Investigating Anticipated Conventions of Wearable Devices as a Mainstream Technology

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Abstract

Conventional uses of technology are capable of influencing the direction technology advances in a society. They are constructed from the collective knowledge and cultural behaviours which users adopt. What manifests from the conventions is a rigid structure that inhibits future, deviative or innovative technology to sustain in society. The conventions influence how society continues to engage with technology in daily activities. The influences from conventional uses of technology are not restricted to such organic processes, but can be influenced by us, if we take action to do so.

The purpose of this exegesis is to illustrate ways we can create approaches to shaping and directing the evolution of technology. This is illustrated from a set of approaches discussed on changing how a selected technology, wearable devices, is established in society. The societal impacts of *factors* related to user engagement with wearable devices are first investigated and speculated. The approaches are then created through theorising how relative *factors* can be mediated to alter the establishment of wearable devices.

The speculation on how wearable devices become established in society accumulated to a practical outcome: *Wearable Beacon*. This project visually portrays the researcher's own perception on the ways wearable devices mediate and relate to the user's body. The outcome communicates the researcher's idea of wearable devices enhancing and functioning in similar ways to that of the nervous system.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed

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Introduction

Conventions concerning how we use specific technologies can change over time. These changes can occur without purpose and thereby deviate from society's construed understanding of technology and its uses. In this research, technology is described within the parameters of mainstream contemporary objects as they are used by routine users. These are technologies the user has common knowledge of, alongside the established ways of interacting with them, e.g., mobile phones and automobiles. Most people have some knowledge of how to use these technologies and to do so in various situations. The conventions of a technology become established over time, forming cultural behaviours which a user adopts.

The collective knowledge and habits that exist between users constructs the conventions of the technology. It is difficult, however, to pinpoint whether these conventional uses benefit the user, as they can unexpectedly aid users in adopting or rejecting innovative development for a technology, which occurs as a result of conflicts or correlations with the innovation (Rogers, 2003).

Innovative ideas can alter the effectiveness of associated technologies. What renders an idea innovative in the context of this research is its capabilities to improve on a user's activity and outcome as achieved with said technology. Through a variety of means, such innovations can channel the established technology into a different context or instigate the development of a new technology that radically changes the purpose of the established one. As Rogers argues, for something to be innovative, it does not need to be an entirely new idea (Rogers, 2003).

Attempts to mainstream technological innovations are not always successful. They can often conflict with established conventions. In the Literature Review chapter, the example of the standard computer keyboard is described; although it does not represent the most effective design in terms of being a key type configuration, it is nonetheless the most conformed to design convention for keyboard innovation. The power of such conventions can result in certain technologies being easily accepted within society, while alternatives remain underdeveloped.

Conventions are established by society's perception of technology. Heidegger describes technology as revealing truths within the world, which people in turn use to shape reality (Nadal, 2010). The creation of technology exposes possibilities for future technology development based on their efficacy and reliability. Technology users become attached to such qualities; conformity to these types of technologies establishes technological imperatives as if they are absolute truths, banishing the introduction of other possibilities. It is the dissemination of these perceptions within society that creates the conventions and determines the sustainability for new technologies. Society's common or mainstream views regarding the truths of the world are therefore influenced by the conventional use of a technology. Being aware of the impacts that the conventional use of technology have on our perception of the world is not necessarily

suggested here as a desire to change these current habits. Rather, it is intended to provide information that allows for a society to continue adopting progressive technology. This awareness allows us to question the type of engagement with technologies we want to adopt, and if its adoption will allow technology to continue to evolve. This research therefore seeks to understand the directions in which conventional uses of technology are taking society's engagement with technology and ultimately asks how this understanding can be utilised to aid technological advancement. How conventional technology can hinder innovative ideas is elaborated on in the Literature Review chapter.

Investigating the impacts of these conventions resulted in uncovering the *factors* regarding a user's engagement with a technology and presented questions pertaining to how the user's perception of the technology can be changed. The importance of this research is therefore to describe methods for analysing the impacts that the conventional use of an established technology has on society. Describing such methods highlights the impacts these conventions have in directing the movement of technology and reveals opportunities for innovative change within an established technological domain.

Methods

The methods used in this research focus on understanding how conventions influence the use of a technology and questions the value of having these conventions. As such, it consists of various techniques and experimental practices to accentuate this. To begin with, the research employed observational techniques from Ron Scollon's Mediated Discourse Analysis (2002).[1] These techniques reveal relationships between multiple *factors* deemed questionable in a public setting and contributed to selecting a technology field to investigate, i.e., *Wearable Devices*. The selection of the field is one step in the applied method that is used to analyse the conventions of a technology. *Wearable Devices* is in this thesis contemplated in the context of a near future setting, where on-body, digital technology is used in everyday interactions. In doing so, it focuses on the public perception of wearable devices in relation to its user.

The core of this thesis is the unpacking and description of speculated *factors* that impact a conventional technology, as well as the activities in which they are used. The use of the term *factor*[2] is taken from the umbrella term 'activity theory' in order to identify the different components contributing to the mediation of an activity (Kuutti, 1996). In an attempt to simply highlight the types of relationships in an activity, the *factors* are analysed within three categories: (1) function of use; (2) context of use; (3) behaviour of the user with the technology. The focus for the chapter discussing the speculated *factors* is split into these three categories. By separating the discussion regarding the conventions of technology fields into categories, it is

[1] This is discussed further in the Methodology chapter.
[2] *Factors* are usually described as elements when discussing activity theory but have been left out in this research for the sake of continuity.

possible to view the *factors* through a perceptual lens, making them easier to identify and link together.

The categories were selected on the basis of their potential to have *factors* that were worthy of mediation. The categories are also inter-connected; if the particular approach changes a *factor* in one category, it will also change *factors* within the other two categories. It should also be noted that the function of use, context of use and user behaviour are important categories for any conventional technology. Taking this into account should assist the reader of this thesis in seeing the potential for using these methods in other technology fields. Analysing the relationships between *factors* provides an understanding of how the conventions of a technology may be misdirected or misunderstood. A technology that is conventionally used in multiple settings can provide varying and sometimes unwanted outcomes. Once such concerns can be defined, approaches can be taken to pursue a more effective way to establish a technology.

'Approaches' are attempts to address the impact of the conventional uses of and beliefs about a technology. Whether it is by altering how the technology is perceived or by redesigning its physical attributes, approaches suggest ways for mending conflicts between different *factors* and provide a more effective outcome. An engineer, for example, may approach unintended user interaction with a digital technology as requiring errorproof system preventions, whereas a graphic designer may approach the problem by including visual techniques to influence how a user interacts with the technology (Lockton, Harrison & Stanton, 2010). Depending on the approach taken, the technology will deviate from its predicted structure and will yield varying results. Different approaches are presented throughout the three category chapters and are described in the context of the most relevant category.

While the approaches are all discussed theoretically, some are put into practice in order to determine how acceptable such approaches might be for a society. For innovative developments of a technology to be accepted, it has to be communicated through appropriate channels (Rogers, 2003). The experimental methods used in this research serve the purpose of gathering together a more detailed response on how innovative approaches are communicated and the *factors* that impact the approach when put into a real world context. The experiments used practice-based hacking techniques that were implemented for public situations. Practice-based methods develop new knowledge through practice, which is not possible to achieve using theoretical methods (Candy, 2006). By implementing hacking techniques as part of the practice-based research, mainstream technologies are allowed to deviate from their more conventional functions and use.

This produces a limited yet clearer understanding of the potential for the relevant approach being adopted into society. These experiments led directly to the production and outcome of the practice-led project, *Wearable Beacon*.

Outcome

The purpose of this research is to highlight the importance of understanding the impacts of establishing and maintaining the conventions of everyday technologies. Articulated in the following chapters are arguments about why we need to understand the impacts of conventional technology. Included also is a presentation and execution of the methodology used for the technology field labelled *Wearable Devices*. The discussion relates how the conventions of this type of technology are directing society.

The functionality desired by a user for wearable devices is a major factor in establishing digital features as part of an on-body product. Taking into account this understanding of the conventional uses of a technology, we are provided with an opportunity to decide which path we want to follow in pursuing subsequent technological innovation. This process presents approaches to change how wearable devices are to be established in society. This discussion concludes with a presentation of the final practical outcome, called *Wearable Beacon*, which was created as a response to the perceptions and theories the technology field is heading towards in society. The concept of *Wearable Beacon* sees wearable devices serving as a technological step for humans toward enhancing their own nervous systems. This work is a visual statement on the distinctions between a user's behaviour and capabilities with on-body interactive devices, and an observer's capabilities and interpretation of those behaviours. The shirt functions as a beacon, signalling the presence of itself as a wearable device to the public while in the presence of wirelessly transmitting devices. The final outcome is described further in the Outcome and Conclusion chapter.

Literature Review

This chapter contextualises the origins and impacts of the conventional use of a technology through a number of key texts and examples. The definition of technology is introduced using Heidegger's work, *The question concerning technology, and other essays* (1977). Heidegger presents technology as a means of exposing truths within the world and highlights how it frames a person's perception of reality as part of the process. The subsequent section takes this definition of technology further with the inclusion of activity theory (Kuutti, 1996), presenting the emergence of new technology as bringing more *factors* into an activity. The efficacy of these *factors* contributes to repetitive and habitual patterns found in the conventional uses of technology. Overall, the chapter emphasises how these conventions alter technology evolution and concludes by drawing on material from Everett Rogers' *Diffusion of Innovations* (2003) in order to describe why innovations are adopted by mainstream society. This is explained as a communication process that uses certain channels to inform people of the innovation in question.

