The body as mediator of music in the Emotion Light

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ABSTRACT

This paper describes the development of the *Emotion Light*, an interactive biofeedback artwork where the user listens to a piece of electronic music whilst holding a semi-transparent sculpture that tracks his/her bodily responses and translates these into changing light patterns that emerge from the sculpture. The context of this work is briefly described and the questions it poses are derived from interviews held with audience members.

Keywords

Interactive biofeedback artwork, music and emotion, novel interfaces, practice based research, bodily response, heart rate, biosignals, affective computing, aesthetic interaction, mediating body, biology inspired system

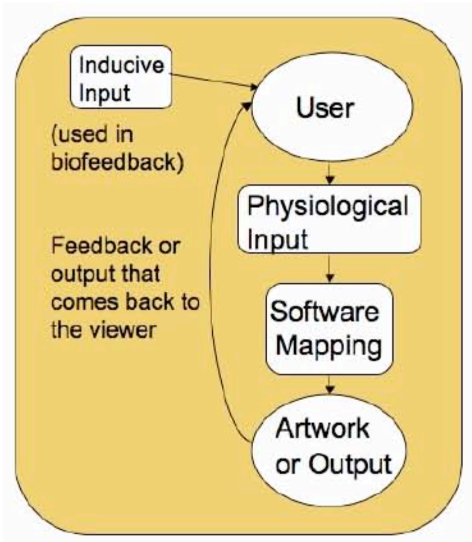
1. INTRODUCTION

Music is often composed not only to express certain emotional states but also to generate these in the listener. I wanted to make an interface that would be able to reflect back such a personal/emotive reaction to music. Biosignals are indicative of emotional variation [1,7,2,3] but there is no one-to-one relationship between particular emotions and values per biosignal. The best-known electrical biosignals are the Electroencephalogram (EEG), the Magnetoencephalogram (MEG), Galvanic skin response (GSR), the Electrocardiogram (ECG/EKG), the Electromyogram (EMG) and Heart Rate Variability (HRV). Emotion research is usually carried out in laboratory settings and results from there cannot necessarily be reproduced in a less controllable setting such as a gallery or conference hall. However, varying arousal levels can quite accurately be obtained from biosignals even in non- laboratory settings.

Originally it was thought that the autonomic nervous system was fully automatic and beyond human control. The arrival of biofeedback technology in the sixties changed this. One can speak of a biofeedback system when it is designed not only to reflect back one's physiological signals but also to help the user reach a specific target state. Biofeedback was experimented with as a treatment for various medical conditions like hypertension [18, 4] and asthma [20, 9]. Although the medical claims in terms of what can be achieved through biofeedback have become more humble than they were in the seventies, the technology has shown that it can help humans to learn to control physiological processes like heart rate, body temperature and blood pressure and it is still used in therapy [17].

The musician and pioneer David Roosenboom made it his life's work to investigate the aesthetic potential of biofeedback. He suggested that the biofeedback interface has to provide both an inducive input and a negative feedback [15]. The latter allows the user to see how far off the goal s/he is and the inducive input helps the user to reach the desired state. This can be visualized in the following diagram.

Diagram 1. System of an interactive biofeedback artwork



2. CONTEXT

An early example of a biofeedback artwork that follows this schematic is Rosenboom's *Ecology of the Skin*, made between 1970 and 1971, where the EEG (Electroencephalogram) and EKG (Electrocardiogram) signals of ten participants are tracked and used to control musical textures. Each participant has a little box that plays a simple tone when the holder is producing alpha waves. It starts at a low volume, but the longer the participant spends in the alpha range, the more control they can gain over the volume of their sound output. The light in the space is a monochromatic blue, and there are twenty light show stations that aim to give the audience an electronic stimulation of phosphenes through low current pulses at alpha frequency [14]. The light and the phosphenes are the inductive inputs and the feedback is the sound output.

