Potential Negative Effects of the Expansion of Smart Home Technology on Psychology and Human Behavior

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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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Smart home technology has been expanding across the world in recent years, adding many devices to the ever-expanding Internet of Things (IoT). It should be recognized that these webs of sensors, algorithms, and technologies combine to create a convenient, efficient, connected home. Smart home technology refers to devices used within the home to digitally monitor, assist, and/or provide automated or connected services to residents (M. R. Alam et al., 2012; Sovacool & Furszyfer Del Rio, 2020). Though the idea of technology introducing more convenience into the home is not new, this market has grown rapidly in recent years.

The smart homes market was valued at approximately USD 64.60 billion in 2019 and is projected to grow at a compound annual growth rate of 25% to USD 246.42 billion by 2026 (Mordorintelligence, 2019). Considering that the S&P 500—a benchmark for general market trends—has consistently shown a compound annual growth rate of approximately 6.9% (adjusted for inflation), the expansion of smart home technologies is extraordinary (Young, 2018). Surveys indicate that much of this growth is due to the convenience, monetary savings, and energy efficiency associated with smart homes (Wilson et al., 2017).

However, these benefits may come with associated risks to human cognition and behavior, and this rapid expansion is occurring without analyzing the risks smart homes may bring to human behavior and cognition on the scale of both individuals and shifting cultural norms. I will be focusing on four themes into which these risks can be organized: loss of skills and deskilling, algorithms affecting user autonomy and categorization, user data and privacy, and monitoring and harassment. Though additions are constantly being made to the IoT in the form of new ways of connecting products, this research will focus on those that have the most

significant potential effects. For this reason, the technologies focused on in this research will be predominantly smart virtual assistants, smart lighting systems, smart utilities, smart security systems, and smart sensors. Simpler and generally less connected products such as smart ovens, dishwashers, washing machines, crockpots, and many other smart gadgets will thus not be discussed. This STS research thesis will analyze the negative effects on psychology and human behavior that may result from the expansion of these smart home technologies. It is my goal to illustrate why these risks should always be taken into consideration when introducing or improving new technologies for the home. After all, it can be argued that the spaces in which we live shape us as much as we shape them (Easthope, 2004).

Literature Review

The idea that the expansion of the technologies meant to connect people and technologies could cause negative mental effects has been around for many years now. In 2013, Rosen, Whaling, Rab, Carrier, and Cheever research this link between clinical symptoms of psychiatric disorders and technology use. This research concluded that general technology use could be used as a predictor for at least six personality disorders and three mood disorders. A similar study found that television watching and computer use were associated with anxiety and depressive disorders (de Wit et al., 2011). Smart home technology, by entrenching users deeper into the web of the IoT, would thus further this issue. Worst of all, many of the individuals studied had a positive view of these technologies and likely did not even consider the negative aspects they hold. Although the negative mental effects of connective technology have become commonly studied recently, extensive research on the effects of these technologies specifically on behavior and cognition are still lacking. By focusing on smart home technologies, the risks of connective technologies can be put into context and further the understanding of users and designers alike to

either create some sort of governance regarding such technology or at the very least impress upon users a sense of awareness.

Yet another gap in research lies in the study of these negative effects on behavior and psychology within the context of the home, specifically regarding smart home technologies. Much of the risk analysis of smart home technologies has to do with the privacy and security threats they pose by introducing a new level of connectedness without taking into consideration the further effects these threats among other aspects of smart homes may incur on the minds of users. And, of this research specific to smart homes, many studies rely on survey data rather than actual observance of users (Wilson et al., 2017). The problem with relying so heavily on survey data is that participants are evaluating themselves rather than being evaluated by an independent party, and participants may not even recognize changes in their behavior and cognition over time. Additionally, many surveys conducted thus far have been on prospective and early-adopting users, so data is in reference to how users perceive smart home technology before experiencing it firsthand. The few studies conducted by sorting users into controlled groups from the start to study the manipulative power smart homes have focus only on the positive aspects of this power, such as fiscal and environmental sustainability (Kroll et al., 2019). This thesis attempts to close this gap in knowledge by referencing research and studies on how humans can be caused to behave and think differently and analyzing how the capabilities of smart home technologies could cause these changes.