Theoretical approaches are exemplified through the history of the computer keyboard and comparatively non-adopted innovations regarding its conventional design.

The Use of Technology as a Process

> *"The essence of technology, then, is the poetic process of bringing something forth into presence and, as a mode of revealing, "frames" a world that is unfolded or unconcealed in the process."*
>
> (Nadal, 2010, p. 3)

Heidegger introduces technology not in its typical form, i.e., as being a means to create a desired end, but as a mode of revealing the means to which said end can be achieved (Heidegger, 1977; Nadal, 2010). In these terms, technology is what reveals possibilities; it shows people how they can utilise a technology to fulfil their desired goal. This 'revealing' on behalf of a technology initiates its usage in an activity and determines its efficacy for doing so. The activity provides information about both the capabilities of the technology and of the person using it as part of the process. The revealing nature of a technology reframes reality for a person, revealing new *factors* and *factor* relationships within the world. To demonstrate how a person uses technology to frame reality and discover new paths, the origins of the modern computer keyboard is briefly explained below.

The computer keyboard was developed from the mechanical typewriter (Norman, 2002; Rogers, 2003). Typewriters gave typists the capability to use their fingers in new ways, revealing a form of interaction with a machine that put ink on paper faster and cleaner than writing by hand. However, a problem for early typewriters using alphabetic configurations was the constant

jamming of the machine when multiple keys were pressed. To combat this, Christopher Latham Sholes designed a key layout known as QWERTY, which was least likely to jam, even in the case of fast typists. As a result, Sholes' QWERTY typewriter became a popular and long-established design layout for typists. To this day, it remains the most conventional key type layout.

Typewriters presented a new process for writing on paper, but the QWERTY design also framed how people interacted with typewriters as a result of its popular key layout. The QWERTY design established its finger-to-key interaction as *the* process for typing. The impacts of popular designs and technology uses on subsequent innovations can be examined by investigating a number of relative *factors* between these two categories.

Describing the use of technology as a process of framing reality focuses attention on the *factors* that contribute to the outcome of the process. Activity theory[3] outlines an activity as a process between a network of connected *factors* (see Figure 1) (Kuutti, 1996). It highlights activity as containing more than simply a subject utilising an object, but also many external elements that factor into the activity, such as abiding laws, observers and other mediating objects. The use of an emerging technology contributes to incorporating more *factors* as part of the mediation process. Social conventions (labelled 'rules' in the diagram) are part of the *factors* of an activity. These *factors* can have a minor impact or remain unnoticed throughout the process of the activity. However, the intricacy and diversity involved in the mediation between *factors* makes each activity unique. At the same time, patterns between *factors* that have been established over the course of regularly repeated activities minimise the degree of deviation (Kuutti, 1996).[4]

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Figure 1: A simple diagram of the activity theory system, developed by Yrjö Engeström.

[3] Activity theory is also included as part of the applied methodology for this research.
[4] Activities are constantly changing entities and continue to develop a history of their own. The activity can develop in many different directions and can embed older phases into a situation, which is what creates the patterns between *factors*. The history of an activity can be analysed to better understand its development and its current situation (Kuutti, 1996).

The repetition of user engagement and interaction with the typewriter exemplifies that users do not want to deviate from their activity routine. As the typist is habituated to typing with the QWERTY typewriter, it becomes harder for them to attempt different forms of typing, which inhibits the uptake of alternative designs no matter how efficient they may be. “[Technologies] themselves have been created and transformed during the development of the activity itself and carry with them a particular culture – a historical residue of that development” (Kuutti, 1996, p. 13). Typing habits escalate from user to user, influencing what key designs are used and subsequently, what key designs are available. The tautological loop between the habitual uses of a technology and its uptake influences the acceptance (or lack thereof) of innovative technology and directs the evolution of the conventions regarding that technology. Thus, pathways for new technological development become dependent on the established conventions.

The QWERTY typewriter became a conventional tool that hampered the development and acceptance of other designs and innovative finger-to-key interactions. Eventually, this convention became embedded within the design of the computer keyboard, a non-mechanical typing tool (Rogers, 2003). The original motivation for using the QWERTY design became obsolete in future non-mechanical designs; keys no longer needed to be shaped according to mechanical limitations, but have nonetheless been imposed on by the QWERTY typewriter design as a result of established conventions.

Shaping the Computer Keyboard

When subsequent typing tools like the computer keyboard were being designed, its creators did not need to consider the possibility of keys jamming, as the hardware made use of electronic inputs. However, instead of using a faster and more ergonomic design suited to the user’s fingers, the computer keyboard took advantage of the already established QWERTY design (Rogers, 2003). This reinforced consumer interactions through a technology they were already familiar with. Additionally, by using existing manufacturing systems, the financial costs pertaining to keyboard production could be reduced by adhering to the established QWERTY format. Thus, financial *factors* incentivise the continuation of established technologies, regardless of the benefits that can be gained from new innovations. For an innovation to reach consumers, developers and manufacturers need to recognise potential gains in its production process before they will risk deviating from an established technology.

The QWERTY design and its conventions limited the production and advancement of more efficient design choices. While the innovative design of the Dvorak keyboard was later introduced and officially accepted as an alternative keyboard layout, there has been practically no public or commercial uptake of this particular keyboard (Rogers, 2003). “Superior technological innovations do not necessarily diffuse themselves” (Rogers, 2003, p.10).

Too many people remain invested in the (still) standard QWERTY keyboard design. This not only impacts on the computer keyboards of today, but also on future typing interaction development. Keyboard users who have not learned how to type are by default inculcated into using the QWERTY design, thus continuing the conventional typing path.

Technology therefore both enables and limits the user (Kuutti, 1996). It reveals an activity/process as a means to an end, providing the user with skill and experience in the process, yet at the same time limiting them to the affordances of the particular technology and restricting them from the potential of adopting other technologies.

Channelling the Innovation

This is not to say that innovations are not capable of superseding the conventions of technology. As Rogers assertively implies, the adoption of an innovation by society requires certain channels of communication to be sustained over time (2003).[5]

The innovation needs to be articulated in a way that appeals to a potential user through various channels, such as its physical features, media outlets or interpersonal conversations. This shapes the user's perception of what the innovation is and in this way, can easily spread between members of a society, creating both positive and negative influences in terms of its adoption (Rogers, 2003). If the benefits of an innovation are communicated inaccurately, the way in which the innovation is used may alter its optimum usage and inhibit uptake. Understanding how different cultures may perceive an innovation is important for determining what it becomes (Miller & Horst, 2012). Examining the conventions or cultures within a society can influence the approaches for portraying an innovation and influence its successful uptake by users.

The designers of the standard computer keyboard were able to understand the importance of the conventions within society at the time. They understood the popularity of the QWERTY typewriter and used it to convert users to computers. In the case of the standard computer keyboard, it was the typewriter user's perception of typing interactions that contributed to its adoption. Transforming how *factors* associate with and mediate the perception of an innovation can significantly influence how we engage with a technology and ultimately determine what becomes of that innovation. This presents an optimistic view of our role in the development of technology, presenting it not as limited to an organic process but as more of a self-determined path (Kuutti, 1996).

To suggest that there has been no other keyboard design besides the QWERTY option would overlook several different keyboard layouts. Mobile phones are only one example of how finger typing has become established within modern society (Faulkner & Culwin, 2005). However, this

[5] Rogers refers to the communication process for an innovation being adopted as *diffusion*. "It is a special type of communication, in that the messages are concerned with new ideas" (Rogers, 2003, p.5).

type of technology is not considered to be part of the same utility category as the computer keyboard. While they both input commands digitally, their output results differ. The keyboard is primarily used to display characters on a computer locally, while the mobile phone effects this function on another distant, non-locationally-specific device.

The mobile phone did not present any conflict with the computer keyboard when the former was introduced, because it did not involve an either or choice where the two devices were concerned. As the mobile phone evolved and became the 'smartphone', its finger typing interaction evolved as well, with many contemporary mobile phones digitally allowing users to have either the Dvorak or QWERTY key layouts for digital touch screen interaction. The point here is that the mobile phone facilitated another form of typing decades after the typewriter had been conventionalised. It also promoted the acceptance of single-handed typing, when previous attempts at this had failed.

The Chorded Keyboard

Compare the development of the mobile phone typing interaction to the origins of the chorded keyboard (Figure 2) over 50 years ago. The chorded keyboard was invented as a one handed typing device, originally created as a computer keyboard (Norman, 2002). Its typing speed for a proficient user was (and remains) unparalleled to any other key type interaction. However, like the Dvorak keyboard, when it was first introduced, the chorded keyboard did not become a sustainable everyday technology. The *factors* of learning multiple key press combinations and adapting new finger interactions was too steep a learning curve for a period in which computer interaction had not yet been integrated into everyday use (Buxton, 2013). Additionally, interactive habits with the QWERTY design had already been established.

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Fig 2. "Intelligent Image Processing" by Steve Mann, John Wiley and Sons, 2001. Retrieved from http://en.wikipedia.org/wiki/Chorded_keyboard#/media/File:Septambic_key_numbering.jpg

The development and original framing of the chorded keyboard as a computer keyboard prevented it from being widely adopted. It was not until decades later that the introduction of new *factors* such as mobile messaging interactions contributed to the chorded keyboard being

reinvented by mobile phone technology. A technology can be created long before it is perceived as a new innovation by an individual (Sahin, 2006).

In retrospect, however, it does raise questions regarding where the chorded keyboard could have been integrated in other mobile or one handed uses available at the time of its development (i.e., altering the dialling functionality of the rotary phone). Evidence that this technology could have developed differently is present in many of its modern iterations (Figure 3) that had been created by companies and consumers for a variety of uses (Lyons, Starner & Gane, 2006). This shows that typing devices can be used not just for desktop computers, but also as an addition to other portable devices.

