Ethical and Social Construction of Wearable Technology

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Throughout history, engineers have built society with the technology they design. Consequently, public perception of emerging technologies is always contentious as innovations are always subject to conflicting opinions. The future of computing is an example of this, since computers have undergone such drastic progress in such a short time. Computing power has increased exponentially to the point that we all hold computers in the palm of our hands millions of times more powerful than the ones used to send the first astronauts to the moon (Puiu, 2020). Devices are getting smaller and smaller while continually improving in performance and taking on more of our responsibilities. Society has generally accepted more computational complexity in return for the benefits and comfort it returns for its users. This is because the benefits are clear: the rise of computers and the internet has allowed us to work faster, automate more tasks, and boost our overall productivity, ultimately allowing us to accomplish more each day. As our technology has become more personal and compact, they can now be comfortably placed on our bodies. "As wearable computers shrink and become further integrated into daily life, they become extensions of ourselves" (Starner & Martin, 2015). From wearable medical devices to fitness trackers and smart watches, the wearable computing and technology industry is growing because we are allowing the technology to take on a larger part of whom we are.

For the most part, we are still in control of our own responsibilities and choose what we delegate to computers. However, as processing power continues to rise and the technology we wear constantly evolves behind the scenes, it may soon overtake our ability to make decisions, influence how we act, and play a larger part in how we think. There will eventually come a time when processing power in these devices will overtake human capabilities. The point when this happens, when technological growth becomes uncontrollable and irreversible, is known as the

"Singularity" (Kurzweil, 2005). Looking toward the future, the ethics of more advanced and intrusive, "wearable" technologies like brain computer interfaces and the work being done by private companies like Neuralink will need to be evaluated before we pass this point of no return. Going forward, engineers need to be mindful of how they venture into innovating current and future wearable technology, given its proximity to our bodies and its ability to influence and affect the way we live. A socially driven approach to engineering wearables is therefore necessary, as it will elicit the greatest benefits for society while acknowledging and reducing ethical risks along the way.

Literature Review

As wearable technology is being developed and integrated into society, academics and technology enthusiasts are having an open discussion on the ethics of engineering and developing these devices. Many highlight the benefits and improved quality of life from wearing more technology where others warn of the possible dangers. Most literature revolves around the opinions of experts and scholars, and whether or not we should pursue innovation in personal wearable technology for medical or casual use. While the field of wearable technology is vast, researchers often focus on specific applications such as wearable medical technology in the health system or the influence of wearables on the activity of the user. Many of these studies give insight into how engineers can build a better product using socially driven factors.

One study by Michael Rupp and his colleagues at the University of Central Florida attempted to quantify the relationship between social factors and the use of wearable fitness technology. They conducted their study with a large group of participants who would use fitness-tracking technology and be surveyed based on their trust and motivation to wear the technology.

They based their hypothesis on the theory of Intrinsic Motivation, which explains the phenomenon of using an object or doing an activity because it, in and of itself, is intrinsically motivating (Ryan & Deci, 2000). Another theory by the same authors called the Self Determination Theory is used by this study. It states that an individual will want to do an activity to support three basic desires: autonomy over doing the object or activity, competence in using the object or doing the activity, and relatedness to others by feeling accepted while doing the activity (Deci & Ryan, 2012). The survey and tracking data was used to compile a model comparing trust, motivation, and use, and it supported their hypotheses that wearable technology usage can be leveraged by a gain in trust and a resulting intrinsic motivation to use the devices (Rupp et al., 2016). They concluded that wearing fitness technology has a direct correlation to fulfilling internal psychological requirements, and analyzed the reasons people feel autonomous over wearable smart devices. Although this study is useful for quantifying two social factors behind wearable technology usage, they do not go into detail about how numerous other factors, of which the user might not even know about, affects the social acceptance of the technology. Remaining completely transparent about the system and personal data is essential to true ethical product development.

Other research from Technical University Munich explores both sides of the ethics of wearable medical and fitness devices. The researchers found health, monetary, and temporal benefits to using wearable devices, but also found three major ethical concerns: security, personal data handling, and normalization of the product via societal pressures (Volger & Schwab, 2019). The authors both then give opinions on how they believe these ethical issues can be curbed, but their arguments are both technologically deterministic in nature. While this

research deeply explores the positives and negatives of current wearable technology, it does not fully demonstrate the importance of societal influence on developing new wearable technology.

Much of the attention directed toward wearable technology and current literature does not look into the underlying social ethics of the actual development of these technologies. The motives behind developing new software and fabricating innovative wearable hardware are more interesting than studying the acceptance of already finished products. This becomes even more important as technology begins to evolve beyond the Singularity — we need to be mindful of the motives for such rapid innovation of wearable technology. Nevertheless, contemporary studies and research on current wearable technology are still very useful, especially when considering future development. Put simply, engineers need to ensure their technology will ultimately benefit society by being diligent at maintaining an ethical, socially driven approach to engineering.

