned as a projective tool in some sense. The next example shows how a participant refers to herself when contrasting her reflective garment with another one randomly selected.

**Participant:** He was feeling very attracted by hot colours, red, orange and yellow. He was putting these more than blue.

**Interviewer:** Which kind of person do you think could feel attracted towards these warm colours?

**P:** I think that a very enthusiastic, maybe a really active guy or girl. I think I would be putting more blues, or other milder colours.

**I:** Are you suggesting that you're less enthusiastic than this person?

**P:** (Pause) Maybe I'm more detailed, you know, you have so many options here, I would put any single colour rather than just focusing on the warmer ones.
In contrast with the participant’s inference, rather than being enthusiastic, the person who crafted the previous reflective garment was particularly impassive and calm during the interview. Despite the fact that such garment was mostly saturated with warm colours, the participant described being relaxed during the interaction. Furthermore, he referred to the experience by using few words in a slow pace, keeping his feelings private.

In a different example, another participant also projected her subjectivity through the other’s artefact, revealing more about herself through the comparison. Even before asking the question, she reacted at the moment the second garment was displayed as shown in figure 5.

In a different example, another participant also projected her subjectivity through the other’s artefact, revealing more about herself through the comparison. Even before asking the question, she reacted at the moment the second garment was displayed as shown in figure 5.

**Figure 5. The outgoing and the reserved.**

P- Very different to mine!

I – This one belongs to a previous participant. What do you think this person was feeling?

P- I think this person was very calm and cautious where to put the dots. He was like a designer measuring the space (...) I think it expresses the personality type. Maybe this person is more reserved... maybe.

I- If you compare yourself to this person according to his/her garment, could you find similarities and differences? How do you think it is?

P- Definitely different. I feel like this person is a lot more reserved. Compared with this person I'm more show off. It's like "look at on my dots". Different personality type, this one is shy, and this other (hers) more outgoing.

I - Do you consider yourself like that (more outgoing)?

P - Well, I consider myself like that when I see my garments, my clothes. I like more showy clothes. Maybe I'm more reserved, but sometimes I don't wanna be seen by the world like that, so I show myself more expressive.

In this case, at the end of the dialogue the participant admits to be more “reserved”, as shown in the other person’s garment. However, she did not want to be seen like a reserved person at all times.

In another example that shows how participant's feelings are reflected through comparison, one of the participants was worried about the fact that she had to be at the airport, so her interview was particularly brief. When comparing the garments, she said: “I see a flower; maybe this person was thinking in the outside”.

Self-projection in the other through comparison was a predominant feature during interviews. It seems that by means of comparisons, participants are not only open to describe obvious differences, but they may also reveal personal desires, secrets or existential contradictions.

**Self-awareness is cyclical when the body is the focus of attention:**

As described in Núñez-Pacheco and Loke (2014) and illustrated in Figure 6, self-awareness is cyclical in our approach to body-centred technology, which is defined as technology that utilises self-awareness as a resource for self-growth and understanding. Even though body-centred technology encourages the awareness of the self over the machine and context, the body and device moves constantly between the foreground and the background of our consciousness. This leads to bodily data that becomes evident by means of the visibility of the device. Such visibility fluctuates between the attentional focus on device and the body. In that sense, stages of body-tool visibility through the interaction were detected in Eloquent Robes. Through each stage of visibility/invisibility of the body-device, extracts from different interview data will be quoted in order to exemplify the cycle's dynamics.

**1 - The interaction starts with the placement of wearable technology on the body:** Awareness towards the body as well as the device is evoked and both become visible. In Eloquent Robes, this stage of awareness is particularly enhanced by the aesthetic ritualisation from the beginning of the experience. For instance, the request of taking the shoes off as well as being dressed up was surprising for most participants. In addition, the pulse sensor’s...

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**Cyclical process**

<table>
<thead>
<tr>
<th>STAGES OF INTERACTION</th>
<th>BODY AND DEVICE</th>
<th>DEVICE FEEDBACK</th>
<th>BODILY FEEDBACK</th>
<th>DEVICE FEEDBACK</th>
<th>BODILY FEEDBACK</th>
<th>SURROUNDING CONTEXT</th>
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<tbody>
<tr>
<td>1 - Interaction starts with placement on the body</td>
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<td>2 - Feedback recognition and understanding</td>
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<tr>
<td>3 - Feedback ownership</td>
<td>Bodily interaction</td>
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<tr>
<td>4 - Observation on device for changes in display</td>
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<tr>
<td>5 - Feedback ownership</td>
<td>Bodily interaction</td>
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<tr>
<td>6 - Interaction finishes</td>
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**Figure 6. Cycle of awareness between the body and the device.**
functioning was described while simultaneously placed on the body. Such actions were intended to situate participants in a self-focused mode of consciousness.

2 - Feedback recognition and understanding: The device starts functioning, drawing attention towards its feedback. Through careful observation we interiorize the interactive task as well as the device’s features. Aspects such as assessing the correct functioning of the device in correlation with our perception are observed during this stage.

