A forecast of the adoption of wearable technology

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A Forecast of the Adoption of Wearable Technology

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ABSTRACT

This research aims to quantify the current market size for wearable technology, and determine why this market has struggled over the past decade. These are products which are worn on the body and enhanced using electronics. Forecasts have been made as to how this wearable technology is likely to develop in terms of market size and product design or function. It is predicted that in five years the wearable technology market will be several times larger than it is currently, and entertainment devices will overtake fitness to become the largest product category. Medical devices will be used to reduce healthcare costs by monitoring patients within their own home and wearable technology will allow businesses to improve customer relations and productivity.

Keywords: Electronics, Entertainment Devices, Medical Devices, Technological Forecasting, Wearable Technology, Wearable Technology Market

1. INTRODUCTION

The previous year has seen a marked increase in the number of companies that have released, or are planning to release, wearable technology (WT) devices in the hope that these products will become the next major sector of growth within the consumer electronics industry (Stinson, 2013). These products are worn by users to prevent them from being inhibited by the device. This research focused on the development and future of WT, and aims to test two hypotheses. Firstly, that despite this product market existing for several years it has thus far failed to become commercially viable due to it being made increasingly redundant by the rise of smartphones, and secondly that these products are, will continue to be unpopular with the older generation who are more technologically averse.

Predictions of market growth and technological developments were collected from secondary research sources. Consumer’s attitudes were investigated through a combination of primary and secondary research. A mixed method approach was adopted here which comprised online questionnaires used to quickly gain quantitative data that can be easily compared to discover overall trends, and qualitative data from group interviews were used to add further significance to these results by providing a better understanding of consumer’s feelings (QRCA, 2013).

1.1. Limitations

The limitations of the research methods chosen were also be considered during data scrutiny to determine areas for further research. The
intended contribution to current knowledge identifies a number of barriers to the adoption of wearable technology with a view to forecasting the wider adoption of wearable technology.

2. LITERATURE REVIEW

Wearable technology is a term that refers to garments or accessories that are created or enhanced using electronics (King, 2011). They serve users by providing them with information or entertainment (Buenafior et al., 2013) and due to their close proximity to the body they can be used to better monitor information about a user or their surroundings (Svanberg, 2013). WT is further differentiated from other portable devices such as mobile phones in that it is designed to be indistinguishable from everyday life (Casson et al., 2010) so that it may go unnoticed.

Generally WT can be divided into two distinct categories. The first of these is ‘wearable computers’ (WC) where electronics are housed within a fashion accessory such as a bracelet or a watch. Due to their discrete nature, WC can enable consumers to carry out tasks in a relatively unobtrusive way and socially acceptable way leading to increased levels of productivity or enjoyment (Rackspace, 2013a). Secondly there are ‘smart textiles’ (ST) where using either the physical properties of the material, or electronics woven into the fabric, products can measure and/or react to stimuli from the user or environment (Hertleer et al., 2012). Whilst being more limited in their range of user interactions than WC, ST allows users to wear sensors comfortably for longer periods of time without skin irritation. This makes them more useful for long term monitoring applications or for circumstances where aesthetics are highly important (ibid). The first wearable computer was shown in 1966 by Thrope and Shannon; a cigarette-pack sized analogue computer with four buttons, it measured the speed of a roulette wheel and transmitted predicted results to an earpiece (Seymour, 2008). However the consumer wearable products market did not begin until the mid-1970’s with the release of calculator watches such as HP’s 01 (Rhodes, 2001). As devices at this time were driven by the miniaturisation of electronics with technology becoming 100 times smaller each decade (Evans, 2013), watches were a popular starting point for WT as expanded functionality could be achieved without precluding ‘wearability’ (King, 2011). Evolving from this came one of the WT industries first major successes, the Casio Databank watch (Figure 1); it was capable of storing contact information and went on to sell almost six million units (Casio, 2010).

By the late 1970’s the WT market had also begun expanding into the entertainment industry and quickly achieved success with Sony’s ‘Walkman’ cassette player (Figure 1) in 1979, which went on to sell 220 million units (Jarman, 2010). Not all forms of WT were as successful, with the ‘Private-Eye’ head-mounted display failing to become financially viable despite being incorporated in the ‘Nintendo Virtualboy’ videogame system (Rhodes, 2001), but nevertheless WT has seen strong sales in the past. Wearable devices have often reflected changes in technology with the ‘Walkman’ being updated to use the proprietary CD format, and with the release of the GPS ‘Pathfinder’ system which represents just one of many devices adapted from military technology. Eventually in the 1990’s WT was utilised within the workplace, with pager devices allowing workers to send short text based messages and Xerox’s “Forget-Me-Not” system being used to automatically record business conversations and with whom they were with (ibid).

