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PAPER

Diversity and Inclusivity in the Age of Wearables: A Buzzword, a Myth, an Uncertain Reality

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'Wearable Technology' is a buzzword of our contemporary era. It could be argued there are few examples of aesthetically pleasing devices that are designed to meet our needs and/or our consumer desires. However, do we focus on design and aesthetics of technology as a holistic action with the capacity to simultaneously engage conceptual and practical shifts that make our society a place with no boundaries? To design inclusively is to engage the user deeply throughout the design process, sharing our practices and amalgamating people's unique knowledge as technological interventions. Design diversity and inclusion seems to be used interchangeably with two other terminologies, a) Universal Design and b) Design for All. The terms have a parallel purpose but their origin and use is distinguished in various parts of the world. For example, Inclusive Design is used within Europe and goes beyond age, ethnicity, gender, sex, and disabilities to focus on other excluded groups to deliver mainstream solutions. Inspired by the limited understanding and choices around aesthetics and personalisation in wearables, this article discusses how we use technology to empower individuals in a variety of contexts; to improve our way of living in the world, through a number of contextual resources and practice-research, which were devised and conducted to address women's concerns and preferences on wearable technologies.

Keywords: Wearables; design; technology; gender; diversity; inclusivity

'Wearable Technology' is a buzzword of our contemporary era. The wearable devices currently on offer vary in functionality, including: activity tracking, medical monitoring, mobile connectivity and more. However, it could be argued that there are few examples of aesthetically pleasing devices that are designed to meet both

our needs and our consumer desires. The question then, is whether we focus on the design aspect and aesthetics of technology or, whether we should make utility the focal point and centre of our attention instead. Aesthetics can often be a matter of taste; subjective, personal and therefore diverse. In contrast, utility is more inclusive in that, design in this context encompasses the needs of a wide range of people and must appeal to the growing needs of an increasingly global culture. Nevertheless, in the design process the terms diversity and inclusivity are not necessarily a contradiction in terms. To design inclusively is to engage the user deeply throughout the design process, sharing practices and amalgamating people's unique knowledge as technological interventions; it is therefore inclusive, precisely by including the diverse. Design diversity and inclusion seem to be used interchangeably with two other terms, a) Universal Design and b) Design for All. This article looks to investigate artistic practices that engage with the idea of diversity and inclusivity in digital technologies and particularly, the gendered body which, is in keeping with the scope and focus of BST Journals' publications.

One of the marginalised groups that have been under-represented regarding choices and design in technology are women. Technology and tools when aimed at this group have often embodied stereotypes that could be seen as patronising and are often superficially marketed, for example, through the use of stereotypical colour schemes such as, 'pinking' (Schroeder, 2010). Also by being accompanied by condescending accoutrements or texts such as, recipes (Laird, 2010). In 2011, the *Fitbit Ultra* clip-on activity tracker came in a choice of a black enclosure with a pink (named 'plum' by the manufacturers) or blue underside, which upheld an obvious western gender stereotype and marketing ploy of pink as feminine and blue as masculine. Inspired by the limited understanding and choices around aesthetics and personalisation in wearables, this article discusses how we use technology to empower individuals and in particular women. This article will engage with this question in a variety of contexts and through a number of contextual resources and practice-research studies, which have been devised and conducted to address women's concerns and preferences on wearable technologies. What then, are the implications of diversity and inclusivity in wearable technology for women?

Dominant Stereotypes and Other Myths

Culturally constructed gender stereotypes begin in childhood and can have a substantial influence on children's self-concepts (Witts, 1997). For instance, toys can communicate and reinforce gender-based stereotypes. Toys for boys are often highly manipulative and/or electronic (Caleb 2000; Sanders, 1997). Whereas, toys for girls tend to be designed to include interpersonal interaction, like dolls which encourage the development of social skills and relationships instead (Caleb, 2000). Researchers such as, Sanders, Koch and Urso (1997) have long asserted that girls are not exposed to toys that encourage scientific, mathematical and technological thinking and are therefore less likely to develop any interest in related subjects. These cultural stereotypes are communicated and reinforced from a young age and consequently often influence and inform the school curriculum developing gender identities in adulthood (Fighting Stereotype Stigma). This then informs the technological design process and the features which will be marketed to either men or women. Does this lead to a more complex design process? Or, does it in fact do the very opposite i.e. promote reproductions of gender pigeonholing perpetuating the myths of gender stereotypes?

