Understanding and Evaluating User Centred Design in Wearable Expressions

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ABSTRACT
In this paper, we describe the shaping factors, which simplify and help us understand the multi-dimensional aspects of designing Wearable Expressions. These descriptive shaping factors contribute to both the design and user-experience evaluation of Wearable Expressions.

Keywords
Wearable expressions, body, user-centered design.

1. INTRODUCTION
Screen-based desktop computers are beginning to transform into additional electronic gadgetry, such as mobile phones, MP3 players, game consoles, PDAs and of course in the form of Wearable Technologies, which in this paper are called "Wearable Expressions". This nomenclature emphasises the usability, ergonomics and user-centred perspective rather than the technology itself, looking towards engagement, usefulness, ease and enjoyability of use. Hence, the central issue in Wearable Expressions is comprehension from the user's perspective, i.e. both comprehensibility of content and also of controls, manipulators and other interactive elements of the interface and representation (display).

It is very important to state in the beginning that Wearable Expressions is Wearable Technology. However, there are instances that need to be acknowledged in order to avoid misinterpretation.

The first instance is Wearable Computing, which is thought to have started when a pocket-sized analogue computer was developed by Edward O. Thorpe in 1961 to predict roulette games results in Las Vegas [10]. However, the important distinction in this early stage is that wearable computers were basically portable gadgets, not worn on the body and not especially correlated or designed with the body-based nature of a wearable device in mind. Essentially these are miniaturised, portable computers following the traditional screen-based desktop computing paradigm.

The second instance is Wearable Art. The main theme and purpose here is more likely - if not always - for purely aesthetic reasons. The reason why Wearable Art is included as Wearable Expressions is because the tendency towards fashion is very strong and also there is a sense of technology embedded. Further, that fashion is very much related with the world of garments and materials, reflects the technological culture of the world we live in today [10].

Therefore, we emphasis that Wearable Expressions mentioned in this paper should be perceived as smart gadgets or devices that are wearable on the user's body, not limited to a fashion ensemble but which also embed certain computing intelligence in the wearable device itself. Technology as art that has no user-centred functionality to impart, gather, communicate or interpret information is not the kind of expression explored in this paper.

2. USER CENTERED DESIGN IN WEARABLE EXPRESSIONS
The public has not responded the emergence of Wearable Expressions in the commercial market field positively. An example is the reception of the earphone-embedded Oakley THUMP sunglasses. These sunglasses have MP3 players and earpieces embedded into them. However, there are several common issues, such as the six-hour power supply and also the reasonably high market price might be a significant issue for users [9].



Figure 1. Oakley THUMP Pro [9]

The paucity of wearable technology take-up in the consumer marketplace is also evidenced by the lack of wearable expressions in our everyday life. For instance, we are still very often choosing to hold our phone to our ears when there are numerous and various wireless or non-wireless mobile phone hands-free headsets available on the market. There are simple yet often taken for granted reasons and explanations. For example, issues that would very commonly appear include cost, comfort and appearance. Where many researchers have focused on the capabilities of the technology, this research also emphasises the ergonomics, usability, usefulness and aesthetic

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possibilities of the Wearable Expression in trying to understand people's receptiveness and take-up of new designs.

2.1 The Importance of User Centered Design in Wearable Expressions

The understanding of the user cannot be ignored in the design process of wearable expressions or technology, which place the user in the epicentre of experiencing Wearable Expressions [13]. The fact that the technology is worn on user's body invites multiple layers of considerations in designing Wearable Expressions.

Comfort and appearance are amongst other important key factors, which if broken down piece by piece, creates a complex matrix of understanding that requires full attention by the designers in the process of building, creating and improvising Wearable Expressions. Therefore it is very important and essential to discuss the matter in order to allow Wearable Expressions to expand and be embraced by more users. Some of these overlooked attributes have led to Wearable Expression being misunderstood as a portable, miniaturisation of the desktop or even hand-held computing paradigm. Qualities derived from desktop computing such as screens, hard surfaces, textual communication do not always translate as the best mechanism for communication in a body-worn, washable, flexible, expressive modality.