The Technology Acceptance Model (TAM) (Davis et al., 1989) forms the foundation of the conceptual model for this study, and includes two specific beliefs that are relevant for WT use, namely perceived usefulness (U), the degree to which a person believes WT would enhance his or her performance, and perceived ease of use (E), the degree to which SSBTs are regarded as easy to understand and operate. Behaviour (B) is determined by behaviour intention (BI), which is in turn jointly determined by the individual’s attitude towards WT (A) and perceived
usefulness (U). Finally, perceived ease of use (E) is a direct determinant of attitude (A) and perceived usefulness (U). These variables are those added to the TAM in this study to further our understanding of perceived usefulness and perceived ease of use, the main input variables in the TAM. Starting from the bottom left, the first of the additional variables is perceived self-efficacy. Based on previous findings that computer self-efficacy has a positive effect on perceived ease of use and perceived usefulness (Venkatesh, 2000; Wang et al., 2003), it was hypothesised that perceived self-efficacy regarding confidence in one’s ability to use WT would have a positive effect on an individual’s judgement about the usefulness and ease of using WT.

Despite this long history of development, by the late 2000’s the amount of WC being released had dropped significantly (Smith, 2007). Buenaflor (2013) takes the view that this was due to consumers no longer perceive single function products as useful when compared to multipurpose devices like smartphones that incorporate many of the same utilities and benefits (Svanberg, 2013). Troster (2011) is of a similar opinion believing that smartphones offer the unobtrusiveness and constant internet access that previously only WT could provide.

This change in popularity is reflected in a textual analysis, conducted by Martin (2012), of the papers presented at the ‘International Symposium of Wearable Computing’ between 1997 and 2011 (Figure 2). This shows the types of WT devices that currently in development and examination of this study reveals that the wearable computing has steadily decreased over the last decade. Focus has instead moved to sensor-based ‘activity recognition systems’ that can determine a user’s actions. Figure 2: Percentage of Papers Discussing Mobile Devices and Wearable Computing (Martin, 2012)

This time period coincides with the rise of the mobile phone in the early 2000’s and
specifically the release of the Apple iPhone in 2007; consequently it can be argued that smartphones have been a major factor in this shift. On the other hand research by Innovation Labs (2013) states that historically, two-thirds of wearable devices have actually been created by individuals aiming to assist daily living. Therefore it is possible that many of the products designed have simply lacked the budget or exposure required for success rather than having that success stolen by smartphones. This brief history shows that wearable computing has existed for almost four decades, but in that time the functionality of many of its product lines such as mp3 players, has been replicated within smartphones. Consequently this research agrees with the hypothesis that many wearable products have been superseded by smartphones causing a market decline.

With companies now looking to reverse this decline, a new generation of internet enabled smartwatches and augmented reality (AR) connected glasses are being released. A popular example is Samsung’s ‘Galaxy Gear’ (Figure 3), a smartwatch that can take photos and connect to a smartphone to allow the user to receive notifications without removing their phone from their pocket. It is hoped that by providing a more convenient way of interacting with smartphones both product markets can coexist.

However, whilst the WC market has declined Dalsgaard (2010) believes that ST are still seeing a wide range of uses within the sports industry, activity recognition systems are enabling athletes to record and review their technique, and low drag body suits helping to reduce wind resistance. The 2012 Olympic Games acted as a market catalyst due to companies and competing countries looking for ways to improve athletic performance (ibid) and these developments are now appearing in consumer sporting apparel where they are being combined with smartphone apps to provide additional information or entertainment to amateur sportspersons (ibid).

Before predictions of the future market size can be made, the current state of the WT market must be determined. Following the decline of wearable products, the current market for WC remains small; just 1.2 million smart watches were expected to be sold in the US in 2013 (Popovic, 2013) and Martin (2013) estimates that only 6% of the country’s population own...
any form of WC. Opposing this is a lower estimate of ownership, given by Transparency Market Research (TNS) (2013), of just 2%. This estimate is likely to be more realistic as the previous estimate focused on surveying consumers who identified themselves as being heavily interested in new technology; therefore they are more likely to be early adopters of WT, meaning that these results may not be representative of the general population. However both surveys were conducted in early 2013 and so, given the fast moving nature of this area, may already be outdated. To validate this data it will be compared to the primary research presented later.

Despite these low sales, further figures from the Berg Insight group show that America is in fact the largest market for WT with 3 million devices being bought in 2012; Europe is second with 1.7 million devices and just 0.5 million devices were sold in the rest of the world (Svanberg, 2013). Out of these, medical devices are currently the largest market for WT at 35.1%, followed closed by fitness aids (TNS, 2013). The current success of these devices is likely due to them being able to incorporate technology that is not suited to smartphones, such as heart-rate monitors, which need to be mounted on the users’ body to be accurate.