A recent (2017) international research exhibition named *Diversity and Inclusivity by Design* [d+iD Research Hub] in London (**Figure 1**), demonstrated artworks which explored how design can empower individuals in a variety of contexts; to improve our way of living in the world; the implications when it comes to wearables and inclusion; and how we can enable designers when they design with, and for others. The selection of artworks showcased in this exhibition demonstrated design thinking through multidisciplinary approaches that positively impact our social and interdisciplinary landscapes. These works explored the deeper meaning of co-design methodological processes through the theme of gender in wearable design, with a focus on "objects" that are designed to engage people from diverse and marginalised groups.

Gender biases and stereotypes are consistently being refuted in contemporary society. For example, the performance artist Viktoria Modesta challenges a stereotypical image of being disabled by using wearable technology, in the form

Figure 1: The diversity and Inclusivity by Design International Exhibition, London (Maragiannis, 2016).

of stylised and bespoke prosthetics to embolden and accentuate her image as a powerful woman (Saner, 2014). Emotive wearables research, conducted in London in 2014, investigates how wearable technology can be used to create nonverbal communication and explores how physiological data drawn from the body can be visualised and broadcast. This research focuses on the preferences and concerns of women in various age groups. The collected data indicated that each group had different expectations and requirements from wearables and this was akin to daily choices made in respect to clothing such as, form, colour, shape, texture and prominence of the object. The feedback also included preferences regarding where on the body devices be worn. This was influenced by new variables determined by the purpose of the wearable and also how exposed it made the women feel in terms of broadcasting and visualising personal data (Ashford, 2018). A large-scale Danish study looking at female interaction with electronic products, which was based on the observation of a male gender bias in tech devices, found that various factors had an effect on motivation and how women operated certain technologies. The outcomes of this research addressed how to make electronic products more relevant, beneficial and appealing to female users, including design aspects and aesthetics. Significantly, according to the authors of this research, the idea of gender-focused design appears to be in conflict with the political idea of gender equality. They claim: "The idea of equality and equal rights for men and women sometimes prevents people from

tapping the potential that lies in an analysis of and a focus on gender differences" (Schroeder, 2010). The study did not aim to dispel gender stereotypes and myths but rather, provide practical guidelines for designing products by avoiding gender stereotypes and working with different female personas and attitudes towards technology based on statistic clusters. However, regardless of intention the study does not entirely manage to avoid gender stereotypes altogether. Rather, it differentiates between male approaches as detail orientated and female sensemaking through coherence; claiming that female approaches are socially orientated and more emotional. It therefore, reproduces some of the cultural stereotypes that it tries to avoid. At the same time, it is important to note that research in technology and emotive or, affective responses is gaining traction.

Applications now exist that are operable through our wearables and other technologies that allow us to reconnect with emotional qualities that can mirror our human essence in prescient terms of artificial responses. These artifacts are now linked with our body through portable intelligent devices including smartphones that drive, send and process data from wearables. We use these technologies in the hope of better communication; the data extracted from these technologies can aid communication by rethinking and reshaping our physical and social interactions. These apps include non-gender specific tools such as EEG headsets which connect and share physiological data with various devices such as computers and smartphones. For marketing and crowd feedback online apps such as, *CrowdEmotion* are used for tracking "attention, facial coding to understand engagement, and implicit testing to quantify memorability" via eye-tracking (CrowdEmotion, 2018). Emotive wearables, such as pendants, garments and accessories which track and broadcast physiological data associated with emotions and mental states such as the *EEG Visualising Pendant* (2012) (Ashford, 2018) (**Figure 2**) may process data in a non gender-specific way, but require some interpretational skills depending on the situation and wearer.