Loss of Skills and Deskilling: A Cultural Shift

One of the most desirable aspects of having a smart home is the associated convenience (Wilson et al., 2017). With smart lighting systems, dazzling lights that can adjust state, color and brightness that once required complicated, manually set clocks and just short of a degree in

electrical engineering can be easily set from one's smartphone. Hiding a spare key under the welcome mat is no longer necessary when smart security systems can allow a homeowner to remotely lock and unlock their front door. However, "with the convenience, the next obvious step is laziness" (Chatterjee, 2019). With no need to put any effort into living comfortably and luxuriously, tenants of smart homes no longer need to learn skills that were once essential. However, without a looking glass into the future, it is impossible to know for sure if we should abandon these skills just yet.

The 20th century was a time of great advancement in technology, and the kitchen was a prominent showcase of many new technologies. However, as preparing food became less skilled through the introduction of premade or partially made meals, the skillfulness of the average person in the kitchen as well as the frequency at which they cooked for themselves both decreased (Lyon et al., 2003). While the goal of—at the time—new kitchen utilities such as the microwave, the modern refrigerator and freezer, and the dishwasher was to make cooking and cleaning easier, there was an unforeseen consequence of this simplicity: loss of skills (Kerrigan, 2018). It is difficult to predict just what this loss of skills may look like in the context of smart home technologies, especially with new forms of said technology being developed every day, but the example of deskilling in the kitchen should at least be considered to anticipate further loss of skills.

Algorithms and Their Ability to Manipulate

Many smart home technologies utilize various learning algorithms to allow for a more convenient, personalized, and predictive experience. In doing so, smart homes are constantly adapting based on both individual and collective user data (Dixit & Naik, 2014). This method is used in a variety of smart home technologies, including virtual speakers and assistants such as

Amazon's Alexa; intelligent lighting systems; and smart refrigerators that can plan meals, order groceries, and connect to home security systems (Kim, 2018; Kota Gopalakrishna, 2015; *Samsung Smart Refrigerator*, 2021). While this clearly allows for convenient and relaxing living, it also poses threats towards user autonomy, oversimplification and categorization of users, and user overconsumption.

Nudging

Within the context of smart homes, nudging refers to the purposeful act of influencing users to behave or act in a specific manner. Nudging can be used to benefit the user and improve the state of the home in many ways. For example, nudging can be used to further the objectives of smart homes to promote sustainable behavior by influencing users to adjust usage of electricity or water (Kroll et al., 2019). This results in both financial savings for the user as well as living more sustainably. By monitoring user behavior, a data-centered persuasion mechanism can be produced to manipulate the user in this way, sometimes without the user even being aware (Shin & Kim, 2018).

However, this lack of awareness on the part of the user can lead to a lack of autonomy and ultimately users making decisions they would not otherwise make that do not necessarily benefit them. In "Consumer decisions with artificially intelligent voice assistants," Benedict G. C. Dellaert et. al (2020) describe how the ability of virtual assistants detect and signal tone and provide answers ranging from immediate answers to various possibilities enhances the trust of the user by creating a more human dialog. This in turn creates an environment where the decisions of the user are guided more by the virtual assistant than by themselves. Further, in a study analyzing the influence of virtual assistants have on consumers, it was found that the simple addition of a name to a virtual assistant—such as "Siri" or "Alexa"—led to significantly

less concern regarding the autonomy within the scope of smart technologies (Voorveld & Araujo, 2020). This ease of manipulation may be inadvertent due to complex AI or could be implemented on purpose as somewhat of a subconscious advertisement. Either way, this shows that smart technologies with built-in virtual assistants, whether it is a Amazon's Alexa smart speaker or Wi-Fi-enabled refrigerators, pose a threat toward user autonomy.

Categorization

Another risk of learning algorithms implemented in smart technologies are the inherent biases including social, moral, and/or regulatory bias (United Nations Institute for Disarmament Research [UNIDIR], 2018). One of the biggest sources of concern with algorithmic bias in smart home technologies is inappropriate focus. Focus bias "occurs when there is usage of incorrect or inappropriate information in the input or training data" (UNIDIR, 2018). This form of bias, which learning algorithms can pick up on without being trained to, can lead to morally irrelevant categories such as race, ethnicity, gender, and religion being introduced into learning algorithms. This has the potential for certain groups of people to be targeted or left out from certain forms or categories of advertising or pricing (McEvoy, 2020).

Categorization not only acts to divide cultures but can lead users to reduce the amount of information they are willing to share about themselves out of fear of being simplified down to categories. Further, companies using this data may inadvertently expose certain groups of people to targeting or exclusion without even realizing, leading to distrust in companies and the use of user data in general. Overall, it is important that this bias is addressed or at least acknowledged to reduce unnecessary negative perceptions of users regarding businesses and vice versa.