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Fig 3: The Twiddler device, A modern iteration of the chorded keyboard. Retrieved from http://twiddler.tekgear.com/

Attempting to change *factors* impacting the use of a technology can assist in its adoption as something more acceptable to society.

Predicting exactly how technological conventions will further impact society is impractical to grasp. As previously explained, they can unexpectedly hinder the progress of one innovation while stimulating the adoption of another. Integrating conventions into the design of an innovation is likely to support the uptake of a technology, as with the example of the QWERTY computer keyboard. Alternatively, if an innovation conflicts with established conventions, an effort needs to be made for promoting factors that communicate the benefit of its adoption. More importantly, however, is to consider the *direction* in which these conventions are taking the development of technology and if this will generate further innovations and establish new conventions for technology within society. Thus, the use of technology exposes pathways that society can eventually yield to (Heidegger, 1977). Considering how society adapts to technologies is an attentive approach for determining if and how this unpredictable process might evolve. A further question to this research being: In what ways do conventions of a technology evolve the engagement and adoption of technology for society?

Conventions are established in a society from habits and common knowledge among users, who become key *factors* in an activity undertaken with a technology. Conventions stand in opposition to innovation or emerging technology. Heidegger describes how new technology reveals new perceptions of reality (1977), while conventions reinforce familiarity. Nonetheless, by viewing the conventions of technology as a self-determined process, we can make more conscious and informed decisions about how technology develops.

Methodology

This chapter describes the process taken for identifying conventional uses of technology and creating approaches for related innovative technological changes to be adopted by society. The use of activity theory (Kuutti, 1996) is reintroduced here alongside mediated discourse analysis (Scollon, 2002) as key ethnographic methods employed for investigating public activities to find a technology to investigate. These methods are put into practice through the use of video annotation software, resulting in the selection and exploration of the *Wearable Devices* field.

The subsequent section describes the application of the design with intent method, which is used to identify patterns in *factors* relative to the potential conventions of the technology field (Lockton, Harrison & Stanton, 2009). The methodology incorporates practice based hacking experimentation, conceived for understanding and simulating the impacts of the approaches. The experiments were deployed into public spaces to gather meaningful contextual responses.

Activity Theory and Mediated Discourse Analysis

As described in the first two chapters, activity theory (AT) examines the *factors* that influence an activity. The theory is applied to this research as a means for understanding the components that make up an activity. Kuutti advocates AT as accommodating discussions on the issues found in a multilevel system (1996). The point of AT is to study the mediation of the factors and the goal or purpose of an activity. It recognises the complexity of the *factors* influencing the use of technology and provides consideration to ways of deconstructing the dynamics of an activity.

With activity theory kept in mind, the research adopted Ron Scollon's (2002) concept of mediated discourse analysis (MDA). MDA provides new interpretations of an activity by isolating interlinked actions into discursive orientation. The actions are translated into basic discourse in order to shed light on the relationship between the factors involved in the action. The method simplifies the mesh of mediating *factors* and asks how they are responsible for the actions within an activity, the focus of this method was to understand the role technology plays as a *factor* in an activity.

Both methods were implemented in the observation and analysis of people in public spaces such as markets and popular streets (Figure 4). These spaces were recorded in the initial steps of the methodology and applied both AT and MDA methods for identifying patterns of behaviour and questions for subsequent investigating. The researcher acknowledges that inserting himself within the public spaces and recording the events gave agency to the activity processes performed by members of the public.

Figure 4: *Observation*. Observation recordings made at a market in Auckland.

The recordings of the public spaces were analysed using video annotation software, which was created by the researcher for this step of the research. As shown in Figure 5, simple descriptions of the objects in frame and the actions taking place were labelled over top of the video content. While the purpose of this research was investigating mainstream contemporary objects, highlighting any object helped to acknowledge the role it had in an activity. The result led to connecting the labels that repeatedly appeared, such as the type of behaviour of a user and the items they wore, such as sunglasses and backpacks. While the validity of information gathered concerning public activities can be subjective, the techniques produced enough questions and interest concerning a technology field to warrant further investigation.

Figure 5: *Observation annotation*. Video stills of the video annotation software using the media discourse analysis method.

Design with Intent

The technology field is briefly analysed through perceptual lenses to single out and focus on the importance that a *factor* or *factors* play in the use of a technology. The design with intent method recommends lenses as approaching the design of a technology through different concepts (Lockton, Harrison & Stanton, 2009). It provides a designer with a particular disciplinary perspective for solving a design problem and trialling different ideas to find the best design choice. This research applies these lenses to temporarily focus on a category of *factors* for analysis in an activity in order to gain a better picture of what the function of the *factors* is. It is an approach that asks questions that are most relevant to the category in terms of how it is influenced by the activity. Three categories, each providing different viewpoints for the technology field are included here: function of use, context of use and the behaviour of the user with the technology.

Wearable Devices Field

Wearable Devices was selected as the field for this research after observing that two objects, smartphones and sunglasses, repeatedly appeared in the public recordings. This raised questions regarding the role of sunglasses in influencing the behaviour of the wearer and how this behaviour changed when integrating the digital functionality found in smart devices, like Google Glasses or iWatch (Molina, 2014).

Mike Michael describes technology as capable of perceptually empowering its user (2000). For example, automobile drivers can become empowered, even aggressive, as the result of a perceived security and strength provided by their vehicle. The car absents the driver from the outside world, shielding them from external conflict. In a similar way sunglasses shield the wearer's eyes, thereby giving another sense of empowerment by concealing information from observers about what their eyes are reading or expressing. Describing technology as a *factor* that mediates a user's activity places the focus on extracting theories and evidence of how wearable items, specifically on-body interactive digital technology, can mediate a user's behaviour.

Wearable devices are defined in this paper as interactive digital products that function as extensions of the human body (Kuru & Erbuğ, 2013). These devices are an integration of digital technology and wearable items – not necessarily a new invention, but a reinvention and redesign of current wearables. They are capable of mediating the user's senses via tactile, visual, auditory and other sensual outputs. Additional to their core functions, mainstream wearable items like watches, sunglasses, shoes, gloves, jackets, helmets and backpacks are now being designed with digital capabilities. This can be sensor inputs or internet access and notification alerts to support a user's daily activities (Dvorak, 2008).

On-body digital products are widely speculated as being on the cusp of breaking into everyday settings, with recent reports estimating them to being extensively used in people's lives by 2016 (Kuru & Erbuğ, 2013). From professional viewpoints, including large technology companies like Google and Apple, wearable devices are leading towards becoming an established part of everyday mainstream technology and inevitable within the next few years (Dvorak, 2008, Molina, 2014). Despite recent media hype[6], wearable devices are currently not yet a mainstream or conventionally used technology. However, focusing this research only on how to make wearable devices adoptable into mainstream use would simply recap many already-existing propositions (Dvorak, 2008, Kuru & Erbuğ, 2013, Molina, 2014). Instead, this research explores the impacts to wearable devices already being established in society and what changes it has to users engaging with the technology.

Accordingly, using the existing knowledge and predictions pertaining to wearable devices, the analysis of this technology is through the theories of its use in the foreseeable future, where such devices exist as a mainstream technology. By speculating on the impacts of wearable devices as an integrated part of daily life, research in this area anticipates obtaining a more conscious understanding it has to societal and technological development.

The selected field includes many digital components as being part of the functionality of wearable devices. 'Digital' is used in this research as a medium that exists outside of physical quantity, its essence existing within computer systems and devices and simplified to bits consisting of 0s and 1s (Miller & Horst, 2012). Digital technology directs information within different types of media and is capable of automating the user's activity (Kuutti, 1996). The rate at which digital technology is evolving and influencing society has left major gaps between the users' understanding and adoption of emerging digital technology. For example, a piece of software is difficult to observe while being used and to interact with, making it difficult for new users to come to terms with what the software is doing (Sahin, 2006). Digital technology is easily changeable and cannot always be observed in terms of how it functions. The rate at which digital technology has come to influence society and the established conventions have rendered it a targeted platform for analysing in this research.

To better understand the efficacy of applying innovative technological changes to a mainstream context and retrieving unanticipated real world information, simulating these changes in a similarly anticipated context is required. As Kuutti states, an activity requires at least a minimal meaningful context to properly analyse individual actions (1996). This is because human actions, e.g., a user interacting with technology, are always situated within a particular context. The activity cannot be fully understood without the context in which it takes place.

To do so, the research implemented experiments to practically examine and test theoretical approaches for creating innovative changes in a technology field. These experiments began

[6] Morton, J. (2015). Bright ideas carry tech into the future. *The New Zealand Herald*. Retrieved from http://www.nzherald.co.nz/business/news/article.cfm?c_id=3&objectid=11465173

with practice-based hacking techniques applied to digital technologies. The hacks were scoped within the context of the approaches theorised in this research and executed to better understand the impact of the approach.

Hacking is a way of using various tools to adopt a new form of thinking or idea (Paridiso, Heidemann & Zimmerman, 2008). It gives the hacker a method with which to customise tools in a way that permits a new idea into existence. Hacking allows for the redesigning of technology or inventions that arise from new technology. In terms of this research, it allows an approach for innovatively changing a technology field and giving that change physical form. Producing a prototype of the approach contributes to implementing practice-based tests for meaningful contextual results[7]. Overall, hacking provides for better understanding of an innovative change to an activity. Following one of the approaches described in the Wearable Device Field Analysis chapter, the testing of these experiments is presented.