Diversity and Design Choices: Aesthetics and Technology

To help understand how design for current wearables has evolved, it is necessary to look back at the history of these devices. Depending on how far back we go, early wearable technology can be traced back to the thirteenth century when eyeglasses

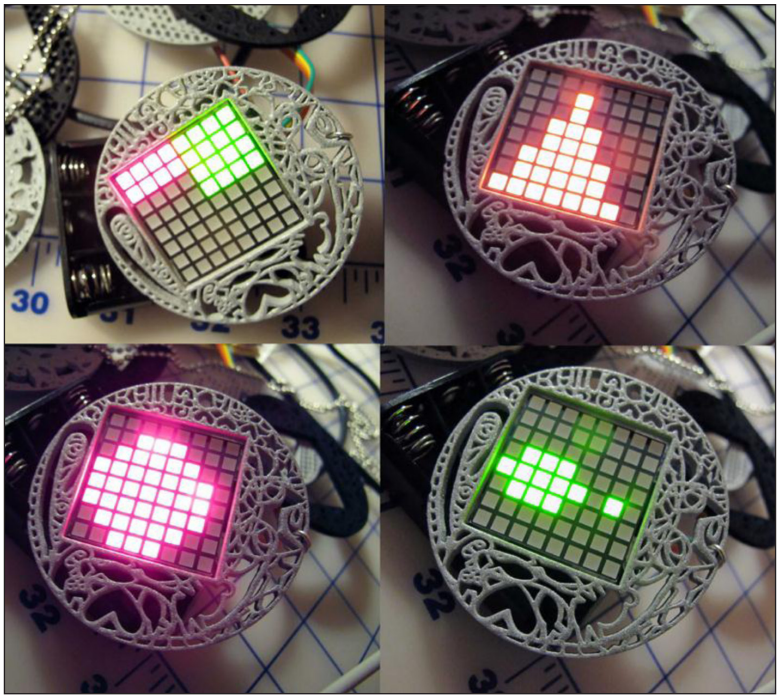

Figure 2: The EEG Visualising Pendant, an example of an emotive wearable by Rain Ashford (2012).

were invented. Three centuries later, one of the earliest portable watches, designed to be worn around the neck and named the Nuremburg Egg was created. Since the twentieth century leaps and bounds have been made in the evolution of these technologies. For example, head-mounted augmented reality (AR) wearables can be traced back to devices such as the 1961 Philco display for remote viewing of surveillance cameras (Mann, 2015; Comeau and Bryan, 1961). In the early 1990s, wearable technology was not necessarily created to be aesthetically pleasing. The priority of many of those working on early wearables was to find ways to achieve a particular function or functionalities from the hardware that was available to them, such as hacking desktop computers and gaming devices and what resulted was often large, obtrusive and complex (Dvorak, 2007). Artefacts that were starting to evolve in research labs and universities were akin to research prototypes and not commercially viable. Yet, pioneering researchers such as Steve Mann and Thad

Starner illustrate that wearable computing was gradually changing the paradigms of human-computer interaction. More lightweight, portable and wearable artifacts were being championed from the mid-1990s' (**Figure 3**). A common trend was emerging amongst independent inventors: "a personal computer should be worn, much as eyeglasses or clothing is worn, to provide access to computing power at all times. These new machines are now mature enough to provide personal, portable, augmented realities" (Starner et al. 1995).

By 1995, in Europe, Philips Electronics had launched its Vision of the Future initiative, which included investigating user needs in technology (Ryan, 2014). Philips followed this with a book of aspirational ideas for lifestyles focused on wearable technology. *New Nomads: An Exploration of Wearable Electronics* (2001) featured clothing for work and leisure with embedded technology intended to make the workload or leisure time of the wearer easier or more enjoyable. The garments were envisioned to work seamlessly with technology including mobile communications, displays and personal audio (Philips, 2000). Ideas concerning both the use and aesthetics of wearables has changed dramatically over the years. The use of wearables has been transformed, for example, eyeglasses as a medical necessity become a fashion artifact. However, some of these endeavours to produce both useful and aesthetically pleasing wearables have failed.