Framework and Methodology

The framework I will be using, which best explains the motives behind the development and dissemination of wearable medical technology in society, is the Social Construction of Technology. Abbreviated as SCOT, this theory postulated by Wiebe Bijker and Trevor J. Pinch argues that social groups directly influence technology at every step of its development (Bijker & Pinch, 1984). On the opposite end of the spectrum is an idea known as Technological Determinism, which advocates that technology itself is the main benefactor in reshaping society. Rather than simply picking a side on whether society shapes the development of technology or the technology reshapes society like many others researchers have already done, I will instead advocate that engineers should maintain and also advocate for a SCOT approach when developing their advancements in technology, specifically wearable technology. An additional

framework, which I will use in my analysis, is Actor Network Theory. This theory stresses the importance of relationships between people and groups, and the interchange of resources and responsibility between them (Law, 1992). Recognizing these relationships will become important as ethical systems become too complex for one person or group to fully take on themselves. For methodology, I will be discussing various case studies that have been conducted on the current issues and implications regarding current and future wearable technology. I will be using a SCOT approach derived from supporting research including experimental data to propose solutions to possible ethical problems that will arise.

Social Construction of Wearable Medical Technology

Challenges to society's growth and development demand solutions and innovation. Through the lens of the Social Construction of Technology framework, it is not that the technology is the start of change, but rather society's recognition of the problem and agency to want to fix it (Bijker & Pinch, 1984). One example of this is the United States healthcare system. For years, the US has needed to find ways it can improve its system and make it more affordable. Upon society recognizing this, gradual changes began to set in over time, and a fundamental shift in how people are receiving care is still changing with newer advancements in medical technology. Wearable medical technology is now an important piece in helping alleviate problems within the healthcare system, by more affordably and efficiently providing care to patients remotely (Gopalsamy et al., 1999). At the turn of the 21st century, the Institute of Medicine outlined goals that would serve as a guide to ethically improving healthcare. These are safe, effective, patient-centered, timely, efficient, and equitable (Institute of Medicine, 2001). From these categories, it is clear to see how socially driven these goals are. Technology is what

drives innovation and growth, but society, in this case once again, has governed the direction toward which technologies are developed next. Researchers at Georgia Tech used these six metrics to develop Smart Shirt Technology. They argue that information is the key to knowledge, which will return better and faster results back to society with speed, safety, sound decision making, ensuring survival of the patient and success of the healthcare delivery (Park & Jayaraman, 2003). A diagram of Park and Jayaraman's proposed framework is shown in Figure 1 below. As long as their access to information does not compromise the socially driven goals they set out to follow, then this is a good example of a transparent socially engineered technology. From their results, their Wearable Motherboard Technology appears to have been successful at maintaining a socially driven process.

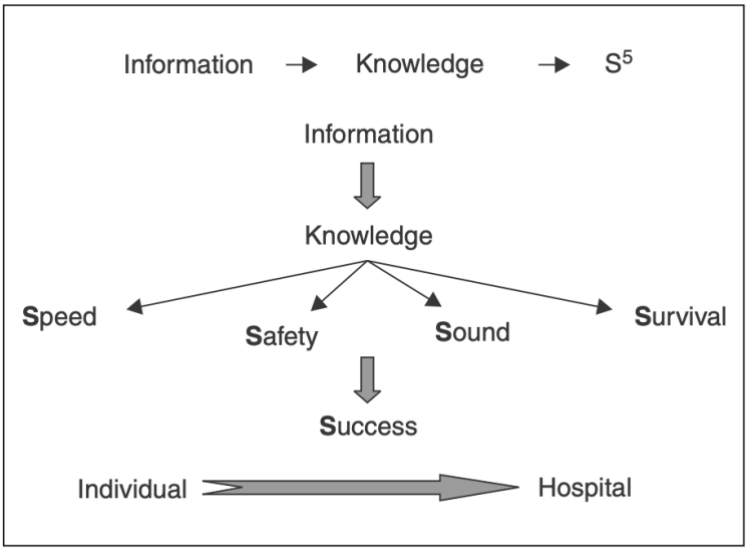

Figure 1. *The Information-Knowledge-S5 Framework*

One final distinction about the social construction of technology is the role that uncontrollable stressors have on society. When disaster occurs, priorities change in order for society to fulfill their wants and needs. The ongoing Coronavirus pandemic is a great example of this. The pandemic has been a stopping force on a lot of research, but it has also shifted development to technological and engineered solutions from the scientific community. Things

like ventilators, testing methods and wearable technology like respirators and smart masks were developed as engineers felt a responsibility to help. This is a clear example of social construction of technology at work — societal pressures from the effects of a deadly virus have returned a boost in technology development. For vaccines, ethical standards and trials are heavily regulated and mandated. However, other technology being rapidly developed during this time may not be. This is why taking initiative on socially driven development is so important.