A recent example that follows the same model is George Khut's *Heart Library Project,* made in 2008-2009. There, the participant lies down on a bench in a darkened room. Holding two heart rate sensors and looking up at the ceiling, the participant sees their own image as an inverted black and white projection floating above them. Superimposed onto this are small floating circles that change colour depending on the arousal level of the participant, with a high arousal mapped to red and a low arousal to blue. A high heart rate varience is mapped to a higher intensity of the colour [12]. Here the inductive input is the image of ones floating self, projected above on the ceiling. Also, lying down induces a calmer state. The negative feedback is the colour and the intensity of the circles. Other examples of artists who have used biofeedback are Mariko Mori, Brigitta Zics, and Char Davis.

3. The *Emotion Light*

The Emotion Light is a sculptural light that uses biofeedback technology to visualize the holder's physiological state. To achieve this, changes in physiological data like GSR (galvanic skin response), heart rate and movement are tracked and translated via code into changes in light patterns. A high arousal level is mapped to red and a low arousal level is mapped to blue with in between is the sliding colour scale of green, yellow, orange. The heart rate is directly reflected in the speed of the pulse of the light. When the user moves the light too much, the light first darkens and then switches off; when it is held still the lightshow plays at full intensity. In the *Emotion Light,* the inductive input is the music one listens to, as this aims to gradually calm down the user. The negative feedback is the colour of the light as the user can quickly assess how far away s/he still is from the blue colour.

Figure 1. Gallery visitor interacting with the *Emotion Light*, *Version 3,* Reg Vardy Gallery, November 2011.

The intention of the *Emotion Light* was to create a wireless artwork where aesthetic experience and technology merge on all levels. Using biofeedback, sculpture, light and sound it aimed to provide an experience that allows the user to see how deeply connected their mind and body are and to reflect upon how these influence each other. This project also explored how biosignals can be best used in an arts/exhibition context, which is much less controllable than the lab environments where emotion research is normally carried out and has aesthetic criteria that inform how the technology can or cannot be used.

This artwork is also *about* the body and aims to unmask taboos or desires surrounding fertility and conception. The shape resembles a stylised uterus but could also be seen as a ram's head or a novel games controller, thus leaving enough ambiguity to intrigue the person who's holding it.

The music is structured around a series of fast and frantic rhythms followed by slower, more admospheric parts, and uses a similar approach to achieving relaxation as the body based relaxation technique that uses the tension and subsequent relaxation of certain muscles in order to make the person more aware of where in their body tension is held.

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3.1 Hardware Implementation

The first input for the user is electronic music that I composed to induce different emotional states [2, 7]. The physiological response of the user was then tracked with sensors. In choosing the sensor input, I was guided by both aesthetic and functional aims. I wanted to use biosignals that could reveal something about the emotional state of the user, but the artwork also had to work real-time, require a minimum amount of instruction and offer a non-invasive experience to the user. This prohibited the use of EEG, which still requires the user to wear a headband. I wanted to obtain the data from touch to give the user a direct bodily connection with the artwork and avoid any medical associations related to 'being wired up'. From a drastically reduced list of sensor options, I chose to track GSR and heart rate. The GSR sensor measures skin conductance across the palm of the hand (in the sculpture two copper circles are embedded in the right arm). The heart rate was obtained from a pulse plethysmograph embedded in the left arm of the sculpture. A 3-axis accelerometer was added to detect movement so that the lights could be dimmed if the user was moving the shape too much.