Conversely, to the low sales for WC, Dalsgaard et al. (2010) argue that the ST industry has seen sustained growth in recent years, increasing by 30% between 2007 and 2010. This is attributed mainly to the sports industry producing clothing for specific sports, but the market increase up to this point is still weaker than expected. This is because the economic crisis that began in 2008 led to greater caution amongst investors and so the capital required to develop ST only came from large established companies such as Adidas (ibid). This information has shown that whilst the hypothesis that WT has been badly affected by the introduction of smartphones is true for WC, the same cannot be said for ST which are used for monitoring physical activities in ways which smartphones are unable.

The negative impact that smartphones have had on the WT industry has now been established, but other issues that may be deterring consumers still need to be explored. Firstly Troster (2011) believed that the poor sales of WT stem from the design process; the companies designing WC are predominately technology companies so users are often treated as “unreliable components in a technological system”. This means that user interactions with, and feelings towards products are being ignored in the pursuit of flawless performance.
ABI Research (2012) suggest that this approach means that ‘wearability’ is being ignored, as are the capabilities of clothing manufacture; because of this many past products have been uncomfortable to wear or poorly made, and so failed on the fundamental aspect of being unobtrusive. Outside of manufacturing, a survey by GfK highlighted many of the concerns that are discouraging potential purchasers. It showed that although consumers are somewhat aware of WT, with awareness ranging from 18-50% depending on the product, price is a major concern. The number of consumers willing to purchase a smartwatch halved to 12% when they were informed that they would cost between £150-200, and the number willing to buy connected glasses fell from 16% to just 7% when they were told that they would cost between £400-600 (Martin, 2013).

It should also be considered that these results mainly focused on 16-24 year olds, and so it is possible that had a larger number of older respondents been surveyed the results may have been even lower as, as hypothesised previously, research by Buenaflor et al. (2013) found that older people and women are generally less willing to use WT as they believe it may be dangerous or easily broken. Equally it is also possible that the older generation may actually be willing to pay more for products as they have more disposable income to spend on devices they find useful; for example those that can monitor health, as this often becomes more important with age (Shively, 2013). This idea is backed by a TNS survey that showed a third of people to be willing to use wearable devices to monitor their health. The survey conducted by TNS did nevertheless agree with most of GfK’s findings, showing that whilst 75% of respondents were aware of WT only 9% were interested in it and 55% agreed that the price was too high. Additionally, this survey probed the reasons why consumers were disinterested with these products (Figure 4) and found that 13% of users worried about the aesthetics of these products, 10% worried about health issues and 24% felt that they already owned too many devices (ibid).

The final section of the TNS survey highlighted the major privacy issues facing WT with 31% of respondents having concerns over its potential misuse (ibid). This is because smartwatches and connected glasses can be used to surreptitiously take and share photos without those around them being aware (Global Data Hub, 2013). Also due to the amount of data wearable devices can collect, consumers are concerned with how this could be misused if it were stolen (ibid), especially as they can store not only a user’s personal information but data on how they live their lives and their current location, and this makes them a prime target for identify theft (Miller, 2013).

Hong (2013) agrees that these privacy issues are a contributing factor as to why WT has become unpopular since the dawn of the internet age, referencing that when the PARC research group introduced ‘ubiquitous computing’, the idea that computers would eventually find their way into every day devices, to the world at large in 1991, a number of negative news articles focused on the fact that privacy issues had not been considered when designing their device. This was because a tremendous amount of work had been put into getting the product to function correctly leaving little time was available for solving these problems (ibid).

Two other surveys agreed with TNS findings on privacy with research by SSI (2013) showing that, depending on the country, 22%-46% of consumers were concerned that privacy may be eroded by wearable devices, and Rackspace (2013a) finding that 51% see privacy as a barrier to adoption. Building on this, Rackspace (2013a) also found that 62% of respondents wanted to see more regulation of these devices and 20% wanted an outright ban on some forms of WT. Hong (2013) presents a counter argument to these concerns in that the general population has formed its views without having any experience of WT, and therefore it is possible that their expectation of others to misuse the devices could be incorrect. As such these products could even become self-regulating, similar to the situation with mobile phones, where the general population decides under
what circumstances their use is unacceptable, such as in a restaurant (ibid).

Finally it is possible that WT faces more fundamental issues from a technology perspective. If consumers are going to rely on these devices as their main source of communication and information, battery life issues need to be resolved (Miller, 2013). These devices are designed to be lived with and so if the user has to remove them regularly for charging, the device cannot monitor the user during this period and so its usefulness is diminished. Furthermore current devices like the Jawbone UP, whilst looking impressive, can be inaccurate at recognising users’ movements and this is causing users to quickly become bored with them (Rackspace, 2013b). Dalsgaard et al. (2010) blames this poor accuracy on the lack of standards for ST and wearable sensors due to the immaturity of the technology, and so over time it is likely that quality will improve as more legislation begins to be introduced.