“At the start there was not much change in the colour because I wasn’t moving so... the start was a little bit confusing. I wasn’t sure if my heartbeat was exactly just there, but the question was on myself. But soon as I started talking, my heartbeat went up and I started getting my first pair of orange dots, so I think that made the whole image more... clear then”.

3 - Feedback ownership and interaction: After the device is examined, we recognize and accept the displayed data as belonging to the body. We experience a sense of ownership towards its feedback. The body purposely interacts with the feedback in order to generate some changes in the display. At this stage, awareness is located mostly on the body, which we term hyper-aware. One example of this type of interaction is a subject trying to control his or her breath in order to change a determined output. The body itself provides feedback on our endeavours to changes its state.

In the next example, rather than focusing on the projection, one of the participants started his interaction by paying attention to the red light situated over the heart.

“I was trying to figure it out if I could feel my heartbeat and trying to see if it matched the red light. I was trying to do that for a while”.

4- Observation on device for changes in display: The cycle re-starts from the point that the device responds and draws attention to its feedback in order to re-confirm that the displayed information belongs to the body.

“I was focusing on being calm, so then my heartbeat would go down and it was really interesting to see where the next dot would come up, and which colour it would have. (...) I tried to be calm and relaxed. Actually it works; the dots got between green and yellow. Initially it was really red, because I was... yeah, I wasn’t exercising but I was walking around and I was a bit excited”.

If the interactive experience makes sense to the participant, feelings such as self-identification, enjoyment and relaxation start mostly between stages 3 and 4. On the other hand, frustration can start emerging earlier during stage 2 if the feedback is not recognised as belonging to the body and interpreted as fake or deficient. Conversely, the lack of control over the data during stage 3 and 4 may also lead to dissatisfaction towards the interactive experience.

5- Feedback ownership and interaction: Reconfirmation. The relationship between ownership towards the data, interaction, bodily feedback and then, observation in the display becomes cyclical.

6- Interaction ends: The device stops functioning. The light in the room is turned on and the devices are removed from the participant’s body. Body and device may become transparent, as awareness is now directed to the surrounding context. In Eloquent Robes, after the interaction with the device, participants were asked to personalise their paper garments in order to foster reflection as well as retain part of the bodily sensations emerging from the interaction. However, the attentional focus is mostly on the crafting activity as an objective outside of the body.

Discomfort of device minimised through the cycle of awareness:

During the interview sessions, four out of nine participants expressed that the weight of the equipment was somehow uncomfortable for them. However, three of them added that they forgot this discomfort after they started interacting with the installation. The fourth subject expressed that her device intermittently appeared and disappeared from her consciousness during the experience. Interestingly, despite the complaints about the equipment’s weight, three out of four of these participants assessed self-identification towards the data with the highest qualification, which suggests that in the case of technologies that use self-awareness as a tool, the comfort of the device may be secondary compared with other aspects such as trust in data reliability and also the provision of engaging imagery that stimulates the generation of theories for self-attributions.

DESIGN STRATEGIES

We now discuss a set of design strategies for interactive biofeedback artworks that aim to address some of the challenges of using physiological data as an aesthetic resource to enhance self-reflection. These strategies have been derived from our experience of designing and testing the Eloquent Robes installation.

1. Stable technology to elicit self-identification: One of the design challenges of Eloquent Robes was the transmission of a sense of self-identification with the piece in order to reflect on the bodily experience. Towards facilitating this process, the avoidance of external distractions was a crucial factor to elicit aspects such as intimacy and self-observance. In this process of facilitating self-identification, there is a design tension between the use of trustworthy data and aspects such as wearability and comfort.

From pilot studies it was observed that trust of data was a relevant aspect to consider in keeping participants engaged with the artwork. When such data reading did not make sense to participants during early stages of awareness (see figure 6, stage 2), they mostly withdrew from the activity after a few seconds of interaction.

In terms of choice of available technology, the use of Pulse Sensor¹ embodied some desirable characteristics

¹ www.pulsesensor.com, Non-amped, 3V version
such as simplicity and wearability. However, during the prototyping process it was noted that the stability of data displayed by the sensor varied depending on which microcontroller was utilised to process such data. For instance, small wearable microprocessors such as LilyPad Arduino were more sensitive to electronic noise than Arduino UNO. Considering the design constraints, it was decided to prioritise stability of data over wearability. This raised some concerns about the role of the device’s weight in participants’ comfort and possible disengagement with the task. However, as seen previously, even though most participants noticed the equipment’s presence, this aspect did not seriously affect their engagement with the piece. In that sense, even though wearability and comfort are fundamental aspects for interactive systems, it can be negotiated in some cases. For instance, some relevant questions to put into consideration are: Is the interactive experience aiming to facilitate self-reflection? Are participants gaining new insights about themselves?

In Eloquent Robes, participants remained in a fixed position, focused on themselves and the displayed output. Furthermore, the fact that this personal data is generally concealed and rarely displayed in an aesthetic form could have had a positive impact in the tolerance of participants in order to satisfy their curiosity.