MDA techniques were reapplied when analysing the experiments. This was again used to translate and identify interlinked actions, this time with a focus on the impacts of the approach prototype.

The cumulation of these experiments provided the researcher with the capabilities to design and produce a final practical outcome in the form of a physical representation and method for communicating to the public the researcher's outlook. This representation and method articulate his view on the direction he expects from the developing conventions in the *Wearable Devices* technology field.

The methodology described in this chapter is aimed at identifying the established or expected conventions of use of a technology field. It provides methods for attaining an awareness of the uses of a technology and emphasises through the applied approaches the possibilities for selectively directing society's use and relationship with technology. The process of the methodology is not a linear structure (Figure 6), but one that is capable of looping through different phases, where in terms of experimentations, multiple iterations are applicable.

[7] The researcher acknowledges that including himself in the testing of the experiments produced *factors* that deviated from a more meaningful activity outcome.

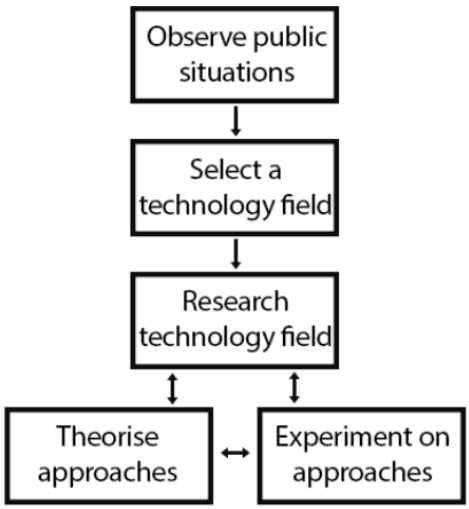

Figure 6: A diagram of the methodology for the proposed research.

The effect of using the above methodology is to give an informed understanding around the question for this research. Of the conventional uses of a technology, what are its impacts on society and most importantly, what are the directions in which technology can further develop? This is demonstrated in the next chapter, which presents the expected conventions of the *Wearable Devices* field.

Wearable Device Field Analysis

The following is a discussion of the implications of using wearable devices as a conventional technology and draws from a collection of sources speculating on the mainstreaming of wearable devices in the near future. Many of the anticipated types of design features are taken from Joseph L. Dvorak in his book *Moving Wearables into the Mainstream: Taming the Borg* (2008), which describes the design elements expected for wearable devices to be embraced by mainstream populations. As explained by Dvorak, much of what influences wearable devices to be adopted are the desires and expectations of potential users. This is explained in this chapter using the three categories of *factors*: function of use, context of use and behaviour of the user. The categories explain user desires as not only entailing change in the design of wearable device functionality, but altering the user's behaviour and social contexts. Each category explains how its relative *factors* are mediated through the speculated conventional use of wearable devices. Approaches then express how these *factors* can be altered to further mediate the use of wearable devices into a different direction. The approaches highlight the innovative input that society can have in influencing the ways in which wearable devices will be adopted and utilised for mainstream use. These approaches address various issues, e.g., changes to the public's social behaviours and the public's rights regarding awareness about the use of wearable devices.

Desire, Design and Development

Interactive on-body devices are not new or untested concepts. From the creation of miniaturised electronic computer components in the early 80s, wearable devices have for some time been trialled for commercial integration (Barfield & Caudell, 2001). Until recently, however, technology progression and contemporary social structures have prevented wearable devices from becoming a mainstream technology. The flow of the user's everyday interactions and activities were disrupted from the use of wearable devices (Karahanoğlu & Erbuğ, 2011); the devices have also caused the user to behave in a way that felt unnatural to them. It is crucial for a technology to be characterised in a way that appeals to users (Rogers, 2003). With the increased capabilities of emerging technologies (flexibility, background functionality, advanced autonomous actions etc.), wearable devices are now reaching a mainstream audience in a way that can meet the desires of potential users (Dvorak, 2008; Kuru & Erbuğ, 2013; Molina, 2014).

Like many commercial products, it can be said that a major *factor* determining the design and mainstream adoption of wearable devices is the desire of users (Dvorak, 2008). Many of these desires are inspired by smartphones, which are capable of a range of features that people are now accustomed to using (Dvorak, 2008).[8] The user desires technology that improves on what they already have. Similar to how the computer keyboard used the QWERTY design, many of

[8] A list of all features ever made for a mobile phone can be found in Joseph L. Dvorak's book *Moving Wearables into the Mainstream: Taming the Borg* (2008).

the conventional uses of established smartphones are desired and expected to be integrated within the next generation of wearable devices. The effect of smartphones becoming mainstream devices has also alleviated wearable device interaction in public to being at a more acceptable level within society.

A defining characteristic of wearable devices is its association with the user's body (Dvorak, 2008). While being in close proximity to and in contact with the user's senses, wearable devices have to function in a way that respects the user's desire for privacy. From a social perspective, the device must also accommodate functioning as a form of user expression. Such desires consequentially shape the *factors* that determine how wearable devices do the following: (1) engages with the user; (2) are perceived by observers; (3) interacts with the environment. The result is that these desires become part of the process of shaping the conventional uses of wearable devices.

Wearable Devices: Function of Use

The functions of wearable devices range from having utilitarian purposes to forms of expression, and provide many ways for supporting their acceptance as a mainstream technology. This research focuses on two core function *factors* for wearable devices: as a form of expression for the user and discreetness of device interaction. These are two *factors* commonly speculated on when investigating what a user desires (Andersson & No, 2014; Dvorak, 2008; Karahanoğlu & Erbuğ, 2011; Kuru & Erbuğ, 2013). What a person puts on their body is an expression of who they are as an individual. Innately, wearable device functionality factors into this expression of self. If the wearable device cannot fulfil these desires it is unlikely to be adopted. Incorporating these desired functions into wearable devices is consequently a significant *factor* influencing the development of wearable devices within society.

Expression Functionality Factors

Admittedly, innovative and mobile digital technologies have begun to deliver specific fashion perceptions, i.e., expressing an expensive lifestyle and financial well-being (Rogers, 2003). However, considering devices as clothing products generates negative connotations, making them appear cold and unemotional and thus contrasting fabric fashion traits (Dvorak, 2008). If a wearable device does not factor into the image desired by its user, it should not interfere with other worn wearables that do function as personal expression (Dvorak, 2008). The digital component(s) of wearables needs to support the expression of the user's clothing and play to its strengths.

As a result, designers aim to produce wearable devices that function discreetly or transparently, camouflaged underneath more conventional wearables (Brewster, Lumsden, Bell, Hall & Tasker, 2003). Many commercial companies already attempting to produce wearable devices have liaised with fashion and body textile designers, cloaking digital technology under a product

item that is accepted amongst popular wearable brands and social circles (Andersson & No, 2014). Wearable devices associated with popular brands and fashion labels give the user an appealing way to visually express themselves by identifying with a particular group through the product (Kuru & Erbuğ, 2013).

For observers of the wearer who are not aware of this camouflaging, it may be difficult to understand the actions of a wearable device user, causing the observers to develop misinformed perceptions about the user. Products like Google Glass and Apple Watch being presented as glasses and watches may trigger the public to assume that all product or brand counterparts have imbedded digital capabilities. Alternatively, the public may remain oblivious to digital technology when it is associated exclusively with a brand that creates mostly analogous wearable products.

The concern here is that when a user interacts with their wearable device, an observer may have difficulty interpreting what they are doing. Just as a person can be misinterpreted when speaking into a microphone on earbuds, other well-disguised actions by a user can be misrepresented. If wearable devices are to be adopted as a concealed and fashionable mainstream technology, it needs to bridge a miscommunication gap between a user engaging with their wearable device and what an observer understands of that engagement.

Wearable Device Approach One:
Surrounding Public Members are Notified of a Wearable Device Being Present

To combat public misconceptions of wearable devices, functionality features that inform public observers of its presence need to be introduced. For example, a product called *OwnPhones* (Figure 7) is a personal, custom designed wireless earbuds (2014). The device becomes concealed by being shaped and selectively coloured the same as the user's ear. To indicate to surrounding people how the user is using the earbuds, they are designed with an LED status feature. The LED changes colour depending on the user's availability. Designing indicative features for wearable devices will help to address concerns related to potential misunderstandings involving users with discreet wearable devices (Dvorak, 2008).

(This image has been removed by the author of this thesis for copyright reasons)

Figure 7: Video still of *OwnPhones* promotional video. Retrieved from http://ownphones.com/

In saying this, indicative functions such as that mentioned above are not considered positive attributes when transferred to other related wearable items. Many focus groups in Dvorak's studies on wearable technology did not want their personal items (e.g., jewellery) to appear "geeked up" with cheap LEDs (2008). Combining digital technology with decorative and expensive ornamental wearables is likely to diminish the latters appearance and value. This further reiterates that the device component cannot interfere with the original function of an established wearable, further supporting discreet design approaches.

Wearable Device Approach Two:
Surrounding Devices are Notified of a Wearable Device Being Present

In this approach, any user with an external device[9] will have the choice of whether to be informed when another wearable device is in its immediate proximity. This proposes that wearable devices will function like beacons, sending signals wirelessly to other nearby devices. This approach is not limited to personal devices, but any technology situated in the environment capable of detecting a wearable device. This approach will allow the public to become more aware of wearable devices and exposes the presence of hidden devices.

