Emotion Lights: from biosignals to light art

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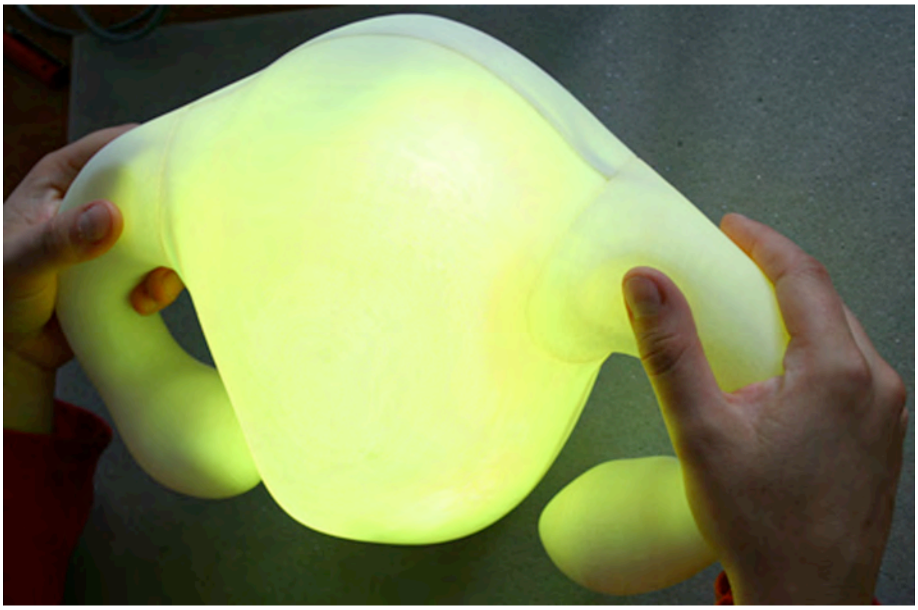

Emotion Light, version 3. Materials: ABS plastic, electronics, copper, Code, Arduino BT, LED's. © Adinda van 't Klooster, 2009

ABSTRACT

The purpose of the *Emotion Lights*[1] was to create a light artwork that could detect, and visually reflect, physiological variations in the viewer and in which sensor and artwork would be seamlessly merged. Technically, the aims were for this to be a non-invasive, portable (battery powered) and wireless light sculpture.

Physiological data has been linked to emotional variation, but the extent of this remains a much debated area in psychology, neuroscience, physiology and

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[1] Project team
Artist: Adinda van 't Klooster (concept, design, porcelain model, sound design and project management).
Hardware design and advice: Ben Knapp, Ken Brown, Marc Boon.
Software: Vincent Akkermans, Ken Brown, Miguel Angel Ortiz-Perez, Nick Ward, Robin Price
Rapid Prototyping: advice on design for manufacturing: Alan Stafford.
3D modelling: Neil Milburn, Iain Barrett, Dave Knapton, AMAP, University of Sunderland.
PhD Supervisory team: Beryl Graham, Lieselotte van Leeuwen, Gilbert Cockton, Lynne Hall, Ben Knapp.

computing. This project aimed to explore how best to use biosignals in an arts/exhibition context, which is much less controllable than the lab environments in which this kind of research is normally carried out, and has aesthetic criteria which inform which technology can be used.

As we wanted the artwork to be non-invasive, we were restricted to only certain biosignals, from which we chose to track GSR (Galvanic Skin Response) and heart rate which can both be obtained from touch. For the touch surface, we used a conductive glaze on a porcelain sculpture and for heart rate we used a pulse plethysmograph that the user slots their finger into. The sensor circuitry used to amplify the biosignals was hidden inside the light sculpture. An Arduino microcontroller captured sensor data, and sent it to the laptop were it was analysed by a Max patch and transmitted via Bluetooth to a bespoke LED lighting system inside the artwork.

In computational terms, we compared two different approaches to working with biosignals. The first was to create a classifier that could detect 8 different emotions resulting in 8 different light sequences and the second was to use the GSR and heart rate in a direct mapping where colour of the light was directly linked to GSR and heart rate to the pulse of the light.

Our findings were that whilst changes in emotional state are reflected in bio signals, there is no one-to-one mapping between physiological data and discrete emotional states. Consequently, the latter method of direct mapping worked better in the context of this artwork, as it was the least reductive method, better reflected the reality of the data and left more freedom in the creative mapping process. We concluded that using biosignals to effect interaction can create powerful feedback loops which deserve further exploration in art contexts.