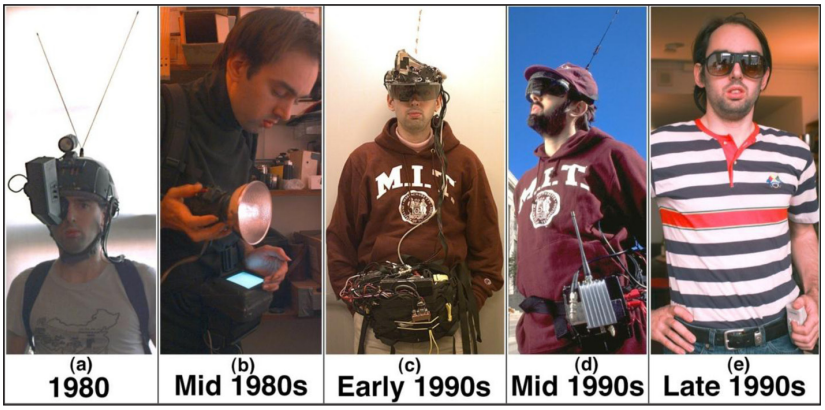

Figure 3: Steve Mann: Evolution of Wearcomp (CC BY-SA 3.0) (2004) https://commons.wikimedia.org/wiki/File:Wearcompevolution.jpg (accessed 30/12/2018).

Despite best efforts of putting wearables on women on the catwalk and in magazines, it has not paid off for all wearables. For example Google's *Glass* was promoted as a must-have accessory. It was sported by fashion bloggers, critics and celebrities in 2013, and featured in a 13-page spread in Vogue, as well as, appearing on the catwalk in the established US designer Diane Von Fürstenberg's Spring 2013 show (Klein, 2013). The non-gendered but prominently geeky-looking headset attracted controversy over privacy and issues of exclusivity, leading to wearers being called "glassholes". The *Glass* project was shelved in 2015 before it became publicly available or had the chance to be taken up or tested properly by women or any other groups. The device later found its place in industry (and various workplaces) where aesthetics and issues around it breaching privacy were less problematic (Levy, 2017). This example illustrates how a wearable product can be hyped and prominently marketed to women via the catwalk but extenuating issues, in this case social and privacy issues, can alter the path of the eventual design and development of a device. Wearing electronics on the body makes a statement about the wearer in terms of their relationship with technology but also how they want to be perceived by others. It is comparable to making a choice about personal style; wearing a particular garment, or a piece of jewellery and/or any other accessory. It is therefore, essential for designers and manufacturers alike to consider that 'one size does not fit all' and to consider giving wearers more options for customisation and consider allowing for more personalisation through bespoke designs.

More recently, a combination of factors such as, the rise of the Maker movement, which embraces collaboration-based learning and demystification of technologies, stimulated the development of smaller and more easily obtained electronics components, sensors and actuators, which has helped encourage interest in wearables. In particular, technology such as, the sewable Lilypad Arduino microcontroller, which was intended to inspire girls and female designers to investigate the design of wearables creation and spark an interest in STEM subjects and lead to the design of technology products better aimed towards women's requirements (Buechley, 2006).

Importantly, media and public interest in wearable devices began to rise when self-tracking became popular due to the Quantified Self movement. The movement

began in California in 2008 and inspired a plethora of inventors, start-ups and industry experts to take an interest in fitness and wellbeing devices through self-tracking (Wolf, 2016). In 2011, the aforementioned *Fitbit* activity tracker was one of the first devices that tapped into and commercialised this interest. It first appeared on the market as a small and unobtrusive device that clipped onto the body and came in limited colour choices with a design that was functional and minimal. At the same time, *Fitbits* were not overtly fashionable items that reflected a personalised look or, a style choice. As the popularity of these devices increased, the availability of similar wearables for fitness and wellbeing grew including Nike's *FuelBand* and the Jawbone *UP*, consequently stimulating discussion around the design and aesthetics of these artifacts. Wearables have faced a multitude of challenges over the years. They have developed from heavy, clunky forms and poor battery life to more streamlined devices. In the past it might have been assumed that design and aesthetics would not be such an issue (in comparison to the functionality of the technology itself), but disappointment with regard to design values were already reported in technology media from 2015. Often wearables were discussed in terms of 'ugly' aesthetics, which put into question women's desirability to purchase such devices, especially from established technology brands racing to get products such as, smartwatches out before competitors (Arthur, 2014). If these early commercial devices were not engaging users through their aesthetics, then what are the other factors that make them compelling? When *Fitbits* and similar devices burst onto the commercial scene they brought with them a certain social cachet, due to wearables being a desirable up and coming technology to possess. These fitness and wellbeing devices connect users through gamification, using various visualisations of accumulated data and are therefore social; they contain social media features that encourage the sharing of data between friends as competitive motivation to increase exercise and ultimately, the usage of these devices. These compelling features required the user to agree to terms and conditions releasing the data for upload and sharing to third-party companies. Users of fitness trackers willingly parted with and shared with others private information gathered by their devices. Due to popularity, *Fitbit* quickly expanded their range of devices, which included more prominently placed wristbands on the

