



Towards an Understanding of College Students' Perceptions of Smart Home Devices

Christine E. Wania^(✉)

The College at Brockport, State University of New York, Brockport, NY, USA
cwania@brockport.edu

Abstract. The concept of a smart home has evolved over several decades. There are many advantages and potential advantages of smart homes, smart home devices and smart living. There are also disadvantages, risks and concerns with smart home devices. There has been significant work examining adults' perceptions of smart home technologies and devices, particularly in adults over the age of 40 in the areas of energy policy and assistive technologies. There has not been as much work examining perceptions of adults under the age of 40. The goal of this research is to further understand college students' familiarity with smart home devices, use of smart home devices, willingness to use such devices, and the perceived advantages and disadvantages of smart home devices. This study extends previous research by gathering college students' perceptions of smart home devices. The results of this study suggest that most of the college students surveyed perceived some usefulness and potential benefits of smart home devices, but they also had many concerns. Less than half of the college students surveyed indicated a desire to use smart home devices. A deeper understanding of younger adults' perceptions, expectations, and concerns may assist device manufacturers, researchers, and potential users of smart home devices. Further work is needed in this area.

Keywords: Consumer perceptions · Internet of Things (IoT) · Smart home · Smart home devices · Smart home technology · Smart living · Ubiquitous computing · User perceptions

1 Introduction

The concept of a smart home has evolved over time [28, 30, 36, 37]. Smart homes and smart home devices have been discussed in literature and researched in many disciplines for several decades. There are many advantages [36, 42] and also disadvantages [9, 18, 42] of smart homes and smart home devices. Research has been conducted in an attempt to understand perceptions of smart home devices and use of such devices. Many research methods have been utilized. Researchers have conducted focus groups [13, 15], interviews [6, 17], surveys [5, 17, 22], observational studies and home visits [7]. Several smart homes have also been built and studied at universities including Drexel University, Georgia Institute of Technology, and University of Colorado, Boulder. Much of the empirical work in this area has focused on adults over the age of 40. There has been significant work examining adults' perceptions of smart home technologies

and devices, particularly in adults over the age of 40, in the areas of energy policy [6, 17, 26], and assistive medical and healthcare technologies [13, 15, 31]. There has been some work examining younger adults' perceptions of smart home technology and devices [18, 22], but not to the same extent as other populations. However, younger adults are certainly a target population for such devices in a market that has rapidly grown and is predicted to continue to rapidly grow [4].

One goal of this research is to further understand college students' familiarity with smart home devices, use of smart home devices, willingness to use such devices, and perceptions of advantages and disadvantages of smart home devices. The other goal of this research is to further refine the survey instrument used in this study prior to distributing the survey to a wider population. This study extends previous research by gathering perceptions from a population that has not been studied as extensively as other populations. A brief review of related work is included in the following section.

2 Background and Related Work

Smart homes and smart home devices have been discussed in literature for decades and researched in many disciplines for decades. During this time the concept of a smart home has evolved. This evolution began with the smart home and is now referred to by some as smart living [36]. The first use of the term smart house has been attributed to the American Association of House Builders, in 1984 [25]. Although similar concepts had been described prior to the 1980s. Smart homes in the 1980s contained many large (r) devices and lots, and lots of wires [23]. The smart homes of today are closely related to ubiquitous computing [40] and the Internet of Things (IoT). The concept of smart living extends the conveniences and functionality of smart home devices to everyday life, not limited to the confines of a home.

2.1 From Smart Homes to Smart Living

There is currently no agreed upon definition of a smart home, a smart home device or smart living, and different disciplines and industries have varying definitions. Aldrich defines a smart home as "as a residence equipped with computing and information technology which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond." [2, p. 17]. Aldrich [2] proposed five classifications of smart homes: homes which contain intelligent objects, homes which contain intelligent communicating objects, connected homes, learning homes, and attentive homes. Not only are smart homes intelligent, connected, and able to communicate, but, according to Aldrich they learn and are aware and attentive to the needs and desires of the occupants [2]. Solaimani, Keijzer-Broers, Bouwman [36] extend Aldrich's definition by adding communication, education and healthcare to the list of things that a smart home promotes.

The concept of smart living extends the concept of a smart home outside of the home, to focus on intelligent living, and not just focus on devices in the home [36]. As Weiser stated "The most profound technologies are those that disappear" [40, p. 94].

The smart home devices and technologies of today seem to have disappeared and be the invisible computers described by Norman [33]. These invisible computers exist in many everyday devices we are already accustomed to having in our homes.