3. SHAPING FACTORS

For the purposes of categorising and evaluating Wearable Expression, these shaping factors loosely group attributes of the design, recognising that there is significant interaction between these attributes and that some attributes are measured quantitatively while others are measured using a qualitative, relatively individual scale. Overall, the objective is to understand Wearable Expression using design paradigms closer to the user's which, therefore may lead to the design of more comfortable, intuitive, aesthetically-pleasing, helpful and ultimately wearable outcomes.

3. 1 Shaping Factors to Evaluate and Understand User Experience Design in Wearables

Within this section, it is very important to state beforehand that these factors do not oppose each other and we acknowledge that there are significant overlaps or interplays.

3.1.1 Size/dimensions

The dimensions of the device play a significant role in the design of Wearable Expressions. Levisohn argues that an integral element of interactive systems should be the body [5]. Therefore, the Wearable Expressions device dimensions should not exceed the user's expectation and anatomy otherwise the design could be considered a failure. Adding load to the body may affect the user's physical factors. The mechanics of the musculoskeletal system is altered immediately once load is added to the user's body [1]. Moreover, the effects of the device on the user's comfort and freedom of movements plays an important part in making the design fabrication decisions.

3.1.2 Device Positions

The positioning of the device is one of the most important factors in designing Wearable Expressions, since this may strongly affect the user's comfort, appearance, and sensation. It also affects the ways in which we interact with it (voice recognition, buttons, vibro-tactile, visible, etc.). The design approach should consider ergonomics and anatomy of the human body. One example from one of the simplest designs of Wearable Expressions is the wristwatch. It is worn on the user's wrist, which provides basic comfort and ability to effectively view time information for the user. Despite various attempts in history, including the pocket-watch or clocks worn elsewhere on the body, we return to the wrist-worn device.

3.1.3 Power Source

There are several aspects to the issue of power source. The first one is the type of device power source. This first element also determines the following essential element, which is longevity. It is also very important to consider whether the device power source is rechargeable or not.

Another element, which should not be overlooked, is the question of whether the device power source requires a power point in order to function. In other words, the question of corded or cordless power source strongly corresponds to issues of usability and function and mobility.

3.1.4 Heat

The issue of Heat is very crucial in designing or assessing Wearables. Heat affects the user's comfort (and ultimately safety) in wearing the device because it will certainly involve contact with the user's body.

3.1.5 Weight

The weight of the wearable device affects the user's comfort. This particular issue is interwoven with other issues: Power Source, Size/Dimensions and Device Position. The size and type of Power Source determines the Size and Dimensions of the device, and also the positioning of the device affects the user's comfort.

In order to illustrate the element of weight, Graves et al. and Miller et al. discovered that using wrist-weights (of 2.3 kg and 1.3kg, respectively) would increase muscular and physiological activity to move the arm about the elbow [3, 8]. A greater amount of muscular activity is obviously needed to move the elbow once the weight is increased. The issue of physical constraints of a human body affects the success in designing Wearable Expressions.

3.1.6 Durability/Resistance

The resistance and durability of the device(s) worn on the user's body is strongly dependent upon the quality and the robustness of the enveloping material. There are a few elements that require thoughtful design decisions, such as: flexibility, absorbency of user's body natural excretion, heat distribution and robustness, for example water resistance for designs intended for outdoor use, e.g. GPS devices, sports devices, etc.

3.1.7 Washability

The washability factor should be considered in the process of making design decisions or while evaluating Wearable Expression devices in order to respond to hygiene issues that may arise after usage.

3.1.8 Enveloping/fabrication

The choice of enveloping or fabricating material of a wearable device is relevant to the two factors mentioned before.

Washability and Durability need to be anticipated by design decisions about the enveloping of a wearable device. Enveloping/fabrication includes the choice of materials, flexibility, and the way in which it covers the internal electronics, and provides accessibility to controls or sensors and displays.