Overconsumption

Suggestive learning algorithms within smart homes focus on monitoring user behavior to attempt to provide the user with what they want in a convenient manner. Using various sensors and data processing techniques, smart home technologies can even make suggestions to the user before the user is aware of their desires (Wang et al., 2016). There are primarily three potential negative behavioral effects related to this suggestive methodology: overconsumption of products, overconsumption of data, and reinforcement of bad habits.

The overconsumption of products may occur when an algorithm provides suggestions too often. Although the algorithm may be attempting to help the user by providing them everything they want as often as possible, in doing so the user may become convinced to order products they do not need. For example, the Amazon Alexa may respond to a request about the current weather with the weather information and then a suggestion to buy something, or it may suggest restocking a previous order after a specific period (Snell, 2020). Overall, this potentially compulsive purchasing behavior can lead to feelings of tension or anxiety and a feeling of relief after making a purchase (Black, 2007). Virtual assistants are not the only smart home technology capable of overconsuming products; other examples include smart refrigerators suggesting restocking and ordering food more often than one should and smart entertainment systems suggesting purchasing or renting media.

The overconsumption of information is also a risk with smart home technology. Again, this risk results from smart home algorithms that attempt to please the user without considering consequences of this behavior. Individuals often seek confirmation bias without realizing, and when this is paired with an algorithm trained on a user's behavior, information will become more and more tailored to the user (Peters, 2020). As a result, information sources from which a

virtual assistant may gather information will create a “filter bubble” to fit the opinions of the user (Ciampaglia & Menczer, 2018). Not only can this misinform the user, but over time the user may have their views confirmed so often that their opinions strengthen to the point of isolating themselves from other views and consequently other humans in general.

Although the previous two negative behavioral effects were primarily associated with virtual assistants within smart technology, nearly any smart technology that learns from the behavior of the user can lead to entrenchment in bad habits. Smart lighting and HVAC systems have the capability to learn routines of users and adjust to better react and fit to these routines (Kota Gopalakrishna, 2015). Although this adds a substantial element of convenience to the smart home, risk arises when the user has already developed poor living habits, such as an unhealthy sleep schedule. Rather than working towards a healthier lifestyle, learning algorithms such as those in smart lighting and HVAC systems could become accustomed to and encourage bad habits already established within users.

User Data and Privacy

It has been discussed how smart technologies organize and process user data, but it should be noted that there are also problems that could arise due to the gathering and storing of this data. When mismanaged or misused, the plethora of data collected on individuals can threaten users’ privacy, security, autonomy, and trust in companies. Similar to the ideas in the theme of algorithms and their ability to manipulate, the behavioral and psychological risks associated user data and privacy have to do primarily with smart technologies that incorporate behavioral analysis and predictive learning algorithms, such as virtual assistants, smart lighting, smart utilities, and some smart appliances. However, it will be exhibited that smart security systems pose a much greater risk to privacy and security than to manipulation of cognition.

Privacy and Security

Smart homes technologies—especially smart security systems like smart locks, smart doorbells, and camera implementation—in an attempt to make the home safe, can actually lead to vulnerabilities in security that would not be there without these systems (Pace Technical, 2017). With smart technologies so connected to the IoT, gaining access to other smart systems via a smart security system or conversely gaining access to a smart security system via other smart systems is sometimes possible. For example, Motorola's Focus 73 outdoor security camera was able to be hacked remotely to have access to its entire camera and video feed (Kirk, 2016). Additionally, a test conducted by Pen Test Partners in 2016 found that Ring doorbells could easily be used to gain access to a home's Wi-Fi network (Lodge, 2016). Even thermostats and lights connected to the IoT can reveal information about the occupancy status of a home if hacked (Zheng et al., 2018).

The knowledge that this these breaches in security would inevitably lead to users having the mindset that there is no privacy. In "What Makes a House a Home," Roderick Lawrence (1987) explains how a prominent purpose of a home is to "distinguish between private and public domains." Thus, the sheer possibility of this attack against the privacy and safety of a home threaten to remove one of the integral dimensions that makes a house a home. In this sense, the smart in smart home may entail the elimination of a sense of refuge and relaxation from the outside world.