In summary, from this research it can be seen that if these products are going to integrate themselves into everyday life, widespread legislation is required for both the quality of these devices, and how the information they gather is used. If this were done it is also likely that the popular media, and by extension the general population, would view these products more kindly. This, combined with increased advertising from WT companies, would help increase consumer awareness of these products. As well as this, the cost of these products needs to reduce to a consumer friendly price point, however this is likely to happen naturally over time as currently these devices are utilising new technology, but as more of these products are created it is likely their manufacturing and development costs will fall. Finally, in order for consumers to be accepting of wearing and using these devices for long periods of time, more testing with end users is required to ensure that the products are ergonomically sound and carefully considered from a stylistic perspective.

As a way of estimating the future growth of the WT industry, market size forecasts will now be researched. Although, as established

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Figure 4. TNS wearable technology research summary (Source: Buehrer, 2013)
previously, there is a low install base for WC, the SSI (2013) survey found that one in three Americans are likely to buy a WC device in the next 2-3 years and due to this growth, Berg Insight analysts expect the American market to grow from just 5.3 million devices in 2012 to 13.8 million in 2017 (Svanberg, 2013), although this is still well short of the 114 million smartphone users in America in 2012 (Blodget, 2012).

In 2017 it is expected that America will remain the largest market for WT at 36% and Europe second at 34%, but the rest of the world will grow to become a much more significant market (Svanberg, 2013). This however differs from estimates made by TMR, (2013) which put America at a much larger 43% market share by 2018, followed by Europe, Japan and South Korea making up 49% of the market. This difference can be explained by looking at growth predications for healthcare devices, which have only been considered by TMR. ABI Research (2012) forecast that by 2017 wearable health and fitness device sales will reach 169.5 million units as opposed to 20.77 million in 2011; of these, roughly 90 million are expected to be fitness based and the remainder healthcare. This is similar to other estimates that expect 100 million health related devices to have been sold by the end of 2016 (Global Data Hub, 2013), and so large growth can be expected in this area. This could also help to drive the consumer market of WT with the extra research into device accuracy, materials and the comfort of long term monitoring helping to drive technological innovation.

Although health and fitness devices are currently the largest product market and are experiencing robust growth, it is expected that ‘infotainment’, driven by smart watches and connected glasses, is due to surpass fitness by 2018 (ibid). Again, Berg Insight also expect that navigation devices, smart watches and personal monitoring devices will grow to make up 17%, 13% and 12% of the market respectively (Svanberg, 2013). This does not however preclude the possibility that wearable fitness devices could see unexpected competition from the smartphone sector with some models begin-ning to incorporate ‘holistic’ fitness sensors (Lanxon, 2014), and this in turn could mean that even for fitness purposes, WT faces being made obsolete by smartphones.

Based on the above information it appears that a large upturn is expected for the fortunes of WC with ‘infotainment’ devices overtaking fitness in popularity. This is likely due to the diversification of product functions as discussed in the next section. As America and the west are expected to remain the largest market for these products, styling of such products is likely to continue to reflect the fashions found in this market. To determine how WT is likely to evolve in terms of product function, emerging trends and technologies will now be examined. To begin with it is likely that that, because consumers must be at ease with wearable technologies for them to become mainstream, the future will see more arm-mounted devices as the TNS survey discussed previously found that almost a quarter of consumers prefer these whereas only 5% prefer over-eye devices (Shively, 2013). This is reflected in other research that showed that 65% of consumers would prefer to use wrist mounted devices, however 55% of consumers would still tolerate using glasses technology (Svanberg, 2013). It should be noted that both of these surveys were conducted online and so they may have a lower number of older respondent’s who’s views generally differ from those of a younger audience (Denscombe, 2007).

Furthermore, Samsung have stated their intention to produce fitness and healthcare devices by 2015, with the aim of incorporating flexible screens into fashion items by 2018 (Kim, 2013a). This is significant as Samsung, being one of the largest electronics manufacturers, can have a substantial impact on consumer awareness. Kim et al. (2013b) are in agreement that ‘interactive fashion’ is a likely way forward for ST. Although previous attempts at incorporating fashion with technology have usually ended up as museum pieces, these products normally involved radical changes or fashions that consumers have felt ill-at-ease with and so cannot be considered representative of the future. These ‘museum pieces’ have generally
been designed to perform a specific task or to monitor something about the wearer, such as their mood, and convey it visually to others; in this consumers become passive observers as they cannot interface with the device to connect to the information space as they would with products such as mobiles that they become emotionally attached to (ibid). Therefore in the future products that the user can configure to suit their needs and match current fashions are required to entice consumers.