body and more colour choices soon followed. These rubberised objects still drew comments on design issues; *Fitbit* responded by partnering with designers such as Vera Wang and Tory Burch to create bracelets for their devices, which gave activity trackers the look of bespoke designer jewellery rather than objects to be hidden (Mahajan, 2016). Although this suggested that there is an audience for fashion orientated wearables that look personal and are chosen to accompany an outfit, there still seems to be a bridge to be crossed where design and technology have hit the right note with consumers (Wissinger, 2017). Reasons for this might be because although younger generations of western women may have more opportunities to use technology through schooling, gaming and mobile communications, generations with disposable income may not; hence, some women still find their personal and domestic technology intimidating, suggesting accessibility to be key (Charara, 2015).

In recent years, the Internet of Things, aimed to link us to all the "stuff" we are wearing, everything we need to work with and for us (Medaglia, 2010). Additionally, we start to see the evolving connection of our bodies directly to the machine and virtual "others"; in particular, by opening up instantaneous encompassing haptic senses to wearable robots and avatars that we intentionally create or choose to wear: "the internet of bodies" (BDS, 2017). Looking further into design choices, issues and preferences for women, emotive wearables research into aesthetics in a 2014 study by Rain Ashford, discussed earlier in this article, also brought up the issue about where on the body women would want to wear devices. The study found that for many this was dependent on whether they were comfortable sharing their data in public, thereby making body areas important to the design. Displays facing outwards suited those who were comfortable with their data being visible, whereas displays facing inwards was essential for those who just wanted to keep their data for their own viewing. Form factors of wearable technology mentioned by women (as preference) included jewellery such as, wrist worn devices, badges, pendants, earrings and brooches but also, devices that are embedded into garment cuffs, lapels and lining which further reflected the discussion on issues of privacy in regard of visibility of emotive data and also when sharing was appropriate. Having devices that

were customisable and personalised to fit usage on different occasions appropriately, such as, work and special occasions made the prospect of using an emotive wearable more viable for everyday use. A 2013 study into cross-cultural societal perceptions of gesture interactions with a wearable e-textile interface, found that American and South Korean women and men's attitudes steered towards favouring the wrist and forearm for placement on the body, but reported some unease with performing touch gestures on the upper body of a female actor (Profita, 2013). *Activity tracking: barriers, workarounds and customisation*, examined the abandonment of popular activity trackers and discovered reasons for unhappiness with their device including the desire for better functionality and aesthetics (Harrison et al. 2015). Investigations found that the physical design was important and could be a barrier to usage. Research into emotive wearables found that when asked about the functionality of such personal devices, potential users requested the ability to customise modes for different settings, which included the aesthetics of how data was displayed. This would allow for the display of certain kinds of emotive data when appropriate or give the user the ability to personalise how data is visualised, so that data appeared to be scrambled or could not be read for privacy or aesthetic reasons (Ashford, 2018). Hence, when discussing aesthetics it is not only the exterior of the object which is to be considered but also, how the information is displayed to the consumer. Utility and aesthetics are thereby, not mutually exclusive issues for wearable technology. Rather, the one tends to inform and depend on the other, as well as, how consumers will take to the product.

Uncertain reality: Data, Women and Privacy

Who is willing to wear the wearables of the future? Designs that encompass bespoke and personalised aspects have been found to be attractive, but the devices themselves need to provide technology that is useful or compelling to women, and also be accessible in terms of design and functionality. For example, the notion of security wearables that track or include a panic button for women might sound like a useful application for wearable technology but brings with it an assumption that women

alone are seen as "victims-in-the-making" (Wissinger, 2017). These are unwanted identities that add to the discussion of what women want from wearables and how a wearable can change how they are seen by others or, how women themselves feel whilst wearing them.