Data Use and Misuse

The risks associated with the aforementioned notion of smart homes collecting data to enhance the interactive and predictive experience of users go beyond autonomy and categorization. As smart home technologies become more complex and connected, the data

collected on users grows and becomes more complex with it (Kim et al., 2020). This data, though helpful to smart home algorithms can be misused when put in the wrong hands. A major example of this was the Cambridge Analytica and Facebook scandal, where the private data collected on millions of users was used by the analytical consulting firm Cambridge Analytica to influence voters in the 2016 U.S. presidential election (Confessore, 2018). If private data collected on opinions and activities of individuals via smart homes were to be leaked or sold, there is no telling the limit to which this data could be used to manipulate the opinions and subsequent behavior of users.

User Perception and Paranoia

It is important to note that there is potential for a negative disruption in human behavior beyond the direct privacy and security of the user. Recently, plenty of fear inducing articles have been circulating around the internet warning users of the many dangers of their data being leaked or hacked. While it is important to discuss and inform individuals on this matter, even if smart technologies were to become completely secure and data could never be leaked, the level of distrust most people have in the privacy and security of their data is at a level where user paranoia is inevitable. In fact, a survey of American adults conducted by the Pew Research Center found that 81% of U.S. adults are not convinced that the benefits of widespread data gathering outweigh the risks (Auxier et al., 2019). This lack of trust is substantial enough that, as smart homes do become more widely adopted, many users will not live as comfortably with a lingering feeling of insecurity.

The Role of Technology in Domestic Abuse

In addition to examining the potential for users to be the victim of problems that may arise within smart technologies, it is essential that ways in which the user themselves could abuse

the power of smart home technologies be analyzed. This concerns namely the idea that smart technologies may expand the reach of perpetrators of domestic abuse with the level of control, especially remotely, that smart technologies provide. Smart security systems, sensors, lighting, and utilities all have the potential to be weaponized to monitor, control, trap, isolate, and discomfort victims of domestic abuse. Although the introduction of smart home technology to a home likely will not have an effect on whether or not domestic abuse occurs, it certainly gives more control to the abuser.

Monitor a Member of a Household

The idea that the IoT could be misused by abusers to monitor and threaten victims is not new. In a 2014 survey of domestic abuse victim service providers, 97% of respondents indicated that the offenders are harassing, monitoring, and threatening victims through the misuse of technology (National Network to End Domestic Violence [NNEDV], 2014). The survey also found that a variety of forms of technology, from cell phones to social media to GPS tracking, was being utilized for such abuse. The cameras smart security systems and smart sensors allow for an abuser to monitor both the occupancy of their home as well as what their victim may or may not actually be doing. Further, utilities and lighting connected the IoT grant the abuser remote access to heating, lights, speakers, and more, allowing for the potential of controlling a somewhat torturous environment remotely. This is especially dangerous when the abuser is the only one with access to these features of the home, which could be a result of anything from the financial situation of the household to password protection of smart home units.

Control/Trap/Isolate a Member of a Household

Ultimately, through the ability to constantly monitor and harass victims of domestic abuse provided by some smart home technologies, abusers can obtain coercive control, isolating

the victim from friends and family and controlling access to resources (Candela, 2016). One of the most significant reasons domestic abuse is so persistent and difficult to stop is this strategy of isolating the victim. Overall, many smart devices would allow for this isolation to persist and strengthen, making domestic abuse even harder to bring an end to than it already is.

Discussion

Clearly, there are many potential ways in which smart home technologies could have unintended consequences. These consequences can result in the altering of cultures, targeting and manipulating of users, enabling of abusers, and even effect non-users and technologies independent of the IoT. However, many of the short- and long-term effects of smart home technologies on behavior and psychology have yet to be discussed or studied. For this reason, it is important that further work be done to research and properly study smart homes. With expansion occurring so rapidly, there is very little time remaining for such studies to be conducted, so more attention and awareness should be brought to this hazardous potential.

Perhaps smart technologies or policies and regulations regarding them should be altered, or maybe bringing awareness to the subject is all that is needed. Regardless, without proper study and attention to these issues throughout the entire lifecycle of smart products, from idea to updating and servicing, the potential for catastrophe looms. In the worst possible circumstances, our world could become a place of helpless, lazy people who can be manipulated at the whim of an algorithm or an analytical data firm. The private information of individuals would no longer be private, the home would no longer be a safe place of refuge from the outside world, and members of households could be controlled and abused easier than ever before. Obviously, this doomsday scenario is unlikely, but every aspect of it is very possible and even probable. A smart home's purpose is to provide convenience, comfort, safety, and control to a tenant in order to

create a unified home ecosystem (*What Is a Smart Home?*, 2015). So, why should we waste the intrinsic benefits of smart homes by proceeding forward with neither research nor caution?

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