Furthermore, the development of wearable products is now beginning to accelerate again due to the miniaturisation of technology and alternative energy sources, such as kinetic or solar charging, starting to become viable options (Seymour, 2008) and this is likely to play a part in solving the battery issues currently facing WT. Also new innovations in 3D printing using pastes have the potential for the creation of commercially available micro lithium-ion batteries which could power wearable devices from much smaller batteries (Kieldsen, 2013), leaving them to appear as just standard items of jewellery. However there are those who believe that miniaturisation can only push this market so far. Powell et al. (2013) believe that as devices have become smaller, data has become harder to input and because consumers dislike conversing with devices, and gesture or expression recognition systems involve unnatural or embarrassing motions, an alternative method of interfacing with products will be required in the future. They believe a possible solution to be a form of ‘mind control’ similar to that currently being developed by the US Army.

This would allow users to control devices using thought alone, but this technology requires immense processing power and so it is unlikely that microprocessors will develop enough to carry out this task within the five year timescale being considered here. Instead Powell et al. (ibid) suggest that cloud computing, where data gathered from the user and their surroundings is transferred to large computer banks for processing, is a likely solution to this issue. This would allow WT to branch into new areas whilst meaning that the devices themselves can be made smaller by requiring less on-board electronics. This concept is considered as the future of wearable devices by Rackspace (2013a) who believe that cloud computing is at the forefront of a WT revolution where data can be generated, captured, analysed and made accessible whenever a user requires it. There are however, those who believe that the constant widespread high-speed internet connections needed in order for cloud computing to be viable mean that the infrastructure currently available is too immature to meet these requirements. Instead Amft et al. (2009) suggest that smartphones will increasingly be utilised as processing hubs for sensors that are built into clothing and transmit signals along smart textile wiring. With several methods of mass manufacturing such fabrics currently under consideration this may soon become a realistic option if issues with durability can be resolved (Troster, 2011) as ST face the requirement of being washable, a hurdle not faced by most technology. A similar, although more basic approach is taken by fitness trackers such as the Nike Fuelband which use smartphone apps to process data; an issue facing this idea however is that as discussed previously, a quarter of consumers feel they already own too many devices (Shively, 2013) and consequently may feel anxious carrying around a combination of wearable computers and smart textiles as they may become targets for theft.

Outside of consumer technologies, assistive care devices that enable hospitals to monitor patients within their own homes are expected to be a large area of growth (ABI Research, 2012) as they free up hospital spaces and therefore save money (Annereau et al., 2013). This is agreed with by Chan et al. (2012), who believe ‘telehealth care’ to be a good way of cutting equipment and labour costs, and backed by estimates from Global Data Hub (2013b) who expect the medical WT market to triple by 2016 with 100 million devices sold, up from $2 billion worth of devices in 2011.

Nevertheless, it must be remembered that similar devices that are capable of alerting carers or ambulance services to patients in need have existed for nearly 30 years, and are now
inexpensive and readily available. However they have never been used extensively in any country as they are held back by the lack of high-speed networks and the limited number of injuries or illnesses that they can monitor (Chan et al., 2012). As a result, Chan et al. believe that going forward there is a need for products that integrate a range of biosensors to monitor a plethora of medical issues, and that are capable of intelligent processing (ibid) to automatically detect anomalies in the more complex data collected.

Opposing this view are Bandyopadhyay et al. (2011); they believe that medical products will move further towards ubiquitous computing to become part of the ‘Internet of Things’, a vision of the future where almost all physical things are connected to the internet and exchange information about themselves and their surroundings (Friedemann, 2004). They believe that by working together, objects around a patient’s home may gain the ability to ‘learn’ the user’s routine and detect when this changes so that carers can be notified about the irregularity (Bandyopadhyay et al., 2011). This would enable the patient’s environment to care for them, reducing the number of wearable sensors required and so creating an even less invasive method of monitoring, but Dalsgaard et al. (2010) suggest that this reduced invasiveness could just as realistically be achieved through the use of ST.

As well as these uses, wearable computing is likely to become more widespread in business as, although it is currently only being utilised by 6% of US companies, it has been demonstrated that it can allow individuals to be more productive and well informed (Rackspace, 2013a) making it a worthwhile investment for businesses. Stewart, quoted by Miller (2013), however states that such technologies would only be useful in circumstances where workers cannot already access a PC or laptop, such as when operating a vehicle, and so only issues with a notably inferior current solution would see any real effect.

