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# An Exploration of Responsive and Emotive Wearables through Research Prototyping

**Rain Ashford**

Goldsmiths, University of London  
London, UK  
r.ashford@gold.ac.uk

## ABSTRACT

Responsive and Emotive wearables are concerned with the visualisation of environmental and physiological data. Four research prototypes were created for doctoral research to investigate the possibility that wearable technology could be used to create new forms of nonverbal communication using physiological data from the wearer's body. The research investigated who the audience might be for these research prototypes and their concerns and requirements. Through a lens of how these artifacts might they be used in social or formal contexts, the research gathered data from fifty potential users of emotive wearables and examined the usage and user preferences of such devices. Findings reflected the concerns of potential users from aesthetics and functionality to ethical and privacy issues.

## INTRODUCTION

Responsive wearables react to the wearer's environmental, interactivity and physiological data by taking signals and amplifying them as sensory output or data, which reflects the wearer's current status in their environment. An example of a responsive wearable is the *Baroesque Barometric Skirt*



**Figure 1** *Baroesque Barometric Skirt*. Image © R. Ashford (2013).

## KEYWORDS

wearable; computing; technology; emotive; engineering; emotions; physiological; data; aesthetics;

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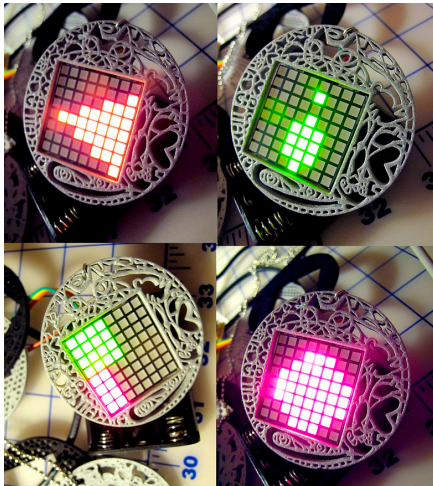
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*CHI'19 Extended Abstracts, May 4-9, 2019, Glasgow, Scotland, UK.*

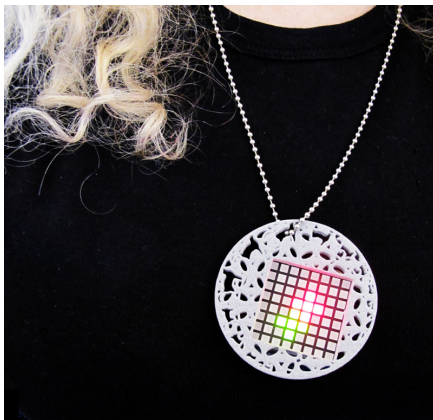
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ACM ISBN 978-1-4503-5971-9/19/05.

<https://doi.org/10.1145/3290607.3313284>



**Figure 2** EEG Visualising Pendant. Image © R. Ashford (2012).



**Figure 3** EEG Visualising Pendant. Image © R. Ashford (2012).

(2013) Fig 1 [3]. Emotive wearables concentrate on the visualisation, amplification and broadcasting of physiological data as nonverbal communication or cues, and their output can also be described as a ‘secret’ or ‘covert’ language. The purpose of these devices is to reveal physiological or emotional states that are usually hidden or concealed from the wearer, or to others around them. An example of an emotive wearable and research prototype that was used in focus groups and field tests is the *EEG Visualising Pendant* (2012) [2] Fig 2,3. The device visualises and broadcasts two streams of EEG data sent via Bluetooth from a *NeuroSky MindWave Mobile* EEG headset [9]. The visualised data may reveal hidden aspects of the user’s state that might not be given away by body language or verbal communication alone, and is amplified by LED display for those around to interpret if they have been instructed as to how to decode the visualisations. Interpreted in certain situations, such as social interaction, these can be associated with the expression of emotions, moods and mental states of the wearer.

### RESEARCH PROTOTYPES

Through the development of research prototypes in my practice, used in conjunction with carefully constructed focus groups and field tests and their resulting data, I have investigated how wearable technology could be used in social and formal interaction to create new forms of nonverbal communication [1]. Through the experiences and feedback of potential users of these artefacts in focus groups and field tests with mixed gender participants I have examined opinions, concerns and requirements around their usage. These studies have led to discussions around social and cultural issues, for example privacy, as well as aesthetics and functionality. My research has paid particular interest to the opinions and needs of women who I believe have been underserved in the design of technology and for which I ran three focus groups with women of different ages. For my investigations I developed four prototypes. The first, the *Baroque Barometric Skirt*, uses environmental and physiological input to visualise and broadcast data, followed by three emotive wearables that process and broadcast EEG data. All four research prototypes have been exhibited at the ISWC (International Symposium on Wearable Computers) Design Exhibition over a period of four years.

#### *Baroque Barometric Skirt*

The *Baroque Barometric Skirt* (2013) [3] Fig 1, is a responsive wearable that captures and visualises data from the wearer’s environment and broadcasts it together with their physiological data. The skirt’s addressable LEDs change colour as the wearer moves within their environment and as they physiologically react to where they are situated. The purpose of this skirt is to provoke conversation around the connections between the environmental and physiological data of the user. The garment contributes a method of sensing and presenting environmental and physiological data together for reflection and sensing oneself within the data of an environment.



