Building Rhythm Aware
Technology to Optimize Productivity
(Technical Paper)

Integration of Policymaking into
Wearable Technology Data Collection
(STS Paper)

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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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General Research Problem: Ensuring the Credibility of Wearable Technology Devices

How can wearable technology be properly regulated to allow users maximum productivity while ensuring individual privacy rights?

In today's society, the presence of wearable technology such as Fitbits and Apple Watches has increased accessibility to personalized health for individuals. Easily interpretable dashboards portraying workout, sleep, and other personal health metrics have allowed users to track physical and mental health progress. These dashboards help goals become more attainable and can lead to healthier lifestyles. With the ever-growing demand for wearable technology comes new and innovative data analysis techniques. In order to deliver a product that optimizes productivity, companies are continuously researching personalization techniques to best accommodate the users of the technology. For example, Fitbit now provides a "Sleep Insights" section which uses all aspects of data collection such as exercise, diet, sleep patterns and more. The purpose of this section is to provide actionable recommendations for improving sleep quality and creating better routines.

Despite all the benefits wearable technology provides, many people still lack a full understanding of how their data is collected, analyzed, and sourced. For example, when users log in via Facebook to Fitbit, they are giving up the rights to their name, profile picture, friends list, age range, and many other personally identifiable characteristics. This simple login feature creates individualized profiles by combining multiple data sources. As a result, Fitbit is able to access several identifying characteristics from the users Facebook page such as likes, friends list, and age among several others. Policy on both the state and federal level for wearable technology is continuously evolving and being shaped based on the actions of the large tech companies that dominate this industry. Additionally, policymaking shapes specific aspects of data that can be collected and researched including physiological and behavioral data collection of wearable technology.-This research focuses on the implementation of wearable technology and how it affects daily behavioral patterns. To be specific, optimizing user productivity and ensuring individual privacy rights remains the primary focus.

Technical Research Problem: Building Rhythm Aware Technology to Optimize Productivity

How can the analysis of wearable technology be implemented into a smart-technology that alerts individuals to the optimal times to perform activities?

In the United States, stress management and mental health topics are consistently emphasized in the workplace in order to maximize productivity. However, according to the American Institute of Stress, 83% of US workers stated they suffer from work-related stress; as a result, businesses lose up to $300 billion annually (Milenkovic, 2019). While the current workplace mental health stigma emphasizes the importance of a work-life balance, workers find themselves unable to meet this challenge without the fear of jeopardizing their career mobility. This lack of work-life balance leads to higher stress and less productivity with workers who do not know how to improve their situations. Currently, there are several technological advances such as wearables that attempt to solve this issue by providing insights into improving wellbeing. For example, fitness trackers can provide suggested times to move around, and sleep trackers can provide insights into the different sleep stages. These wearables attempt to tackle the difficult issues that contribute to workplace induced stress such as lack of sleep and lack of movement throughout the workday. The suggestions provided by the wearables are based on different aspects of data collection such as movement and heart rate patterns, but they fail to provide actionable insights. For example, one key aspect the insights lack is the detection and analyses of Circadian Rhythms. Circadian Rhythms are 24-hour internal processes that affect physical, mental, and behavioral related aspects of an individual's overall wellbeing.

In order to address these productivity and mental health issues, the capstone group will create a new rhythm-aware technology to find and recommend the optimal time for individuals to perform activities. The basis of this technology is to provide actionable insights that better align with individual biological clocks and circadian rhythms. This system will analyze physiological and behavioral data through the use of wearables such as the Empatica E4 and the Oura Ring. The Empatica E4 is a wearable that collects Galvanic Skin Response for varying stress levels. The Oura is a wearable that includes metrics such as heart rate variability, body temperature, respiratory rate, and several other key metrics. This data will be collected from research participants and be combined with free, public use databases. Once the data is collected, it will be cleaned and manipulated into the proper format so that it can be analyzed. The data will require different data analysis libraries such as python in order to merge the data frames into usable sources that can be input into the model. Then, using a series of different tests such as regression analysis and autocorrelation through the Chronomics Analysis Toolkit (Gierke, 2013), the group will create a machine learning algorithm that detects optimal times for sleep, physical activity, work, and other performance activities. These tests will help model behavioral and

physiological rhythms and detect patterns in the period, amplitude, and other rhythmic related behaviors.

The individualized recommendations that will be provided as insights from our analyses will be embedded into smart devices. These smart devices will include calendars that notify individuals of the optimal time to do work, exercise, rest, or any other activity that is best for them at that specific time. These smart devices will also be in placed homes and include lamps that will begin to change hue to more natural lighting when it is the optimal time to sleep. Moreover, this system will provide personally recommended algorithms that tailor to the needs of the individual rather than offering simple tips to a generalized population. These recommendations will help improve productivity overall while reducing school and workplace induced stress. This technical project will provide individualized recommendations founded on wearable data collection of rhythmic patterns. Additionally, the project will begin the basics of product development for embedded smart devices based on circadian rhythm patterns.

STS Research Problem: Integration of Policymaking into Wearable Technology Data Collection

How do the barriers that exist in the United States affect policy advancement of wearable data collection on the federal and state level?

The wearable technology market has boomed in the past 5 years and continues to grow exponentially. In 2017, an estimated 61.5 million shipments were reported during the fiscal year, and a projected 149.5 million are estimated to be shipped in 2021 (Lamkin, 2017). The demand for wearable technology has resulted in advanced data analyses which serve many purposes in benefiting individuals. For example, one goal of the technology is to improve overall wellbeing by setting and tracking fitness goals. Another goal is to help improve health monitoring by predetermining cardiac and/or respiratory arrests, for example.