Besides productivity increases, WT could also be used to improve business customer relations where information relating to that contact, for instance their purchase history or even their birthday, can quickly be accessed making companies seem better informed and caring to help make customers feel valued (ibid). In a general consumer market consumers could also use WT to compare different products similarly to how they would online, and so this would help reinvigorate flagging retail sales (ibid). Although this idea makes the assumption that being able to easily compare products is the main reason that people are moving towards online shopping and not online discounts or the convenience of shopping from home.

3. RESEARCH METHODOLOGY AND RECRUITMENT PROTOCOL

To refine the questions included within the final consumer survey, a trial questionnaire was conducted which focused on the privacy issues caused by WT and whether this would affect consumers intent to purchase such devices. The results of this questionnaire showed that when given no example as to how WT could invade privacy, a lower than anticipated 29% of respondents said that privacy would be an issue for them. However, when participants were informed that WT could be used to take photographs of them without their consent, 65% of participants said that they would change their opinion. Although only a small sample size was used here, it has demonstrated that as this issue had not occurred to 85% of respondents an example should not be included in the final questionnaire as it would skew the results by leading participants towards having a more negative view of WT than they otherwise would have. As well as this, these early results showed that privacy is a much larger concern for females both before and after they were given an example of such problems.

A questionnaire of 133 respondents was used to investigate current awareness and ownership of WT, as well as the boundaries facing these products from a consumer perspec-
tive. These results can then be used to validate the currency of the values documented within secondary research gathered from older surveys, to further understand how the market has developed over the past year. Privacy issues, cost and poor differentiation from smartphones were expected to be the main barriers to success. Firstly only 9.1% of respondents stated that they owned any form of WT, but this is still larger than the 2-6% found presented within the literature review. This increase was anticipated due to the rapid expansion in media exposure this market has seen since these results were published, although this cannot be confirmed as the main factor for the increase without further information as to when these devices were purchased. However as all the respondents who owned WT were male, and all the devices they owned were smartwatches, it does aid in further proving both that females are less comfortable with WT, and that consumers are more at ease with wrist mounted devices.

4. PRIMARY RESEARCH

This survey also indicated that only 6.5% of respondents planned to purchase any WT product within the next year, in spite of the fact that over 85% of those questioned were aware of examples of consumer products, a marked increase on the 18-50% presented in the literature review again demonstrating the increase in media coverage. Furthermore the products respondents were most aware of were smartwatches at 72.7%, followed closely by fitness devices at 63.6% and connected glasses at 60.6%; this awareness of smartwatches is reflected in the current ownership results. Overall, this data shows that despite WT receiving more media coverage within the past year, the majority of consumers have still not been swayed towards purchasing these devices and therefore there must be other issues facing these products. For instance, over a third of respondents stated that they still did not feel well enough informed to justify a purchase, and so it may be that whilst consumers are hearing of WT, a lack of advertising is hindering the understanding of their benefits.

Further analysis shows that based on the views of the respondents questioned the largest issues facing WT is cost with 70.0% of abstainers declaring this a concern. Second was a low perceived usefulness of these devices with 36.7% stating that their functions were simply disinteresting and the same number believing that any possible uses were already covered by their smartphone as suggested in the research hypothesis. Smaller concerns included appearance at 13.3% and comfort at 10.0%; these results match those provided by TNS (Shively, 2013). Privacy concerns were an issue for just 16.7% of respondents, which again is a much smaller percentage than that found in secondary research. Two possible reasons for this are that, based on the results of the trial questionnaire, respondents were unaware as to how privacy could be an issue and, as those over the age of 45 were a minority in this survey, their views are not equally represented which would cause a drop in results if they were seen to be more conservative.

Building on this premise, it is seen that no respondent over the age of 45 had either purchased, or planned to purchase any form of WT. The biggest reason given for this was indeed privacy issues, with 63% of respondents over 45 worried about information being stolen. The high cost and lack of information on these products were also sighted as issues for half of this age group. This result proves the hypothesis that the older generation are unlikely to purchase WT; however only one respondent had concerns over the dangers of wearing electronics meaning that whilst the hypothesis conclusion was correct, the reasoning behind it was not. It should be noted that as the questionnaire was conducted online and the majority of respondent were found through social networking sites, it is possible that the older respondents were more comfortable with technology than many of their peers would have been.

Suggested in the literature review was the concept of using a smartphone as a ‘processing hub’ for external sensors, and as one of the main
Aims of this research was to predict how this technology would evolve in the future, the appeal of this idea to consumers was researched. To do this the number of electronic devices consumers are willing to carry was probed as if consumers refuse to carry several devices this concept is flawed. The results showed that on average consumers willing to carry 2.8 electronic devices but with a standard deviation (s.d.) of 1.2 there is a range of opinions from this value. This is explained by the fact that respondents over the age of 45 had a significantly lower average of 1.9 when compared to that of those below 45 at 3.2. Therefore this idea may be popular with the younger market who are willing to carry several devices but not for the older generation. This is further reflected in the results that showed that four times more people over the age of 45 were concerned about theft than those below this age.