Experiment and Test of Approach

Wearable Device Approach Two was practically experimented on, with the aim of increasing a person's awareness of their digital surroundings. The experimentation was an attempt to test how a person would react when made aware that there was unseen digital technology close by. The experimentation involved hacking together separate components to create a device capable of informing the user of devices in the area. The experiment tested this in busy urban spaces using a Bluetooth module[10]. Bluetooth is a common means for wirelessly exchanging data between mobile devices and is capable of identifying the presence of nearby active devices without connecting to them. The Bluetooth module was controlled by an Arduino microcontroller. Both components were hidden inside a backpack (Figure 9).

[9] Such devices can be smartphones, laptops, environmental devices, etc.
[10] The first experiments utilised a radio frequency (RF) signal receiver to detect electrical devices within a space of roughly 10 metres around the device. The RF device was expected to audibly alert the user each time a radio signal was held for a few seconds; however, the RF device was never tested in public, as the range of frequency was too broad to identify close proximity devices in busy, urban spaces.

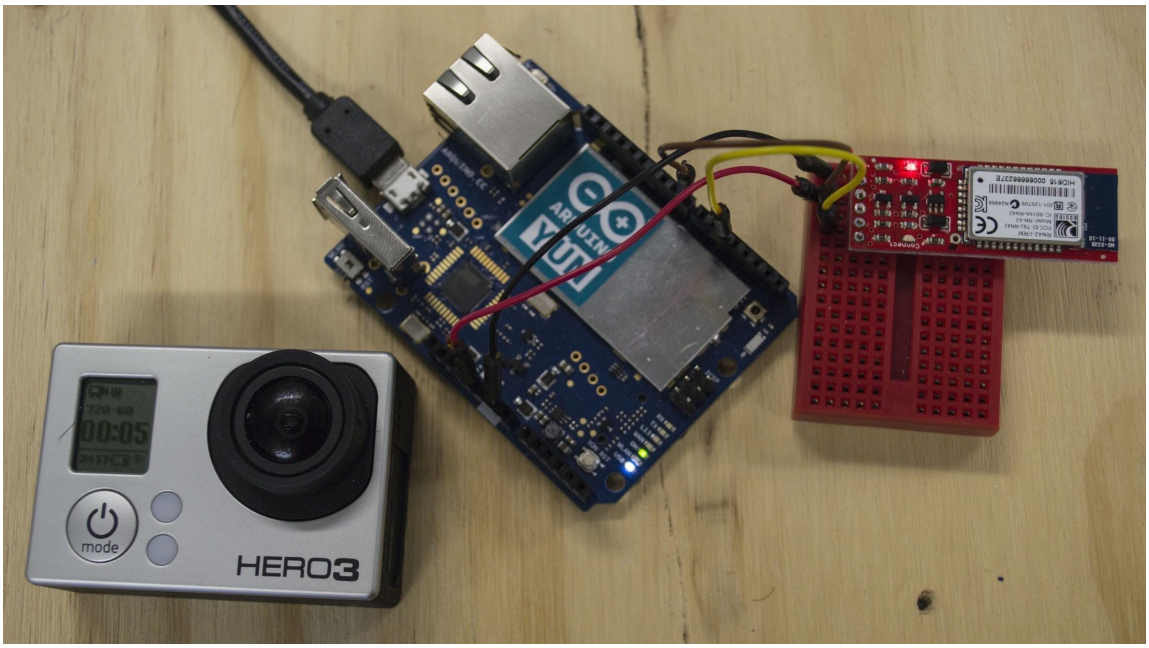

Figure 8: *Experiment hardware*. The Bluetooth module, Arduino and GoPro.

When the hacked device detects another device, it emits a short beeping noise to indicate the presence of nearby devices. The testing of the experiment was recorded using a GoPro camera to provide later analysis of the user's and observers' reaction, and to provide information on the context of the detected devices. The experiment was tested on two separate days, each roughly lasting one and a half hours. The test areas (Figure 10) consisted of main streets and public buildings in central Auckland. During the test, activities consisted of eating, talking and walking.

Figure 9: (Left) *Experiment test setup*. The placing of the GoPro and backpack.

Figure 10: (Right) *Experiment test capture*. Video still of the GoPro recording, capturing the detected devices.

The analysis of the testing used MDA techniques and video annotation software to formulate a more in-depth understanding of the experimental approach.

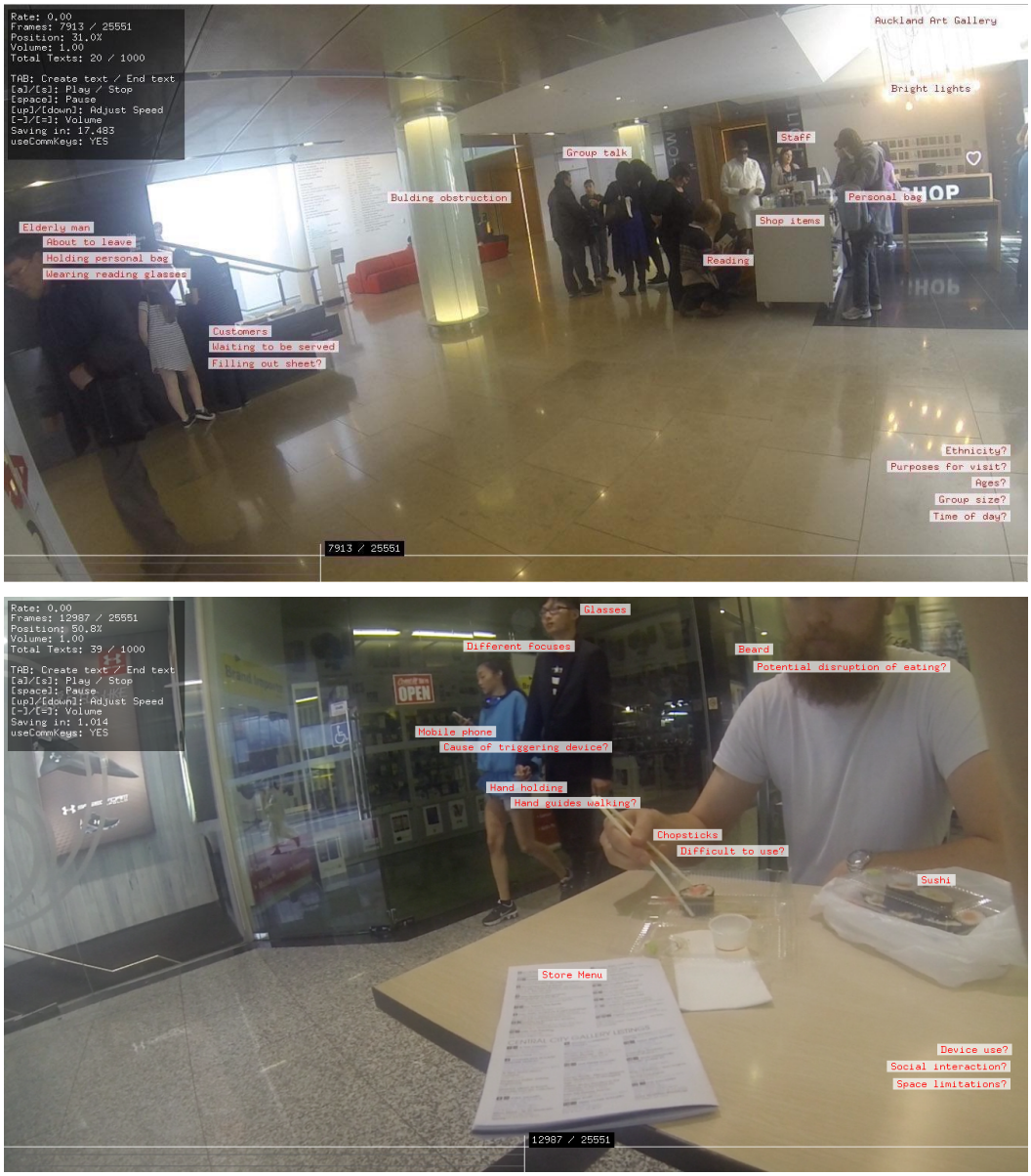

Figure 11 & Figure 12: *Experiment annotated*. Video stills of the annotation software used for the GoPro recordings.

The results of the test indicated prioritisation of the hacked device over other nearby devices detected in the area. The wearer of the hacked device reacted to its device detection noise in a self-aware manner. He became conscious of his actions when around other people and what they were doing. He did not hold himself accountable for the actions of the hacked device and saw it as an independent *factor* to his activity. Although it was the researcher's movements that caused the hacked device to trigger, he identified the hacked device as being separate from himself, with its own autonomous actions. This was perceived differently when the tester saw other members of the public utilising their own personal devices and related their actions as directly accountable for their device's functionality.

This experiment[11] indicated a difference between how a user associated themselves with their personal device and how they perceive other people who utilise their own personal devices. The user did not view their device as a part of himself, but rather as acting on its own volition, working in the background. When observing other people using a device, however, the user perceived the person and device as one system, working together towards a single goal. This raises questions about how society distinguishes between a user and the technology they use. If wearable devices are adopted into mainstream acceptance, the thresholds regarding the above observations will undoubtedly change. The results of this experiment contributed to the concept and development of the *Wearable Beacon* outcome.

Wearable Devices: Context of Use

Observation of Wearable Device Interaction Factors

One way to understand the types of interaction possible with a technology is by observing a user's engagement with that technology in a particular context (Kuru & Erbuğ, 2013). As a wearable device becomes more established within society, they inform both observers and the user about its capabilities. The presence of wearable device interaction in public not only shows observers how to interact with it, but also asserts the social acceptance of the devices being used in that context. Technology cannot be taken at face value, as it may carry with it a particular cultural understanding, based on its use (Kuutti, 1996). When technologies become established within a particular context, they become a *factor* in the social constructs of said context.