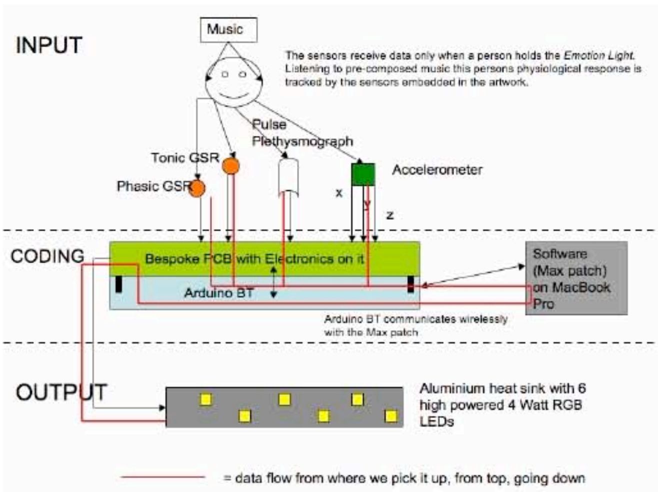
Figure 2. The copper parts of the GSR sensor

Figure 3. The bespoke PCB with electronics soldered onto it

The sensors were embedded into the sculpture and sent their data directly to an Arduino BlueTooth controller [6]. From there the data was sent wirelessly to a Max/MSP [5] patch on a nearby laptop. Interpreting and mapping of the data took place in Max/MSP from where the final colour output was sent back to the micro controller inside the sculpture to change the colour of the LEDs in real-time. The electronics were fixed on a bespoke PCB that fitted directly onto the micro controller.

The data flow is visualized in the following diagram:

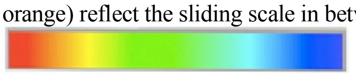
Diagram 2. Input-output diagram of the *Emotion Light, Version 3*.



3.2 The mapping in the *Emotion Light*

How to transfer physiological data into aesthetic interfaces remains debatable. In earlier version of the *Emotion Light (version 2b)* I tried to create a classifier that could detect eight different emotions [8]. This turned out to be too ambitious for the hardware setup combined with the uncontrollable gallery conditions. For the current version of the *Emotion Light*, *(version 3),* the mapping was based on the circumplex model of affect that suggests that all emotions derive from two neurophysiological systems, one related to arousal and the other to valence [16]. The term valence in this context relates to being attracted (positive valence) or repulsed (negative valence) by a stimulus, which in simplified terms means positive or negative emotion. Arousal has to do with intensity and can be read directly from the biosignals. Valence is harder to read from the biosignals, as it is higher-level information: i.e. it has to do more with interpretation. The benefit of using this model to design the system from is that it allows for a sliding scale of emotional/physiological variation, which makes it a more realistic starting point.

Arousal can be obtained from the GSR sensor. The GSR component is divided into a phasic and tonic component [10]. The phasic changes quickly, and shows peaks in the data which happen every couple of seconds; these are called phasic events. The tonic component changes slowly over a longer period of time. One could therefore say that the tonic component reflects mood or general arousal level and the phasic reflects more immediate responses to the external environment: temporary increases in the sympathetic nervous response. The tonic component was mapped to the colour of the light, with a low tonic value (which is the same as a low skin resistance, so more sweat, and thus more arousal) set to red and a high tonic value (i.e. high resistance, so less sweat, and thus less arousal and more calm) set to blue. The colours in between (green, yellow, orange) reflect the sliding scale in between:



A phasic event when detected would bring the colour back a bit towards the red zone. The amount of colour shift can be adjusted to make it harder or easier to reach the blue zone. The length of time it would take for the colour to get back to the tonic value would depend on the frequency and the length of the phasic events. Heart rate is mirrored in the speed of the pulse of the light. Each time a new user picks up the *Emotion Light* it re-scales to the new user to allow for maximum sensitivity of the light.

The user was expected to spend a maximum of ten minutes with the interface. This meant that low frequency variation in people's heart rate, which could have given more information on emotional state, could not be used, as this would involve looking at the data over several hours rather than minutes.

Visitors were met by an invigilator who explained how the light worked and how the user could try to make the light go to the blue area by practicing deep breathing and/or by listening to the music.