Context

Art has refined ways of arousing emotions, and we wanted to explore if we could create an artwork that would also be able to detect what it had aroused and feed this back to the viewer. In order for machines to detect emotion, they need to be able to detect emotional cues. Humans get these from looking at people’s faces and body language and from listening to the intonation of other people’s speech. The computer can use these cues as well but has the added benefit of being able to record and analyse biosignals.

The best-known bio-electrical signals are the Electroencephalogram (EEG), the Magnetoencephalogram (MEG), Galvanic Skin Response (GSR) sometimes also called ElectroDermal Activity (EDA), the Electrocardiogram (ECG/EKG), the Electromyogram (EMG) and Heart Rate Variability (HRV). Biosignals are indicative of emotional variation: Juslin P.N., Sloboda, J.A. (2001); Gomez, P. and Danuser, B. (2007); Le Groux, S., Valjamae, A., Manzolli, J., and Verschure, P. (2008) but there is no one-to-one relationship between particular emotions and values per biosignal.

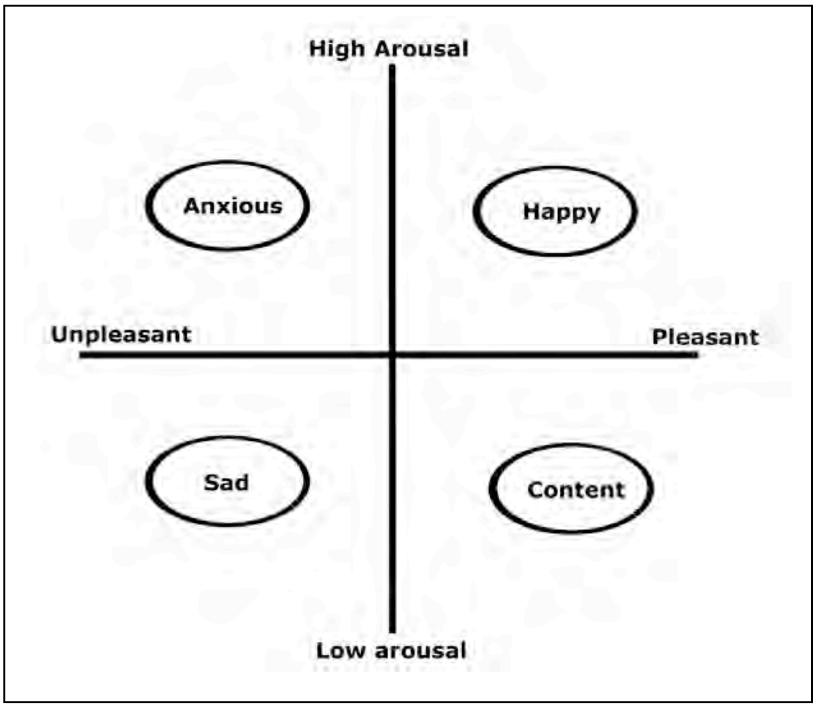
It is getting easier to obtain biosignals in non-obtrusive ways, but analysing the signals in an intelligent way is a complex area of research. There are also large interpersonal differences (van den Broek 2008) and even one person's data varies from day to day. It is also hard to obtain a ground truth: what is neutral in emotional terms and how can we detect it?

Biosignals have been used by artists and extensively by musicians. David Roosenboom, Atau Tanaka, Ben Knapp, Yoichi Naghashima, Miguel Angel Ortiz-Perez and others have used biosignals in their live electronic music performances on an ongoing basis. There are not many artists who have used biosignals more than once. Some exceptions to this rule are Char Davies who made two VR installations: Osmose (1995) and Ephémère (1998) and George Khut who created a body of work that uses breath and heartbeat as input and video and sound as output. Christa Sommerer and Laurent Mignonneau also made multiple artworks using heart rate, breath, blood volume pressure, GSR, and smell which are all captured in their *Mobile Feelings* series and sent to other anonymous users who can perceive and feel these private sensations through actuators, vibrators, ventilators, micro-electromechanical and micro-bio-electrochemical systems which are embedded inside sculptural shapes (Sommerer, C. and Mignonneau, L. 2002-3).

In comparison to the works described, the *Emotion Light* aimed to be non-invasive and portable like *Mobile Feelings* but to create more of an intimate feedback loop between the viewer and their own body data through changing coloured light emerging from a tactile sculpture. The title *Emotion Light* does not mean to imply it is possible to literally visualise people's emotions, as it is much more complicated than that, but it aims to make people consider how much the body and emotions/feelings are interlinked. The shape chosen is a large uterus, an emotionally and symbolically loaded shape. Simultaneously reminiscent of a ram's head and spermatoids, this ambiguous sculpture renders the internal body visible and allows for an introspective and embodied experience. This piece relates to earlier artworks by the author of this article, such as *Receptive Mo(nu)ment*, which is a site-specific installation in Gloucester Cathedral (van 't Klooster, 2003-2004) where she recreated a womb environment by enlarging the pinopods found in scanning electron micrographs of the uterine lining. Pinopods are thought to be indicative of whether an embryo can implant in the womb but much remains unknown about them. By enlarging the microscopic to the macroscopic a new relationship to the body is created. Van 't Klooster's work also tends to choose those areas of science where there are more questions than answers. The field of emotion research is one of those areas.