Additionally, consumers were questioned on both where on the body they would be willing to have wearable devices, and for what purposes they would be willing to use them. This was of importance as research has revealed that consumers must feel that products are beneficial and comfortable for them to be successful. These results showed that respondents felt most at ease with wrist mounted devices, with 96.9% stating that they would be willing to wear a device here; yet again helping to explain the current popularity of smartwatches. This was followed by arm mounted devices at 57.6% and matches well with secondary research (Svanberg, 2013). Waist mounted devices, and devices worn around the neck were also reasonably popular at 45.5% and 39.4%.

Less popular were devices worn on the body at 21.2%, glasses devices at 18.2% and head mounted devices at 9.1%. Based on these results it would appear that wrist worn devices such as smart watches and arm mounted devices like fitness products will continue to be popular, but head-mounted devices may struggle. It was observed that all respondents would be willing to use WT to detect health problems and so as expected this is likely to be a large sector for growth, but not all consumers feel that WT is necessary to improve everyday wellbeing. Other popular uses for WT included internet browsing, communication and navigation at 92%, 86% and 74% respectively; however devices dedicated to functions that can be found on smartphones are unlikely to be successful and so these should instead be considered as standard functionality going forward.

A popular function not found on mobiles was augmented reality (AR) devices at 71%; these would provide users with entertainment or information on the world around them and based on these results are likely to be a successful market, but as most of these devices require a headset this would be at odds with the dislike for head mounted products seen earlier and so further clarification on this discrepancy is required. It is possible though that as gaming devices proved popular, despite video games existing on smartphones, AR headsets for gaming such as the ‘Oculus Rift’ (Figure 5) will prove successful by allowing for greater immersion whilst also acting as an entry point to WT.

Finally only 33% of people would use wearable products for shopping and devices for security, assisted living and life documenting proved particularly unpopular at 19%, 17% and 13% respectively. From the questionnaire results alone the reasons for this are still unclear.

So that the quantitative data from the questionnaire could be better interpreted, qualitative data was gathered via a semi-structure interview with 12 participants between the ages of 19 and 25 so that a deeper understanding of consumer attitudes could be formed. Participants of similar ages were chosen in order for group discussion to happen more naturally. To begin with awareness of wearable devices was again tested, however this time data as to the participants’ main sources of information on WT was sought. It was found that the participants main knowledge of WT came from news stories focusing around ‘Google Glass’, and adverts for the ‘Samsung Galaxy Gear’ which the participants had seen in a television advertisement by the ‘EE mobile...
network’ company. However those interviewed stated that the advert only demonstrated taking photographs with this device and so those questioned had little understanding of its uses other than this. These results suggest that as theorised previously, whilst awareness of these devices is spreading, the benefits of these devices are not effectively being communicated by companies.

Participants were also interviewed about their opinions of using WT for the less popular purposes given in the questionnaire. Devices for retail shopping were met with more interest than expected, but those questioned wanted these devices to be provided by stores and felt that they would only be useful in the electronics or food sector where a wide range of choice is available and so these types of products would be need to be sold to business and not the public. Further understanding of the low participation for assisted living was likewise provided with several interviewees explaining that whilst they felt this category was a worthy cause, as it was not applicable to them they did not feel it was necessary to state this as a use they were interested in and so this category may still be successful as a niche market. Life recording was found to be the least popular product purpose as the participants simply felt they had no need for these devices as their lives were ‘too mundane’ to warrant documenting and interesting events are already being shared via social networks. Therefore because of this, this product market is unlikely to become successful in the near future.

A smartwatch was demonstrated to the group and their popularity was found to stem from them using interfaces similar to smartphones and so they appeared non-threatening and intuitive. Furthermore the security of a device being wrist worn both in terms of the reduced chance of theft and the item being less likely to be damaged was a key selling point, and compared to ‘over-eye’ technology. Similar reasoning was provided for the success of fitness trackers, however these also offered a sense of achievement since users could see their progress and this is not found with most other products. Finally the acceptance by consumers for AR headsets but not general head-mounted displays was found to not be an issue of the products themselves, but their context of use. As AR headsets would mainly be used at home consumers would not need to worry about how they appeared to the public, a main issue facing glasses technology.

In order to summarise the issues discussed previously, a case study of ‘Google Glass’ (Figure 6) was undertaken. Largely prevalent with the media, this glasses style headset allows users to carry out many of the same tasks they would on their phone such as navigation, taking photographs/video, sending messages and browsing the internet, but without the need of obscuring
their view (Powell et al., 2013). This product aims therefore to be a less obtrusive alternative to smartphones, but is representative of many of the issues discussed within this research.