3.1.9 Functionality

The Functionality of a wearable device is contextual depending on its purpose. According to Rens Meijkamp design can be defined as 'the creation of value for people' [7]. Kelvin J. Lancaster defined it as 'the creation of objects, information, environments, services etc that afford the opportunity for people to create value in their use' [4]. Therefore it is obvious and important in any kind of design field to acknowledge and fulfil a client's need. In the case of wearables, it is very important for a device to serve its purpose upon creation. For instance, if the user is intending to use a wearable GPS sensor that is able to monitor heart rate, then it is very important for the device to deliver the results demanded by the user while wearing or using the device. Safety and health products, for example, also exact a higher degree of accuracy and reliability that entertainment and playful-purpose devices.

3.1.10 Usability

The Usability of a Wearable Expression device can be correlated with the word "navigation". A user's ability to navigate his/her way in using the device influences the user's engagement and impression of interactivity and responsiveness of the device. Therefore, it is very important for the designers of Wearable Expressions to observe simplicity in creating a user-friendly device. There is always a balance between control and simplicity. An increase in number/granularity of controls increases complexity, risking increased confusion.

We believe John Maeda's *Law of Simplicity* applies best in providing a guideline in designing the Usability in Wearables. For instance, four out of the entire ten *Laws of Simplicity* would already create quite a demanding set of design guidelines: Reduce [size, waste, visibility and clunkiness], Organize [structure and hierarchies], Time [reduce and use efficiently time to achieve a goal or task], and Learn [6]. The idea of reducing controls to achieve the purposed task of a wearable will benefit the user with simplicity. In order to achieve a thoughtful reduction in design, the designer must carefully organize the functions of each control. The fourth law, which is Time, discusses how the amount of time needed for a task to be performed or executed would affect simplicity in design and can be leveraged to maximise efficiency and pleasure of experience, responsiveness. In designing Wearables, it is very important for the device to be able to deliver the task it is purposely designed to do within an effective period of time, considering the fact that the device is worn on the body.

3.1.11 Sensation (see, hear, etc.)

The idea of enhancing the body's functionality and ability is the purpose of wearable expressions. It is essential to consider what sort of sensations the user might receive while using the device. These sensations could be in many and various forms creating levels of engagement and interactivity between the user and the Wearable Expressions device. For instance, the sensation of hearing, seeing, touching, vibrating and, maybe one day, smell.

Stelarc is an Australian artist who has performed extensively in Japan, Europe and the USA – including new music, dance festivals and experimental theatre. He has used medical instruments, prosthetics, robotics, virtual reality systems and the Internet to explore alternative, intimate and involuntary interfaces with the body. He has performed with a third hand, a virtual arm, a virtual body, a stomach sculpture, and exoskeleton, and a six legged walking robot. His work as an artist is very much themed with the bodily prosthetic issue [11].

One of his works, which will be shortly discussed here, is *The Third Hand.* In this work, he mimics the substitution of the body by a technological construct. *The Third Hand* may be regarded as a form of physical extension of the body, which is connected to an attempt to represent discomfort of this kind of technology [2].

Another very interesting aspect of this piece is the interpretation of computer technologies as sterile and non-organic which have evolved by their pairing with the human body. In addition, the human body is seen as increased and augmented by its attachment to technology (Cyborg notion). With this project, Stelarc viewed *The Third Arm* as a prosthesis of his own body, thus exposing it as a structure that may be assembled or disassembled. These extra 'body parts' somehow evoke a new questioning of the prosthetic body parts as a means of articulating loss [2].



Figure 3. Stelarc and The Third Hand [11].

The idea of extending the body by using *The Third Hand* in Stelarc's work reflects the sensation of adding bodily functions and ability. We believe if Stelarc's *Third Hand* is used simultaneously, it will create the sensation of having three hands, instead of two, which if later on replaced will create the sensation of loss.

3.1.12 Social Connectivity

With the rise of the Internet age and wireless communication technology it is impossible to separate this factor in designing wearable expressions. Levels of social connectivity gained by the user while wearing Wearable Expressions has the potential to increase levels of engagement between the user and the device and also with the social sphere.