Due to the rapid growth of this innovative technology, ethical debates have surfaced about how the data can be collected and analyzed. For example, recently a law firm in Calgary used the data collected from a Fitbit to defend a litigation case. The defendant, who was involved in an accident, claimed she was not able to perform at the same level she was prior to the injury. Therefore, the law firm used the client's Fitbit data and compared it to the average individual with the same characteristics to "show that her activity level is less and compromised as a result of her injury." (Vinez, 2017, n.p.). This is one of many examples of how newly acquired data from wearable technology brings controversy due to the grey area of rules and policies surrounding it.

Currently, there are no federal legislative acts that protect individuals' privacy rights to their own data; rather there are several sector and state-specific laws that protect individuals. In other words, current legislation does not directly protect individuals' privacy. One current, indirectly protecting federal law is the Federal Trade Commission Act which gives the Federal Trade Commission the right to outlaw unfair acts or "deceptive practices" in business. The act often refers to failure to comply with the privacy promises of individuals and to the malpractice and misuse of targeted advertising. On state levels, many states have taken a proactive approach to protecting the privacy of individuals. However, other states have not adopted any kind of legislation and only abide by federal laws. One example of a proactive state is California. As of January 1, 2020, California will adopt the California Consumer Privacy Act (CPPA). The CPPA requires all businesses operating in the state to disclose all personal data they have collected about consumers including the categories of data they have collected, the business purpose for collecting and/or selling the data, and to whom they have sold the data.

As a result of the lack of legislation or knowledge on how to implement policies related to data collection, there are several consequences. One example is social sorting, one of the main methodologies that is being used to group or bin individuals into categories based on characteristics such as income, race, gender, and other factors. Social Sorting, a term explained by the professor of sociology David Lyon, claims that social sorting is "… to focus on the social and economic categories and the computer codes by which personal data is organized with a view to influencing and managing people and populations." (Lyon, 2005, p. 2). In other words, people may be held accountable in ways that they may not understand based on the data being collected about them. Information from wearable technologies can be gathered and used against the user to inflate prices depending on the particular bin in which they have been sorted. The information can also be sold to third party purchasers who then de-anonymize the data and put personally identifiable characteristics together to create personal "profiles". With the lack of encompassing policy on both the state and federal levels, corporations are gaining a greater extent of knowledge on individuals. It is vital that as the extent of data collection of wearable technology grows, so does concurrent policy to protect individual rights.

Situational Understanding:

As a result of the rise of harmful data collection, many new laws and policies have been put into place. These laws and policies vary on the federal and state levels but work to protect individual identities and the manners in which the data can be used. However, there is a lack of progressive action for policies related to wearable technology which can be attributed to several reasons. The first, since wearables do not collect data for the purpose of treating patients, the FDA does not classify them as medical devices meaning they are not protected within the FD&C Act. This act gives the FDA legal authority to regulate medical devices, thus they remain unregulated. Additionally, it is difficult for states to enact specific policies when the technology is constantly shifting and evolving in its complexity. Thus, the policy must be broad enough that it can be

enacted across various cases, but not too broad as to allow it to be avoided. Analyzing different groups of stakeholders will provide a deeper analysis of the current situation. For example, insightful groups to look into include policymakers who specifically focus on data collection and the particular rules and regulations. This could include the FTC, HIPAA, the FD&C Act, and many others. Additionally, researching civil liberty groups, such as the ACLU who work to protect individual rights, would help researchers to better understand how the policy came to be and how it is evolving.

Currently, there are many professional articles and scholarly sources that address different aspects of how a policy is mutually shaped. One example of a research paper from Stetson University (Vinez, 2017) addresses how policies are being shaped due to data collection of wearable technology. This research focuses on how data can now be used as supplementary evidence to incriminate or exculpate an individual based on different metrics collected from the wearable device. The research also addresses how wearables are completely transforming the justice system and the detrimental effects it is having on the industry. The ICLG provides another source that will aid in research by explaining many of the current policies on both the state and federal levels. These professional articles and scholarly sources will help in understanding how the policies came to be and how they are fluctuating due to the evolving technology in wearable devices.

Evidence/Data Collection:

There are several pieces of evidence needed to address the shifting policies on the federal and state levels. For example, the research will refer to the International Comparative Legal Guides (ICLG) page when talking about any current and past policies. These policies are all listed out and can aid in better understanding how they have been shaped and where they will go in the future. Additionally, the researcher has been in contact with a Senior Policy Analyst (Jay Stanley) from the ACLU who specifically deals with data privacy issues and the shifting policies that arise from wearable technology. The researcher plans to conduct a series of interviews with Mr. Stanley to gain his perspective on public policy related to data collection and how the policies have been shaped over the years. His perspective will provide important insight since he will be on the side of the policy that aims to guarantee individual rights and liberties. Conversely, the researcher plans to interview advocates for the usage of data collection specifically regarding wearable devices. These contrasts in opinions will help the research to be all-encompassing in order to best address how these policies came into place and how they evolve. One final, vital piece of information to be collected will be hearings on wearable data collection. The hearings will provide key pieces of the legislative process and discuss the potential rulings to how the policy may be shaped moving forward.

Overall Conclusion:

Wearable technology is becoming an integral part of our society and is only in the infancy of its development. This technology can provide actionable recommendations in improving overall wellbeing. The capstone group looks to build a smart device that finds the optimal conditions for users to perform varying activities. With the growth of new technology comes concurrent policy that must be addressed in order to maintain both the physical and ethical integrity of the product. As this relatively new technology continues on its path of development, so should relevant policy to protect consumers and their privacy. The policy varies on the state and federal levels and continues to be an integral part of this sociotechnical system. Policy will continue to play an increasingly important role in within the current “wild west” wearable technology industry.

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