2. The unfamiliar as a resource for reflection: How can designers foster narratives for self-reflection in their creations? Phenomenological research brings some interesting perspectives regarding unfamiliar scenarios as resource to stimulate participants’ imagination. Especially in transcendental phenomenology, the emphasis on intuition, imagination and how the speech is structured are fundamental to understand how the dynamics of experience are constructed (Moustakas, 1994). This imaginative state facilitates the deep understanding of the situation, by the dynamic interplay between what is considered “normal” and “abnormal”. Where everything can be considered as “normal” and therefore familiar, there is no real need for understanding (Steinbock in Todres, 2007).

In terms of how to translate these ideas to design solutions, unfamiliar does not necessarily mean something completely unexplored, but rather slightly modified. A completely alien approach can be disorienting for subjects, and therefore disturbing, detached from reality and incomprehensible. Unfamiliar implies revisiting the familiar in a slightly different way in order to foster understanding of the world that surrounds us (Todres, 2007). The installation features such as the design of a familiar artefact (garment) crafted with an unfamiliar material (paper), the use of performative elements of ritual as well as the externalisation of heartbeat through coloured circles as metaphor of blood cells were not arbitrary design choices. They were designed to stimulate reflection and self-awareness, a state of consciousness that tends to remain normally concealed behind our daily routines.

3. Reflecting the self in customised objects: Another method for stimulating reflection is through customising objects as metaphors of feelings. This strategy is particularly useful for interactive experiences that encourage bodily self-reflection, since the body itself is not always available to our consciousness (Leder, 1990). Rather, human beings tend to be focused on the surrounding context as an everyday mode of living. When language is insufficient to express outcomes from abstract experiences such as those grounded in the body, customised objects can function as guidelines of unspoken feelings. Firstly, by customising the garments by reflective evocation, participants were able to connect themselves with their creation as well as to revisit the interactive experience. Secondly, apart from focusing on recreating the experience by itself, participants can recall their experiences by speaking through the object, which acts as a facilitator of reflection.

Furthermore, more objects can be introduced to provide new sources of reference as well as enrich the provision of metaphors for self-awareness. Apart from facilitating reflection as clues, the other person’s object can facilitate the projection of his or her own feelings by comparison. As seen in previous examples, participants tended to reflect more about themselves by having an external reference with which to obtain further ideas. As a result, such comparisons should not necessarily being used as tools for obtaining explicit answers regarding others’ needs and desires, but rather as projective artefacts of the self. It was observed that even though participants tried to theorise about the other’s feelings, they returned to themselves at some point. In that sense, reflective artefacts might not be an accurate tool for prediction of another person's intimate thoughts and feelings, however when shared as a metaphor of feelings, it can be an effective tool for the generation of narratives and self-revelation.

CONCLUSION

In this paper, we presented the case of Eloquent Robes as an interactive art installation that encourages bodily self-reflection through technology-mediated interactions with heartbeat data. The study explored methods for facilitating the subjective interpretation of heartbeat data represented in an artistic form, as an aesthetic revelation of the inner self during a moment outside the quotidien. Several design challenges associated with encouraging self-reflection through the application of biofeedback data in artistic settings were explored and resolved through the careful use of ambiguity in visual aesthetic design and facilitated interaction. The crafting of a reflective garment acted as a visual display surface during the interaction, as well as a participant customised object for drawing out self-reflective narratives on their interactive experience.

The key findings from the study highlighted the importance of stable biofeedback data and clear visual data representation to establish ownership of the data, with a strong correlation between active engagement and self-identification with the piece. It was discovered that participants who tried to influence their internal data felt more self-attached towards the interactive experience than those participants who decided to observe the visualisations with no further bodily intervention.
By comparing their customised reflective garment with another, participants were more open to reveal further intimate information about themselves, revealing a mirroring of the self in the other and a tendency to use external references as a projective tool for self-revelation. Further analysis was conducted on the study data by applying a conceptual tool to bring out a cycle of awareness between the appearance of the body and displayed feedback, exemplified through participants’ descriptions of their interactive experience. As a complementary finding, it was observed that the discomfort caused by the heaviness of the device disappeared from participant’s consciousness through the cycle of awareness previously described.

Finally, we propose three design strategies for interactive biofeedback artworks that aim to address some of the challenges of using physiological data as an aesthetic resource to enhance self-reflection. These are (1) To provide stable technology to elicit self-identification, (2) Use the unfamiliar as a resource for reflection and (3) The use of customised objects as reflective and projective clues for obtaining a richer variety of participants’ perspectives.

In summary, Eloquent Robes offers the possibility to reinterpret a biological function from the aesthetic perspective of art and design. Eloquent Robes represents a brief moment of silent self-contemplation in a world where stimuli generally comes from the outside. By offering artefacts displaying aesthetic representations of internal physiological data, participants were able to become aware of, and reflect on, their bodily state – both in real-time interaction with the system, and through later reflection on other’s customised artefacts. This approach opens up opportunities for designers for the creation of reflective and projective artefacts that stimulate the emergence of spaces for aesthetic bodily self-observance.

REFERENCES