Interpretation of user behaviour with wearable devices is therefore context dependent. For example, in 2003, a device was designed to act according to head nodding movements, thus allowing for hands-free and vision-free interaction in busy public areas (Brewster, Lumsden, Bell, Hall & Tasker). The headphone-like device (Figure 13) allowed users to interact with their smart devices by moving their head in a certain direction in order to change a song or switch to a different application. The device outputs responses via a computerised voice from the headphones.

[11] From the allocated time with the device detector, it was difficult to identify stronger senses towards technology; further extended testing is required.

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Figure 13: Brewster, S., Lumsden, J., Bell, M., Hall, M., & Tasker, S. (2003). The wearable system used for the head nodding interaction.

The advantages of using such a head mounted device are its similarities to conventional headphones. The general acceptance of these devices as wearable technology lowers anxiety issues for the user when employing an unconventional wearable device, as it interacts by adopting the characteristics of another socially accepted technology (Brewster, Lumsden, Bell, Hall & Tasker, 2003).[12] However, the head nodding functionality is not a typical means of interacting. Without any visual manifestation of the device, again there is a boundary that prevents observers from accurately interpreting how the wearable device mediates a user's behaviour. The observer is left to relate the user's actions to what they understand as appropriate behaviour within the specific context.

What is perceived as acceptable behaviour in public is ever-changing. Even without observers understanding the cause of the behaviours of wearable device users, it remains uncertain if these behaviours will be appropriated into society. Designing wearable devices that mediate the user's behaviour for a specific context can therefore indicate to observers the specific behaviour and direct how the public will behave within that particular context.

Wearable Device Approach Three:
Context Mediates Wearable Device Functionality

While still underdeveloped, wearable devices have the potential to incorporate usable context-aware applications once the environment criteria has been satisfied (Brey, 2006; Dvorak, 2008; Lockton, Harrison & Stanton, 2010). In this context, wearable devices will change functional capabilities depending on the location and activity of the user. If in a quiet setting, for example, a device might output through a visual display and receive input via touch control. If the user's sight and hands are required for another activity (like driving a car), the wearable device will switch to functioning according to voice prompt services. Context dependant applications should

[12] The headphone nodding device was a prototype that never reached the market and was not tested outside of control groups in private; however, the design of it was described by users as lowering anxiety issues when using the technology.

adapt to the user's behaviour within a particular context; by customising wearable devices with personalised settings, a range of user activities can be accommodated (Kuru & Erbuğ, 2013). This can assist in minimising the misinterpretation of wearable device use.

What the above approach instigates, however, is another direction of technology evolution that will require society to be aware of. Appropriating a user's behaviour in the ways mentioned invokes questions about the autonomous capability of technology over its users. While interfering with a user's interaction[13] can provide a suitable type of agency for a particular context, it gives rise to ethical concerns in relation to the autonomous freedom for the user (Brey, 2006).

Wearable Device User's Capabilities Factors

Another *factor* worth considering is how the enhanced functionality that wearable devices provide to the user relates to the capabilities of non-users in society. As Marshall McLuhan states, technology gives a person the capability to extend their body in nonhuman ways, limiting or strengthening a person's interaction with their environment (as cited in Brey, 2000). Currently, a smartphone user can rapidly use services or access information through the Internet or other wireless means. It is anticipated that wearable devices will soon extend these capabilities by wirelessly communicating with devices in the immediate environment (Dvorak, 2008). Companies and governments will begin to cater to customers who make use of such technology, as they view wearable devices as becoming a mainstream technology (Dvorak, 2008). This will widen the digital divide for people without wearable devices, who will be disadvantaged as future services begin to build support for exclusive device services.

One example of the technological gap between public members is the common cafeteria space. Formerly, it provided a place for customers to eat and socialise in; today, however, it is common for cafes to provide Wi-Fi access for personal devices. Changes such as these take time to evolve, but become established as more customers frequently use cafes that provide such services. However, services such as this are only available to customers who have the technology and skills to use them.

While it can be argued that this service is only required by people who have Wi-Fi enabled devices, there are many cases where smart devices – and specifically, wearable devices – can potentially mediate the interaction and use of virtually all services. For example, locating and purchasing a product could be achieved through the wearable device as a fully automated process, rather than needing to physically go to a store (Dvorak, 2008). The process will not require human resources or the customer's full attention, as everything will be communicated and responded to by the wearable device through a virtual store. This will create a service that

[13] It should be noted that each wearable device user will have varying amounts of interaction. What could be considered the preferred option for one user may be considered limiting for another (Dvorak, 2008). Therefore, the applications created will need to be adjustable to the user's desired level of complexity and sensitivity in order to find the right balance of choice and interaction.

is more efficient for all participants involved. By giving technology-enabled users access to certain services, companies will be able to keep track of particular user profiles and social statuses (Brey, 2006). The companies will also be able to use the data from this digital process to formulate better strategies for customer services. Establishing technology such as wearable devices is useful not only for the user, but also for its contextual *factors*, such as its use for companies.

Using wearable devices for tasks such as the above is expected to take place on a daily and simultaneous basis. While this change will allow for acceleration in terms of task completion for the user, it indicates a distancing between daily experiences and the relatability of users and non-users to wearable devices. This impacts how, where and with whom members of a society interact in public. If these types of engagement become conventional ways of accessing contemporary services it will place pressure on non-users to become technologically enabled (Brey, 2006).

Wearable Device Approach Four:
Wearable Devices Designed for Specific Contexts

To prevent widening the affiliation gap between members of society, wearable devices can be designed for an appropriate context. An effective example of this is one of the first commercial wearable devices, called *Recon Snow* (Molina, 2014). Released in 2008, it was designed specifically for skiers to use on mountain ranges. The *Recon Snow* can be used as a standard pair of ski goggles, but also features a digital heads-up display. This provides the user with information such as their speed and the environmental temperature. The design of the goggles make them acceptable for use in a mountaintop environment, while also rendering its digital functionality less apparent to other people in the same surroundings. This is achieved by having *Recon Snow* fit into a context where the use of the device is only relative and consequential to the user, without altering how they interact with any surrounding people or to an extent, the environment. The use of the device fits a context specific niche, and is therefore less likely to cause a differentiation between users and non-users. The active nature and change in a skier's behaviour is also unlikely to provoke anyone's attention, because the particular context accommodates such behaviour.

While this approach may appear to be irrelevant for mainstream wearable devices, it should be made clear that technology can be mainstream while still being designed for use in distinct situations. What the *Recon Snow* device highlights is that its features are suitable for members on the mountain, while in the main street of a busy city, for example, it becomes less relevant, thus making its impact only valid to the mountain context. Wearable devices designed for use in a particular context only affects the members that are affiliated with said context. If the context allows non-users to continue their activities without needing a wearable device, there will be less of a distance between users and non-users' daily experiences. Having a range of wearable

devices shaped for different contexts means the device can be more accommodating to users and non-users in a particular context.

Wearable Devices: Behaviour of the User

> *"Technologies always have consequences for human behavior, and for understanding human behavior it is necessary to take into account the ways in which it is influenced by technology."*
> (Verbeck & Slob, 2006, p. 385)

When a user begins to interact with a new technology they consciously act it out, orientating themselves with this unfamiliar new activity (Kuutti, 1996; Rogers, 2003). As explained in the Literature Review chapter, once a user discovers the efficacy of a technology, repeated use habituates it into the user's activities. Habitual behaviours are not the essence of a technology, but part of the user and how they associate and engage with objects in the world. The operations and perceptions built up in this way are not restricted to one subject, but transferrable to other activities that fit the criteria.

Text messaging is a conventional way of communicating via mobile phones and demonstrates how it has overlapped into discursive human conversations (Faulkner & Culwin, 2005). Text messaging has also produced new colloquial words that people use to express themselves outside the context of mobile phones. Initialised words like "LOL" and "OMG" that were originally used for texting are now being used in other media and have been added to the Oxford English Dictionary (Lee, 2011).

Similarly, wearable devices mediate a user's engagement with the world by closely mapping their senses in a way that can leave impacts long after its use. While briefly touched on in the previous subsections, this category of *factors* focuses on the impact that wearable devices have on the user's behaviour, with a particular emphasis on their impact after a user has used the device.

Perception and State of Mind Factors

As articulated by Michael's car analogy in the Methodology chapter, technology mediates how a user engages with the world (2000). Currently, mobile device users can be physically present while mentally using their device within a digital realm (Dvorak, 2008). This type of situation is expected to become even more common as wearable devices, with their proximity to the body, see an increase in their influence on the physical and mental states of the user (Dvorak, 2008). Whether a wearable device user is conversing within a social group or driving a vehicle, the device will integrate with the user's senses in an immersive manner that can potentially impair their attention in the physical space. Furthermore, knowing if the average user is capable of habitually and rapidly switching between two mind states is difficult to judge without wearable devices first being adopted and adjusting the everyday engagements of its user.

Another form of attention diversion can occur when the user instantaneously retrieves and absorbs information online. This functionality, coupled with invisible interaction, can allow users to interpret situations or people using online information and without any surrounding people knowing they are doing so. The functionality mediates the user and their dynamics within social contexts, similar to face-to-face communication (Dvorak, 2008). While having a conversation with someone, a wearable device user might also be able to absorb information about the person they are speaking to via the Internet.

These features illustrate only a few ways in which wearable devices can influence a user's state of mind and their perception of the world in which they engage. As stated, the wearable device can leave the user with less of a presence in the physical space, or provide information to the user *about* the physical space. These capabilities mediate how the user feels and acts; the utilisation of wearable devices is in this way very much a mental *factor* influencing a user's behaviour. How the user perceives wearable devices changes their attitude towards it. A user may feel superior to their fellow associates because of their newly enhanced abilities and may misuse or abuse the technology.