Emotion Light, version 2 (porcelain prototype) © Adinda van 't Klooster, 2009
Materials: Porcelain, gold lustre, electronics, Code, Arduino, LED's.
Dimensions: 36 x 21 x 14 cm

There are many different theories of emotion and many different classification systems, and there is no general consensus. There is clearly also the problem inherent in classification itself, in that it doesn't leave much room for ambiguity, something intricately linked to emotions. The model of discrete emotions claims that emotions are isolated from one another and even derive from independent neural systems, whereas the dimensional model supports a view where all affective states arise from overlapping neurophysiological systems (Posner, J., Russell, J.A., Peterson, B. 2005). A much used dimensional model is the circumplex model of affect which suggests that all emotions derive from two neurophysiological systems, one related to arousal and the other to valence (Russell 1980). 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, and arousal has to do with intensity and can be read directly from the biosignals. Valence is much harder to read from the biosignals, as it is higher-level information i.e. it has to do more with content. The circumplex model of affect employs a sliding scale and thus leaves more space for different shades and intensities of emotions than the discrete model.



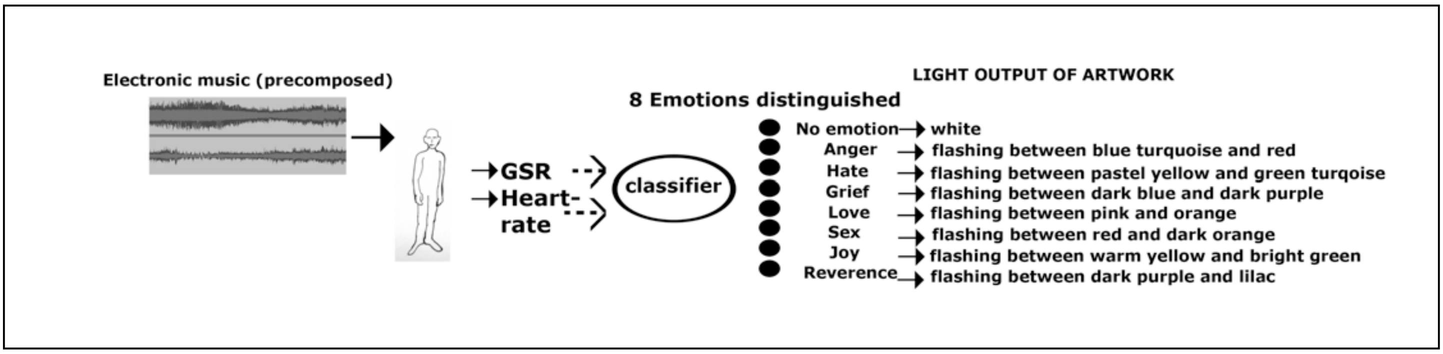
'The circumplex model of affect' (Russell 1980)

In the field of Affective Computing, a research field which aims to create Human Computer Interfaces that can sense and recognize the user's affective state or style, in order to adapt the machine's behaviour accordingly, one of the methodologies used is to create a classifier. This is a computational algorithm that can detect similarities and patterns in a database of, for example, biosignals tagged to different emotions. Using this method Picard reported a success rate of 82% in computer recognition of one of eight emotions: No emotion, Anger, Hate, Grief, Love, Sexual Desire, Joy and Reverence (Picard, R.W., Vyzas, E., Healey, J. (ud). This categorization was taken from the sentics theory developed by Manfred Clynes (Clynes 1989). To create a database as input for the classifier, Picard used 4 bio signals and only one person. This means that her classifier worked on that one person only was due to the interpersonal differences in biosignals. Van den Broek (2009) had reported a success rate of just over 61 % for a person independent classifier using a system of 4 emotions (neutral, positive, negative and mixed emotion) and the K-NN (=K nearest neighbour) classifier on the dataset of 24 test people.