**Figure 4** *ThinkerBelle EEG Amplifying Dress*. Image © R. Ashford (2015).



**Figure 5** *ThinkerBelle EEG Amplifying Dress*. Image © R. Ashford (2015).

The following three prototypes visualise, amplify and broadcast two streams of EEG data, which are sent from a *NeuroSky MindWave Mobile* headset. All three prototypes use two contrasting colours to represent EEG data. These are: red for data that suggests ‘attention’ and is connected to concentration, and green for ‘meditation’ associated with relaxation. The three devices map and visualise both states simultaneously and are constantly updating and changing with the arrival of new data from the NeuroSky headset. In regard to choosing the colours to represent the ‘attention’ and ‘mediation’ data, due to colour interpreted as various meanings and symbolism depending on culture and religion [6], I did not find a definitive colour to represent each state. Instead I based selections on a Western interpretation of colour mapping akin to the theories of W. J. von Goethe [8] and ‘colour extraction’ of designer Claudia Cortes [6]. This resulted in choosing red for ‘attention’ as it is reminiscent of activity and enthusiasm, and green for ‘meditation’ as this has been used to represent calmness and neutrality.

#### ***EEG Visualising Pendant***

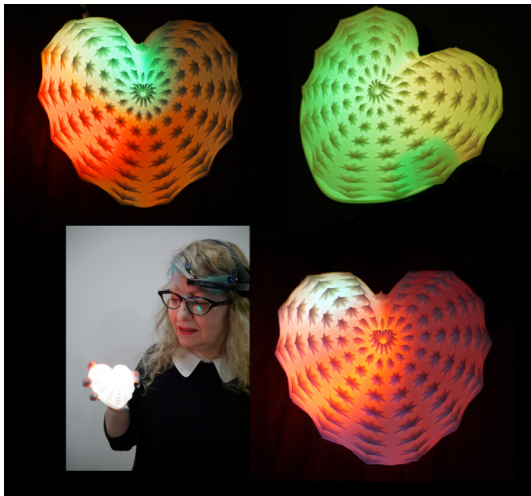
The *EEG Visualising Pendant* (2012) [2] Fig 2,3 comprises of bi-coloured LED matrix embedded into a changeable and bespoke 3D printed frame. The pendant, which featured in focus groups and field tests, hangs around the neck at chest level. It was developed for use in social and formal interactions, or for personal observational use. The pendant visualises the data as a series of patterns that constrict and grow depending on levels of ‘attention’ and ‘meditation’ data.

#### ***ThinkerBelle EEG Amplifying Dress***

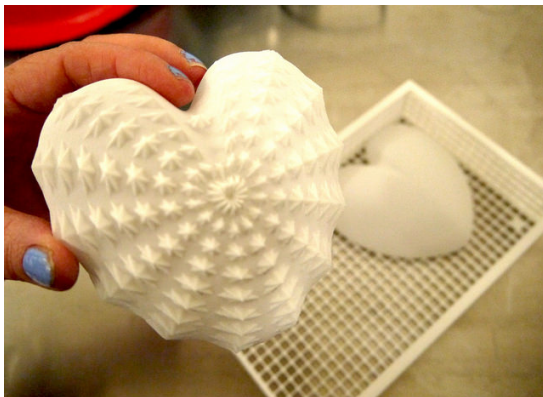
The *ThinkerBelle EEG Amplifying Dress* (2015) [4] Fig 4,5 was designed as a response to a focus group with young women who vocalised enthusiasm for an emotive wearable that could convey their physiological data to others via an illuminated garment. It is intended for usage in social situations where there is loud music, low lighting, dancing and when people would be observing each other and taking cues from nonverbal communication including body language or gestures. The fibre optic strands are positionable for personalisation and move with the body when dancing.

#### ***AnemoneStarHeart***

The *AnemoneStarHeart* (2016) [5] Fig 6,7 is an oversized heart-shaped, multifunctional pendant. The device was developed for women participants of user studies who stressed they wanted to visualise their data in private rather than in public places. They also stipulated that they’d also like to be able to use the device as mood lighting to illuminate a room. Uses for the pendant include broadcasting data in intimate social situations with friends, partners and family, as an aid for relaxation via meditation, and also for monitoring productivity. The pendant is formed as an opaque selective laser sintered (SLS) nylon heart, in which is embedded the device’s electronics. The opaque nylon heart acts as a diffuser for coloured light emitted from LEDs (light emitting diodes), which react to and visualise the incoming EEG data.



**Figure 6** Various EEG patterns mapped on *AnemoneStarHeart*. Image © R. Ashford (2016).



**Figure 7** Enclosure of *AnemoneStarHeart* after SLS printing. Image © R. Ashford (2016).

## CONCLUSION AND CONTRIBUTIONS

The research established that there is a potential audience for wearables that convey forms of nonverbal communication during human interaction. Distinct contributions to knowledge include insights from user studies that discuss attitudes to wearing such artefacts, form factors and personal choices in terms of aesthetics and functionality. How participants compared the visualisations to ‘secret’ or covert visual language suggested various uses, especially between groups of friends. Privacy issues also shaped how potential wearers would be willing to wear such devices and where on the body they would be located. The research introduces the terms ‘responsive wearables’, and ‘emotive wearables’ to the broader field of wearables to describe devices that visualise and broadcast environmental and physiological data. It also introduces the term ‘emotive engineering’ to describe how users of emotive wearables might use the record and playback functionality of these devices to change the synchronicity of visualised data, which could influence or manipulate social and formal situations and is reminiscent of Goffman’s [7] theories around the presentation of the self. Analysis of feedback from user studies allowed for various observations, for example how emotive wearables could be used for ‘secret’ or covert languages, how usage might affect relationships in social, cultural and personal terms, and what form factors these devices might take. I contributed development process notes for design, programming and electronics in regard of the aforementioned research prototypes and developed a method for managing the progress and development of multidisciplinary projects. There is much more to be investigated in the area of responsive and emotive wearables, this includes the areas of usage, form factors, investigating new forms of sensory engagement, functionality, also ethical issues, plus the bespoke and personalised.

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