For example this particular product currently costs testers approximately $1500, and yet consumer demand is already low for similar connected glasses devices that cost less than half of this showing that cost is a significant hurdle to WT. Furthermore, some consumers are troubled by the appearance of wearable devices and primary research has shown the lenses-free frame of ‘Google Glass’ to be off-putting to those questioned as they may look peculiar to onlookers. As well as this, Hong (2013) believes that the current narrative of the popular press is that ‘Google Glass’ represents the privacy issue surrounding internet enabled devices due to unsolicited image sharing, and so unless this perception can be altered, this and other similar devices are unlikely to expand beyond the core early adopters as the general population will not be aware of their benefits. This is even more crucial when it is considered that news stories about this product were cited as one of interviewees’ main sources of information on WT and so could negatively impact the entire market place if not resolved. These concerns are now already starting to be reflected in the real world with ‘Google Glass’, being banned from some public areas, such as coffee shops and restaurants, due to customers feeling that they could be being spied on (Gray, 2013). It is also probable that the number of establishments that place bans will increase WT poses a threat to copyright by giving users a less conspicuous way of filming events or films (ibid). If the locations in which these devices can be used becomes overly restrictive, this could have a major impact on their sales as many are designed to be used almost continuously and so if the user had to turn off, or remove them regularly, they could quickly be viewed as an inconvenience. Finally as the market is seeing low demand for head mounted technology in general (Shively, 2013), even if consumers are willing to tolerate such devices ‘Google Glass’ will struggle to see the same level of success as smart watches or fitness devices and therefore the industry will see lower levels of comparable products going forward.

Figure 6. Google Glass (Simpson, 2013)
5. CONCLUSION

In conclusion the hypothesis that smartphones have made WT redundant is only partially correct. Although smartphones have indeed had a detrimental effect on the sales of WC due to them incorporating many of the features historically offered by these devices, sales of ST have risen due to increased demand for sports and fitness devices. These products have seen success by incorporating sensors that need to constantly be in close proximity to the body and so are not suited to mobiles. Therefore smartphones have made many WC redundant in the past but not ST.

The second hypothesis that the consumer WT is, and will remain unpopular with the older generation has been proved to be true; however the reasons for this are varied. Secondary research has shown this is due to fears over the possible dangers or poor robustness of WT, but primary research on their other hand found privacy concerns and a high price to be much more significant issues. Despite this, some of this age group would be willing to use medical devices to diagnose illnesses. Cost was shown to be the biggest issues facing WT for all ages, but privacy was found to only be a concern for the older market. Other boundaries to success were the aesthetics and comfort of these devices and consumers not being well enough informed on for them to justify a purchase. Based on secondary research it is predicted that the next five years will see a large expansion of the WT market, with 2017 seeing almost 14 million devices sold compared just over 5 million in 2012 and sales are expected to increase further beyond this point. Sales of fitness devices specifically are expected to increase by over eight times in a similar time period, but growth in smart watches and the like will make infotainment the biggest market for WT.

Furthermore, the future is likely to see more devices that are mounted on the wrist or waist as these are the areas of the body consumers are most comfortable with. WT is likely to adopt internet browsing and methods of communication as standard features for parity with smartphones, but have primary functions based around areas not possible with mobiles, for example augmented reality. Finally products will increasingly use cloud computing and become part of the internet of things to process data from sensors, keeping users well informed but the devices themselves small.

The research completed in this investigation could be advanced by repeating the same tasks with an older population. Due to time limitations and participant recruitment constraints research into differences between genders could not be done. By having more participants, any differences caused by gender could be highlighted and may produce additional insights which would have the potential to guide technology developers’ success at providing for more user markets. This would also form more definite results as quantitative analysis could be conducted. In addition, to gender comparison, comparing sub-groups of age would be a further opportunity to establish any other differences between more narrowly defined user groups.
REFERENCES


Tom Page’s background is in electro-optics development and production and worked for Ferranti Defence Systems Ltd. in Edinburgh. In 1990, he took up a two-year fixed-term research assistantship at the Engineering Design Research Centre in Glasgow. Upon completion of this role, he taught Computer-Aided Engineering at the University of Hertfordshire in Hatfield. Since moving to Loughborough University in 2003, Mr. Page has taught electronic product design, interaction design, design and manufacturing technology and physical computing. His research interests are in engineering design, value management, technology education and electronic product design. His work has been widely published in the form of journal papers, book contributions, refereed proceedings, refereed conference papers and technical papers. He has supervised research students, examined PhDs and MPhils and has acted on the reviewing panel of a number of key journals and conferences.
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