3.3 Audience Experience

The *Emotion Light* was first exhibited at ISEA09 in Belfast where several hundred people interacted with it. The invigilator who was interviewed at the end of the conference made some interesting observations. She said:

"*Over the past three days I've seen so many people interacting with the piece. From all ages and both genders, and a sort of pattern emerged over the three days which sort of distinguished between age but also distinguished between gender. Now with age it seemed like the younger the person was, obviously the heartbeat was faster, but it also seemed to be that the colours changed more rapidly with the younger person. The conclusion I came to was that younger people tend to have a shorter attention span, you know, and their minds tend to wiz from one thing to another very quickly. Because the older the person was, the more stable the colours seemed to be and the more stable the heartbeat was constantly."*

She also made the following observation:

…*"And similarly with gender difference it emerged, from my experience anyway, that with gentlemen it tended to go red very quickly and then it calmed down whereas with ladies it seemed to hover around the green and the blue a lot longer. With ladies it changed more often but with men, when they settled down after the initial red, theirs kind of stayed a constant colour whichever colour it was going to be, regardless of whether they were listening to the music or not. The music definitely affected the ladies more. Because as women were listening to it did have a lot more of a calming effect, it seemed, than on the gentlemen. Why that is, I don't know.*"

It would be interesting to do further tests to investigate whether this perceived gender difference can be sustained with evidence. One obvious function of the headphones themselves is that they block out external noise. A female visitor said:

"When I was playing with the Emotion Light I had headphones on as well and I was listening to the soundtrack that was made to go with it. And I think taking away the environmental sound and allowing me to focus on what's being played through the headphones made me really focus on the experience I was getting from the work. So I think it was adding a lot. It made it a more immersive experience because my eyes were watching the pulsing and my hands were holding something and my ears were blocked from the general chitchat. I think the sound really does help the experience. When I took the headphones off, my anxiety levels were higher because I was watching what was going on around me and I could hear stuff so I think yeah, it probably plays a role in calming you down which is all part of the experience."

It also seemed that was that the interface was easy enough to understand for people. A female visitor said:

"*Yeah, I just had a go; I had an experience with the Emotion Light. I had a couple of goes actually. The first go I really could understand that it was responding to my heart rate straight away and so I felt myself trying to control my heart rate to change it, but I couldn't really detect any change in the way that the light was pulsing as my heart was beating. And then the second time when I had more time with it I could understand that the heat of my hand or the sweat or whatever on my hand, was affecting the way that the colours were changing in addition to the colours pulsing because of my heart rate. And it was interesting when I was looking around when people were coming up whilst I was playing with it, I was obviously getting excited or anxious, because it was changing to a red colour. So I began to really understand quite quickly how it was changing while I was holding it, and it was nice. It was externalising my internal biological processes, which I really liked.*"

This layer of being emotionally affected by the fact that others can see the colour of the light as one is interacting with it, added to the intensity of the experience and the questions about privacy the work posed. A male visitor said:

"I kind of felt, working with the Emotion Light, that I was quite anxious that it didn't go red because, because I kind of felt like red was showing that I was quite anxious and nobody wants to be portrayed as someone who's in that state of mind. But it went red a lot. Ha-ha-ha!"

3.4 Future Improvements

In order for the system to become able to detect accurately detect valence (positive or negative emotion), more biosensors would need to be added to the system [1, 12]. A temperature sensor is feasible in this context as it can also be measured from touch. Also, a more intensive analysis of heart rate variance could help to obtain more information on valence [19].

4. ACKNOWLEDGMENTS

Dr. Ben Knapp advised on biosensors. The *Emotion Light* software was written from scratch by Vincent Akkermans, and was based on the earlier Biotools [11] software, by Miguel Ortiz Perez and Nicholas Ward. Marc Boon improved the hardware using a bespoke PCB, and Ken Brown adapted the Arduino Code. Various other software improvements were then implemented by Robin Price in Max/MSP, prior to the first public launch of the *Emotion Light* at *ISEA* in Belfast in August 2009.

Dave Knapton and Neil Milburn from AMAP in Sunderland helped to turn the porcelain sculptural model into a rapid prototyped ABS plastic version.

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