The design and aesthetics of wearables for women is a problematic area because we need to consider that one form, one set of aesthetics, or functionalities does not work for everyone. As mentioned previously, in regard to the barriers for accepting fitness devices, an artifact that is unattractive is not likely to be used by women and may be hidden, or shunned. This is something that various studies have discovered through focus groups and field tests and demonstrated by looking at possible audiences for wearable technology. The studies conducted (and mentioned above), returned valuable feedback about the use of technology in everyday life scenarios such as work and socialising. This included inquiring about aesthetic qualities and functionality. Designing for privacy is an important matter for women, so wearables need to consider carefully how any data is broadcast. For those who feel comfortable about sharing their physiological data this is not such a problem, but for those who are worried about, for example, how physiological data concerned with emotive states might be recorded or interpreted by others, it was worrisome enough to be a barrier to usage and so would require measures in place that would reassure them.

Conclusion

No two people have the same taste in clothing or fashion worn on the body so it should be assumed that no two people will have the same taste in wearables. This was made apparent in user studies where particular attention was paid to the requirements and concerns of women. The studies indicated that when women were asked what they required from wearable technology, in terms of aesthetics, they emphasised a requirement for wearables to have elements of personalisation and to be customised to suit different situations and styles. One size or style does not fit all, which was reflected by those who said they were comfortable with conspicuous or brightly lit wearables on the body, compared to others who said they would prefer their wearables to be discrete or with muted or toned down visualisations

of data. In terms of wearables in everyday interactions, prominence is a factor and so design elements to enhance or, make technology more in keeping with the rest of one's dress sense is desirable. Lessons should be learned from the early commercialisation of wearables where complaints about large, ugly, clunky and very masculine wearables, such as smartwatches were common. A very important factor in the development of wearables is the social and cultural connotations of these devices, how they then portray women and whether women are ready to accept the attention that these devices might bring to them, this includes privacy and what data these devices might give away to companies and those sharing information via social media or directly viewing these devices. What is coming next though for wearables? Through practice-based research we could amplify, diversify, and mobilise this under-investigated aspect of practice and discourse; where design acts inclusively regardless of disability, gender, ethnicity, vulnerability, language or age; where design can empower individuals in a variety of contexts; and improve our way of living in the world. Looking to the future, how will women use wearables to enhance their day-to-day lives and empower themselves? Will it be through the idea of using technology to further longevity, or physical perfection as transhumans? That is, as feminist Haraway discussed in 1990 through the eyes of a chimera in her *Cyborg Manifesto* (Haraway, 1990) which, is still relevant today as we try find our own ways of expressing ourselves and personal meaning through the use of technology.

Competing Interests

The authors have no competing interests to declare.

Author Information

Dr Anastasios Maragiannis

A designer, academic and researcher, Dr Anastasios Maragiannis has devoted his career to exploring and understanding the fundamentals of design diversity and inclusion, within the context of the digital landscape and a multidisciplinary approach to design thinking. Anastasios is currently the Deputy Head School of Design at the University of Greenwich, London and a Fellow of the Royal Society of the Arts. He is the director of the d+iD – diversity + inclusivity by Design research

unit which explores how design acts inclusively regardless of disability, gender, ethnicity, vulnerability, language and age. He is also the Design Critique Lead for TypeThursday London with a great interest on how computational technologies impact on the existing principles and forms of design (readability and legibility). Anastasios presented in a number of international conferences and he has been showing his work in various places including the London Design Festival, and the V&A museum, London.

Dr Rain Ashford

Rain Ashford is a creative technologist, designer, lecturer and consultant working in the field of wearable technology. Her research investigates how wearables can be used to create new forms of nonverbal communication using physiological and environmental data. Rain was selected for a Convocation Trust Student Entrepreneur Award (2014), and was a finalist in EPSRC's UK ICT Pioneers Competition (2015). Her Baroesque Barometric Skirt was featured in New Scientist Magazine. In 2015 Rain was part of the organising committee for the Critical Wearables Research Lab at LCF, UAL London, She has presented her work extensively in the UK and internationally in Europe, Asia and USA.

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