Wearable Device Approach Five:
Communicate Responsibilities for Using Wearable Devices

If the technology is communicated and viewed with specific requirements for use in public, it places on the user the responsibility to behave with it in an appropriate manner. Video cameras already have regulations in place concerning the use of recording in public spaces. When filming, it is expected that the camera's focus will be kept away from an individual if the videographer has not been given their consent to be filmed. Similar responsibilities could be placed on wearable device users when using the device in public. Advising the wearable device user to be conscious of how to behave with the device will prevent users from forming antisocial or dangerous habits like the ones mentioned above. Establishing regulations for wearable device usage and their enforcement, however, would not be up to society only, but should also involve the government and law.

User Independence Factors

It is generally thought that technical objects are created as an extension or amplification of the body to assist motor, perceptual and cognitive functions (Brey, 2000). In terms of wearable devices, this is rather literal, as the technology attaches to and interacts directly with the body. The use of wearable devices is expected to enhance many aspects of our senses and change how we receive and learn new information (Dvorak, 2008). A user may find themselves utilising a wearable device to instruct them in a-step-by-step manner how to complete a task using visual and audio cues. However, utilising wearable devices like this will lower the required skill level of the user to complete the task. While it will enhance the capabilities of the user, it will

also create a larger dependency on the wearable device to facilitate the gap of learning and experience of the user.

Becoming too familiar with these enhancements can render the user heavily reliant on the information they access through the wearable device. Even though the technology reveals new activity processes to the user, it also restricts them from alternative possibilities (Strijbos, 2006). Wearable devices may allow the user to accomplish tasks they were not capable of doing by themselves; inevitably, however, it will prevent them from functioning more independently. The technology will thus become part of the user's way of functioning as its use becomes habituated and the device latches onto their body, becoming a semi-permanent system.

Wearable Device Approach Six:
Society Co-evolves with Technology

This research has shown evidence for (1) technological determinism: a belief that technology changes society; and (2) social constructionism: a viewpoint that sees technology being accepted and shaped by society (Rogers, 2003). From a social constructionism standpoint, the habitual behaviour of wearable device users evolve parallel to society, producing an environment for the habits to exist in (Lockton, Harrison & Stanton, 2010). It is society that enables the creation of a technology and allows it to become established. Society co-evolves with technology, alongside many other *factors* that are constantly influencing this evolution. This suggests that society will accommodate the habits associated with a wearable device as it becomes established.

(This image has been removed by the author of this thesis for copyright reasons)

Figure 14: *Steve Mann*. Image of Steve Mann and his wearable device attached to his body. Retrieved from http://daichuanqing.com/index.php/archives/date/2013/10

A technology has not been rendered mainstream when a user, habituated to its uses, can become distressed without it. A cyborg named Steve Mann (Figure 14) wore a wearable system

almost every day for 20 years that became part of him and his daily activities (Dvorak, 2008). Mann relied on the device to be able to function. Once, while moving through airport security, the system was forcibly removed from his body, causing him physical and mental stress and disorientation. The system was taken apart and did not function in the same way when put back together. Mann was not used to operating without the device and airport security were not able to accommodate his need for it, because the technology was not a common object to be carried. If the technology had been commonly used and well known, the airport may have had protocols for accommodating Mann's requirements. While mobile phones are not fixed to the body like wearable devices are, they demonstrate how airport security and to a larger extent, society, have been able to accommodate the public who use established technologies. Aircrafts, for example, are now equipped with Wi-Fi capabilities, helping users to stay connected to their phones while in the air.[14]

The environment is part of what has made the user dependant on technology. The habits a user develops with wearable technology are developed from having only one way to complete a task. When there is no alternative support for the user's habits regarding technology, a disruption to the activity occurs. Wearable devices being established and conventionally used in society means that *factors* are present to support a user's habit of using it. This optimistic approach to wearable technology development takes into account the changes that are happening in society that already support wearable devices being established. It points out that the conventions of technology have become established because, as a society, we have accommodated to these changes as part of our evolution with it.

[14] Daniels, C. (2004). Sky's no limit to the internet. New Zealand Herald. Retrieved from http://www.nzherald.co.nz/technology/news/article.cfm?c_id=5&objectid=3604958

Outcome and Conclusion

Figure 15. *Wearable Beacon*. Photograph of the practical outcome tested in public.

What developed from the investigations of this research was a physical embodiment of the core points addressed by this research. A digital shirt, titled *Wearable Beacon*, was created to articulate its relationship with establishing wearable devices and the importance for society to be aware of these relationships.

As described in the Literature Review chapter, when a user initiates an activity with a technology, the *factors* associated with the activity mediate its outcome. Due to the complexity of these activities, it is difficult to take into account all the *factors* involved and what it is they are mediating. This has shown to be especially true for wearable devices, which are desired to function in a concealed manner while mediating the user's behaviour. As demonstrated by this research, investigations concerning the conventions developed from a technology allow us to better understand the impacts of using the technology in society. The investigations made on wearable devices as a mainstream technology have presented a clearer picture of its advancements and setbacks to society and technology.

The *Wearable Devices* technology field was investigated in this thesis using different perceptual lenses, thus briefly allowing the research to focus on understanding the impacts on and of a limited category of *factors*. What resulted is a portrayal of potential changes to observers, environments, fashions, behaviours, habits and the capabilities of users of wearable devices. From the information gathered on wearable devices, these changes are likely to take place over the next decade; developing an awareness of them now allows us to decide if an approach can better direct how users and observers of this technology are to engage with wearable devices in

public. The intention of the physical component of this research is to communicate awareness and perception of how the researcher sees wearable devices impacting society. The digital shirt demonstrates that the evolution of wearable technology as a mainstream technology is continuing along a path in a given direction, with or without society's awareness of it.

The researcher identified several potential impacts of establishing wearable devices as being connected to how society interprets wearable devices. These impacts relate to the desired functionality of wearable devices by users, such as digitally enhancing their capabilities, and doing so in a transparent and expressive manner. As described earlier on in the Wearable Device Field Analysis chapter, many wearable device designers are working closely with fashion labels to better integrate the technology into modern everyday fashion styles. The expected characteristics of the technology are to also integrate closely with the user's body, mediating their senses and behaviour, giving them skills and capabilities out of reach for anyone without the technology. Furthermore as this mediation is commonly used by the user it can leave them reliant on the technology or device in question. These desired characteristics create a threshold, separating users from their device hard to distinguish. It is important to realise that the developments for this technology identified here, relate to the user's body in a highly influential and personal way, one that in some instances mimics the invisible sensory information inputs and outputs of the human body. For the most part, the biological sensors of the body can be identifiable and to an extent, understood between different people. Wearable devices however, (currently) are not an always utilised input/output for the everyday person. Communicating this to society will help to consciously administer how the technology is designed, behaved with and where it is used.

A Digital, Wearable Nervous System

> "*We have extended our central nervous system itself in a global embrace, abolishing both space and time as far as our planet is concerned. Rapidly, we approach the final phase of the extensions of man – the technological simulation of consciousness, when the creative process will be collectively and corporately extended to the whole of human society, much as we have already extended our senses and our nerves by the various media.*"
>
> (McLuhan, 1966, p. 19).

The mediation of using a wearable device mirrors many of the characteristics related to the human nervous system. While the nervous system is permanently part of the body, the device acts in similar ways. It is physically attached to the user's body and imbued with humane and anatomical qualities, moving to the shape of the user with flexibility and lightness (Kuru & Erbuğ, 2013). The nervous system also functions in the body as a network between a number of different internal parts. Where the nervous system transmits signals directly to the brain, wearable devices extend these signals through their technological enhancements, transmitting signals and data from long distances to the brain. Both of these systems are difficult to observe; however, where the nervous system is concerned, a person can still perceive the mediation it

has in relation to someone else, because we are able to sympathise with the nervous systems of other humans. Wearable devices differ in this respect, since not everyone has experienced using one. It can be difficult to understand the effects of using a wearable device for an observer if they do not have any knowledge of its use or functionality. The wearable device also produces a network between external parts, capable of sending to and from the user information from all parts of the physical and digital world. What the research implies is that society can uptake a better understanding of the impacts of wearable devices by interpreting them under the context of a larger and more enhanced digital nervous system, transmitting information through long, invisible and wireless streams over the Internet. By being aware of the impacts of wearable devices society can channel how the technology becomes established, taking the appropriate steps towards resolving the relations between different members of the public. This aim is not to limit the adoption of technology by society, but continue in an efficient and effective path for technological development. This has been presented as being possible by using approaches like the ones mentioned throughout this research.