In order to elaborate on this subject, consider the social micro-blogging website: Twitter. It has created a new way of communicating and socializing among its users and Twitter can create social connectivity in terms of Wearable Expression device. A recent example of the "marriage" between them would be the Twitter dress worn by an artist known as Imogen Heap during the Grammy Awards 2010 [12].

Walter Moritz and Imogen Heap created the Twitter dress. It allows Imogen Heap to receive tweets from her fans and the

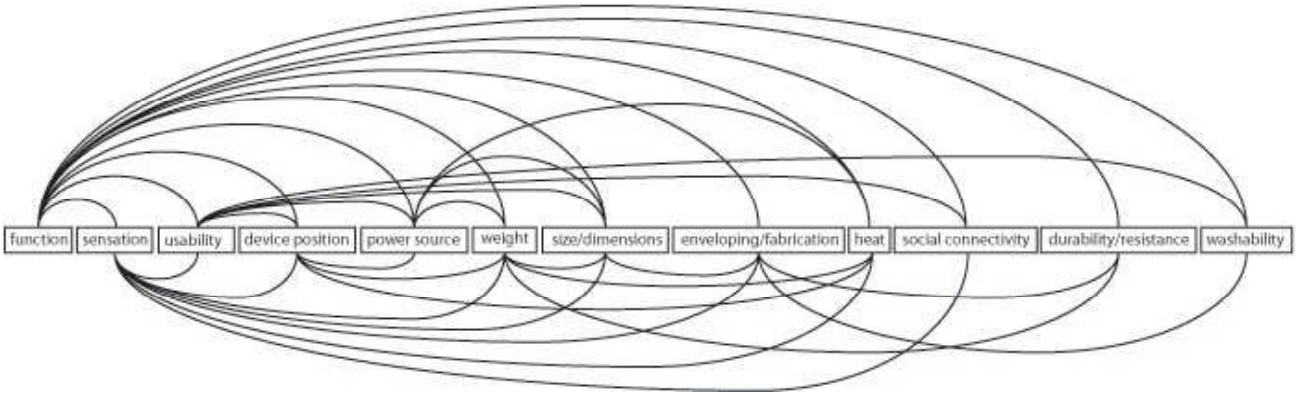


Figure 4. Diagram describing the overlapping relationship of shaping factors of Wearable Expressions

LED collar of the dress and images are displayed on an iPod Touch built in a Fendi purse she carries. The wearable device is connected to a wireless router that connects the Twitter dress to the virtual world [12].

The idea of 'including the fans' to the Grammy Awards stage creates a two-way connection between the fans and the artist, through the medium of Wearable Expression devices. The fact that in order to create the new level of engagement with her fans she was wearing a form of Wearable Expression, there is a sense of engagement and levels of sensation between her and her fans.



Figure 5. Imogen Heap at the Grammy Awards 2010 and the LED collar of the Twitter dress [12].

4. FUTURE DEVELOPMENT

This first step has involved a survey of existing wearable technologies, devices and wearable artworks to arrive at this framework of attributes important in the design and evaluation of the user experience for Wearable Expression, particularly guided by a design and user-centred approach. The next step will be to evaluate designs and assess the efficacy of this framework for analysis and evaluation on a small group of prototypes for different purposes, exhibiting distinct physical characteristics (e.g. flexibility, location on the body, type of sensors and information conveyed). Our evaluation will look at a) how the Wearable Expressions perform for the user, assessed in several different ways to correlate the results, e.g. observation and reflection on a goal-oriented task and questionnaires/interview to gather more qualitative impressions; and b) how the Framework performs as a metric of important design criteria. We will examine the relationship of scores for design attributes in our Framework against users' impressions and performance in the corresponding dimensions. The second iteration of the Framework will be modified and improved accordingly. The outcome will be a Framework that can be used by designers in the prototype and iterative stages of new Wearable Expression product design to hopefully achieve a more user-centred and taken-up generation of Wearable Expression devices.

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