Methods

We compared two different approaches to using biosignals in a portable light artwork. Both had in common the final exhibition context where a pre-made sound sequence would instigate an emotional reaction in the viewer and this would be translated to light output through capturing the viewers GSR and heart rate. The difference would be in how the computer would analyse and map the bio signals. The first method was to use a classifier for Clynes eight emotions, each of which would be mapped to a different light behaviour. The second method involved using the raw biosignals, and map live variations in GSR to colour, and heart rate to the speed of the pulse of the light.

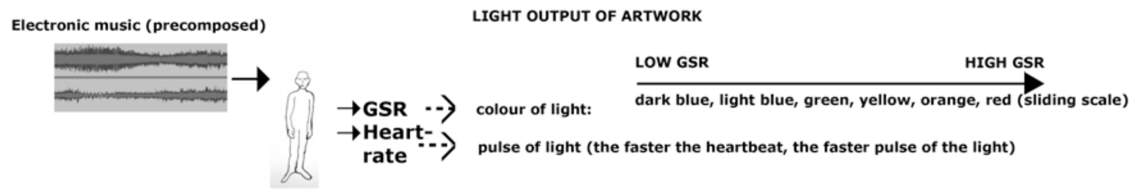
Method 1.



The first approach involved creating an offline database of GSR and heart rate signals from 20 people whilst they feel the emotions we want to detect. To induce the emotions, we let people listen to Clynes Sentic Cycle. (http://senticcycles.org/) Consequently, various clustering and classification algorithms were tested on the features of the biosignals in the database. Further technical information can be found on the STEIM blog: http://steim.org/projectblog/?p=762.

The GSR signal was obtained from a home-built sensor using an electrical diagram provided by Ben Knapp. This sensor could capture tonic and phasic separately and gave a good signal. The heart rate was obtained from a pulse plethysmograph, which we built from the diagram on http://www.picotech.com/experiments/calculating_heart_rate/index.html.

Method 2.



The second method was to use the biosignals directly as input to steer the colour and pulse of the light. GSR is divided into a phasic and tonic component. The phasic changes quickly, and shows peaks which happen every couple of seconds, and the tonic component changes slowly over a longer period of time. One could therefore say that the tonic component reflects mood and the phasic reflects more immediate responses to the external environment and emotional variations. The tonic component is also closely related to the stress level of the person. We mapped high tonic values to warm colours with the maximum set at red, and lower tonic values to blue and green hues.

A faster heartbeat indicates a higher level of arousal and was mapped to a faster pulsing of the light. More information, such as low frequency and high frequency variation, can be obtained from the heart rate signal by looking at it over a longer period of time, so we analysed the heart rate data in Max/MSP on the laptop, rather than on the Arduino as it did not have enough memory. We also added an accelerometer to the system, to detect when the signal was unreliable due to too much movement. The artwork was programmed so that more movement resulted in a darker light output and when the shape is held still the viewer is rewarded with brighter light.

Results

The first method of creating a person independent classifier for Clynes 8 emotions, gave success rates that were only slightly higher than chance level i.e. the computer could not clearly detect these categories from the biosignals. We only got success rates of 75% when limiting the classification to two different categories: no emotion and anger, and looking at GSR and heart rate for only those emotions.

The second method was much more fruitful in the context of this artwork. Direct mapping from physiological changes to light can already create an interesting feedback loop between artwork and participant. GSR provides instant feedback indicative of emotional changes and instinctive physiological responses to the external environment and so clearly lends itself for a direct mapping approach.

Conclusions

In terms of creating a person independent classifier with our lost cost sensors and only two biosignals, we concluded that a classifier for 8 emotions did not reflect the reality of the data. Person independent systems should use fewer classes. A major concern with Clynes induction method was that the participants reported difficulty in truly feeling some of the emotions. Added to that was the difficulty that the emotional descriptors meant different things to different people, i.e. reverence was not familiar to some people. Anger was the easiest category for non-actors to feel on demand and this was clearly reflected in the data.

There is no one-to-one relationship between emotions and body data, but body signals do reveal something of the emotional state of the person in question.

The second method of direct mapping was not only more simple and elegant, it also mirrored the complexity of the data much better. In the domain of psychology there are contrasting opinions on how to classify emotions, and by directly visualizing the output in colored light patterns, we didn’t have to opt for a system of discrete emotions, and could be more ambiguous. Emotion is like colour - it does not have distinct boundaries. The direct mapping approach also circumvented the problem of interpersonal differences in the data.

Further development

It would be interesting to develop these ideas further with an interdisciplinary team of neuroscientists, psychologists and computer engineers who are already developing advanced methods of introducing emotional intelligence in computing.

I also plan to further expand on the mapping and make at least four *Emotion Lights*, using different shapes and slightly different behaviors. People could then participate simultaneously and compare their lights and body data with each other.

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