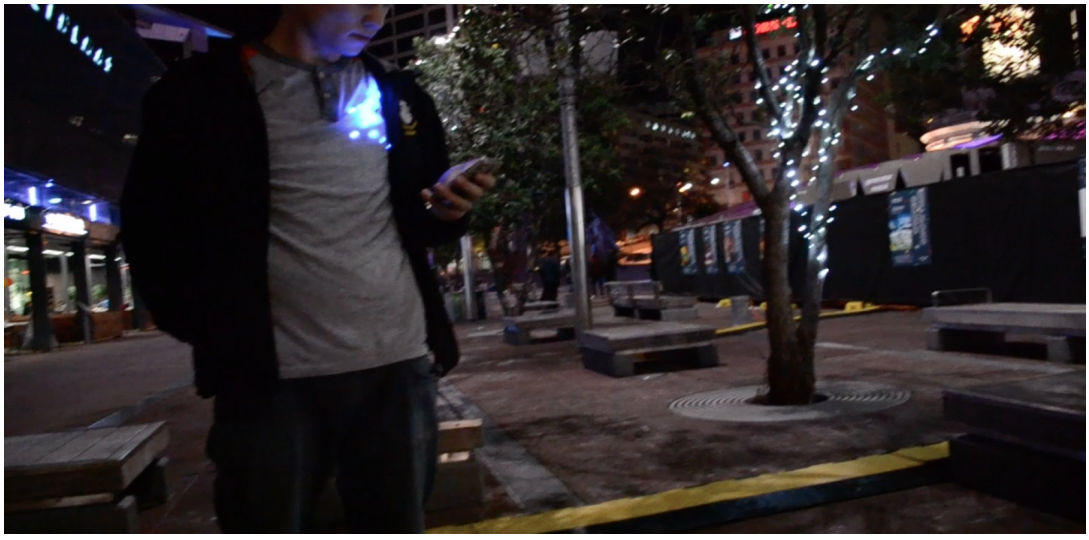
The experiments and tests involved in the approach described in the Wearable Device Field Analysis chapter identify the user as interpreting their use of personal technology in ways that differ from the perception of other device users. In previous experiments, the tester disassociated himself from the actions of his hacked wearable device, but held other users accountable for the devices they were using. To address this, a change in a user's perception of wearable devices as being a type of enhanced nervous system can potentially impact the user's behaviour when they use their own wearable device. Communicating the relation wearable devices have with the nervous system can help to reveal to the user their enhanced capabilities as a result of using the technology, compared to individuals who do not have such devices. Even just by communicating to the public about the similarities and relations between wearable devices and the nervous system can be the provocative step needed for future users to be more conscious and responsible about their behaviours with wearable devices. This is what the practical outcome of the research attempts to do.

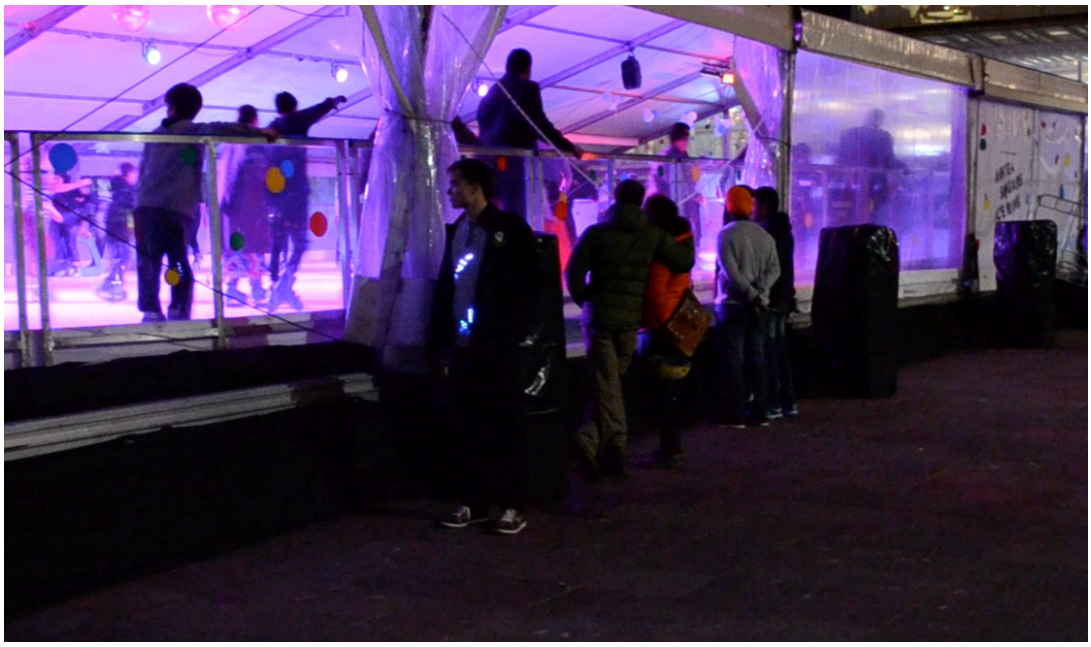
The outcome of the research is not to be thought of as an approach to changing wearable device engagement, but rather a testament to the importance of society being aware of wearable devices as a nervous system. It suggests that wearable devices are directing everyday engagements between members of the public, in relation to each other and their environments. *Wearable Beacon* highlights the presence of wearable devices in public by inversely functioning as a wearable device when in the proximity of digital devices. The digital shirt[15] initially visually appears to be the same as any other conventional shirt, without any visible digital qualities. The wearer moves within public spaces with the shirt, 'searching' for concealed devices. When the digital shirt enters the range of other wirelessly transmitting

[15] The technical components of *Wearable Beacon* are made up of two Arduino microcontrollers, a Bluetooth module and WS2812B LED strips. The Bluetooth module and an Arduino Yun search for any device with an active Bluetooth or Wi-Fi signal in close proximity and informs an Arduino Mega of how many devices are present. For each device detected, a light pattern is triggered onto the LEDs, creating the signal animation. For further information on the development process please visit www.martyf1y.tumblr.com.

technology[16] it reveals itself to the public by showing the digital lights hidden underneath the fabric (Figure 16, 17 & 18). The lights display animated signals that rapidly flow from the bottom of the shirt towards the head. Visually, the light animations symbolise the invisible data not normally seen by the public. In relation to wearable devices, it is a visual reference of the signals being sent through to the human nervous system, which transmit to and from the brain. The shirt contrasts the previously discussed characteristics of desired on-body interactive technology through the use of visually invasive bright light patterns to attract the surrounding public's attention. *Wearable Beacon* informs the public of its presence and provokes them with questions of how it may be mediating the user's activity. Observers of the shirt transition between perceiving the digital shirt as simply a piece of clothing, to realising it has concealed functionalities that mediate the user's activity. Overall the shirt brings light to the digital components that are worn by the user and how easily an active electronic circuit can be concealed in public.

[16] Wireless technology use Bluetooth or Wi-Fi components to send and receive information wirelessly.





Figures 16, 17, 18, 19 & 20. *Wearable Beacon*. Image of the digital shirt used in public.

Wearable Beacon was tested and documented in a public context at night time (Figures 16 – 20).[17] The wearer of the digital shirt moved around an ice rink event in a populated urban space. As he moved closer to members of the public and their devices it would cause the light animations to trigger. The shirt was able to detect up to four devices while in the space, creating four separate light patterns to flow at once. When the shirt was lit up, observers of the shirt would pause what they were doing and try to understand what was creating the light patterns. The shirt would draw people towards it and have them wanting to get a better understanding of how it worked. While the shirt was not focused on communicating to the public that it was being triggered by nearby devices, it did cause for nearby people to briefly break from what they were doing (including using their own personal devices). These people would pause for a moment and try to come to terms with what this mysterious and unknown digital shirt was doing.

Wearable Beacon functions as both a beacon and an invasive wearable device. Unlike other communicative devices, including traditional wearable digital technologies, it does not communicate directly to the user, but signals to the public its own presence as a concealed device mediating an activity. It uses itself as an example to encapsulate and communicate ideas about how wearable technology closely enhances and mediates the senses of the user's body, similar to the human nervous system. The observer of the digital shirt becomes aware of the change in appearance of the shirt and leads on to wonder how it is changing and what else it could be doing without their knowledge.

This research presents the importance of understanding the impacts of establishing the conventional uses of technologies in society. By being aware of these impacts we can generate approaches to question and determine which direction society should take in developing future technologies. This was demonstrated through an investigation of the *Wearable Devices* field of

[17] A video of the shirt can be found here: https://vimeo.com/132664622

research and suggests possible ways in which this technology may become established. This research highlights the potential directions wearable devices can become established in as a conventional technology in society and emphasises what impacts this has for the progression of future technology engagements. The use of wearable devices as a conventional technology has left unanswered questions concerning its mediation to the user, the context and relation to the human nervous system. The digital shirt is important for this research as it raises awareness to these questions for the public by functioning as a wearable beacon. How will observers interpret the behaviours of wearable device users? How will wearable devices segregate or associate its users and non-users? How much will wearable device users begin to rely on the technology for their day-to-day activities? These are questions society can interrogate and attempt to answer before wearable devices become mainstream, and consciously direct the next step for the technology in its progression into becoming a mainstream technology.

From the theorised approaches, the *Wearable Beacon*, a metaphorical visualisation of the researcher's concept of the anticipated presence of wearable devices in public was manifested. If we can consciously comprehend the types of engagement with technology we wish to adopt, we will be capable of deciding what path to follow when it comes to pursuing subsequent and future technological innovation. Technology development can become a self-determined process, but this will only be the case if society takes the necessary actions for this to occur.

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Appendix

Activity – a network of different *factors* containing a subject and an object. In this research, a network comprises a user and technology. An activity results in an outcome.

Approach – a theory that concerns how a technology field can be changed in an innovative manner.

Conventions – the common way of conducting an activity within a society.

Observers – people in a public space with close proximity to the technology user.

Experiment – an approach that has been put into practice. This is done to better understand the approach's effect and how the approach should be communicated to society.

Factors – the various influences within an activity. *Factors* are connected to one another in some way, mediating the outcome of the activity. Such *factors* can be weather, observers, other objects, etc.

Field – a specifically-described group of technologies that is to be investigated.

Innovation – an idea or new impact on a technology that renders said technology more effective or re-establish its purpose.

Technology – everyday objects used in everyday activities; specifically, contemporary or modern technology.

Test – an experiment tested in a public context.

User – the one who utilises a technology for a specific purpose in an activity.