The ethics on the spread of information is an important topic researchers are studying, especially as society looks to shift into a post-pandemic world. On the one hand, it has been observed from previous infectious disease outbreaks that ease of information transparency "facilitates cross-sectoral collaboration among actors, network arrangements across levels of social organization, and global scientific cooperation" (Galaz, 2009). On the other hand, questions of privacy come into play, when tracking technology and contact tracing can overstay its welcome. This will be a contentious topic in a post-pandemic world, particularly once the majority of society feels we are past the need for extensive data sharing. Now is a crucial time to evaluate how engineers develop technology for the future, and this current pandemic has been a good metric into how we will prepare in the future and show us what to avoid.

Ethics of Developing Wearable Technology Today

Ethical concerns can be better explained when looking at more examples of wearable technology already in society. One clear issue with strapping technology so close to our bodies is privacy. It is clear that data collected by devices in such close proximity to the user's body should be dealt with in an ethical way. Nevertheless, in today's world, once the data is collected, it is becoming harder for that data to remain in one place. One clear example of this, which lots

of research has been conducted on already, is biometric data in sports. Wearable technology tracking devices collect concussion and other important injury data among amateur, collegiate, and professional sports. Evidently, this data should be dealt with ethically in different ways depending on the user (Arnold & Sage, 2017). Regardless of the level, it has been proposed that everyone involved should "work together to promote sound ethical policies through the formation of a data governance council, whose goal would be to adopt best practices for the collection, use, and storage of biometric data, including those generated by wearable technologies" (Karzakis & Fisherman, 2016). This idea of a distributed group of policy-making on the ethics of biometric data from wearable devices supports the idea that Actor Network Theory should be given credit as an important framework to bring out the best results of an ethically sound, socially driven technology. This would also apply social pressure on the development of wearable technology and how biometric data is handled in the future, further supporting the social construction of wearable technology.

Current wearable technology goes far beyond just fitness tracking data and smart watches, though. After a notable failure at the first iteration of smart glasses, Google Glass, Google has also researched and developed SkinMarks, a conformal skin electronics that resemble wearable "tattoos" (Weigel et al., 2017). These rub-on tattoos serve as on-body input/output interfaces on different trigger points, which set the stage for future wearable technology to be expanded upon. Google is definitely not the first group to start the digital tattoo market. Researchers at MIT have previously developed DuoSkin, which uses skin-friendly materials and a cheap fabrication process to make digital tattoos capable of turning the human body into an interface for data measurement and programmable actions (Kao et al., 2016). Using gold leaf and other simple but useful materials, they hope to simplify the process of engineering

wearable micro-devices to expand upon in the future. DuoSkin "closes the gap of prior work on fabricating body interfaces by repurposing accessible materials for rapidly prototyping on-skin user interfaces" (Kao et al., 2016). Extracting data from the skin can be useful in some situations but dangerous in others. Observing blood glucose levels and detecting when someone with diabetes should take their insulin is an example of the benefits of this technology. The dangers come with the possibility of what can be done with all this information. Wireless communication has been achieved already with DuoSkin, paving the way for bodily data to be sent to a microcontroller to take pre-programmed actions or make its own decisions. As microprocessors continue to enhance at an exponential rate, one-day humans may not be able to fully control the decisions these devices make.

What is more concerning about these digital tattoos is the lack of emphasis on the ethics and judgement behind the engineering process. Google SkinMarks would have easy access to all of Google's databases, implying that people wearing digital tattoos can be targeted, uploaded, or even tracked and influenced. Neither Google nor MIT researchers went into any detail about the possible ethical problems that could happen down the road in their papers, which in and of itself is alarming. The need for higher quality biometric data may have urged society, in general, to accept and push for more research and development of wearable micro-technology. Going forward, society needs to keep steering the development of the technology in the right way so powerful companies do not step out of line. A more socially driven approach would have been nice to see now from a company like Google, but soon it will be essential to convey a more transparent, socially driven process to gain societal trust in order to move the technology forward.

Conclusion

A socially driven approach to engineering wearable technology will result in a more controllable system that will return benefits back to society in the years to come. For wearable technology, maintaining an orderly, ethical network will ensure that devices do not advance too far beyond what is acceptable. Both the Social Construction of Technology and Actor Network Theory provide insight into how technologies as intimate as wearable devices can be engineered in an ethical way. It is evident that wearable technology exists in a dangerous space between our identity and our benefit. Adhering to social input remaining fully transparent will help technologies gain social trust, resulting in a more ethical set of technologies that can be monitored in order to not step too far beyond these boundaries.

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