Smart home devices have been studied in many disciplines including: Architecture and Construction, Computer Science, Cybersecurity, Energy Policy, Healthcare, Human Computer Interaction, and Networking, among others. Smart home devices have been studied in these disciplines for varying reasons such as reducing energy consumption, providing independence and healthcare to older adults, and for comfort, convenience and security. There have been many large-scale smart home projects including the Aware Home at Georgia Institute of Technology [27, 28], and the Drexel Smart House [19]. Academic and industry researchers have examined smart home advantages, disadvantages, challenges and accomplishments. Reviews of the literature are provided in various disciplines [1, 16, 36].

Smart home devices have been developed in many areas including, but not limited to: energy, entertainment, healthcare, and security. Advances in technology have allowed for new developments. As the technology has advanced and prices have decreased, it seems as though there is more interest in smart home devices and smart living. Interest in smart home devices can be seen in new product development, product sales, and the Consumer Electronics Show [11, 12]. In 2019 smart home technologies were named one of the 5 technology trends to watch by the Consumer Technology Association [4].

Another way to examine interest in this area is by inspecting Google Trends. Google Trends examined in January 2019 for the time period of 2004–2018 indicate an increase in searches that include terms such as smart home and several similar variants beginning in and around 2013. Note: the Amazon Echo was introduced in 2014 and Google purchased Nest Labs in 2014.

In the literature, potential advantages and disadvantages of smart home devices vary based on the industry, application and the specific smart home device. Some of the advantages or benefits of various smart home devices discussed in the literature include: convenience, comfort, safety, security, cost savings, energy savings, and time savings. Research suggests that consumers have adopted these devices for convenience, safety, security, to save money [6, 15, 31, 43], and in some cases simply as a desire to be identified as an early adopter [29].

There are also many concerns, risks and disadvantages of smart home devices described in the literature including: control, cost, interoperability, privacy, reliability, security and usability [6–9, 29]. In some cases consumers simply do not see a need for smart home devices. Edwards and Grinter [20] identified seven challenges of smart homes, including the need for a systems administrator or someone to manage the smart home. Some of the barriers and challenges with adoption described by Gann et al. [21] and Edwards and Grinter [20] appear to still be barriers and challenges today.

According to the Consumer Technology Association, smart home product revenues were more than \$3.3 billion in 2017 [4]. The Consumer Technology Association's 2018 *U.S. Consumer Technology Sales & Forecasts* report predicts that sales of smart home products will double between 2018 and 2022, with revenues surpassing \$6.9 billion in 2022 [4]. Clearly there is currently interest in smart home devices. However, we still do not understand enough about peoples' perceptions of these devices.

2.2 Technology Adoption, Acceptance and Use: Theoretical Frameworks

There are many theoretical models or frameworks for understanding adoption, acceptance and use of emerging technologies. A brief review of several such frameworks is provided here. The diffusion process described by Rogers in *Diffusion of Innovations* suggests that innovation is communicated over time through particular channels [35]. Rogers describes the innovation decision making process that includes five steps: knowledge, persuasion, decision, implementation and confirmation [35]. The decision phase includes a decision to adopt or reject a technology. In this diffusion process as described by Rogers, the first adopters are categorized as innovators, followed by early adopters, early majority, late majority and laggards [35]. This framework also addresses communication networks, diffusion networks, personal networks and reaching critical mass [35].

The Technology Acceptance Model (TAM) [14] focuses on organizational systems and the acceptance of such systems by end users in an organization. TAM suggests that perceived usefulness and perceived ease of use are of particular importance in the acceptance of technology by end users. TAM suggests that perceived usefulness and perceived ease of use determine behavioral intent to use a technology [14]. The Unified Theory of Acceptance and Use of Technology (UTAUT) by Venkatesh, Morris, Davis, Davis [38] built on previous frameworks, including TAM, and considered individual acceptance and use of technology, primarily in organizations. UTAUT contains four constructs that provide a richer understanding of individual acceptance and use of technology in organizations: performance expectancy, effort expectancy, social influence and facilitating conditions [38].

Unified Theory of Acceptance and Use of Technology II (UTAUT2) by Venkatesh, Thong, Xu [39] extends UTAUT [38] and addresses consumer acceptance and use of technology. In addition to the four constructs in UTAUT that are adapted for the consumer context, UTAUT2 contains three additional constructs: hedonic motivation, price value and habit [39]. These constructs deserve a bit of explanation. In this context, performance expectancy refers to the benefits to consumers from the use of a particular technology [39]. Effort expectancy refers to the amount of effort/ease associated with the use of a particular technology [39]. Social influence refers to one's perception of others' beliefs about one's use of a particular technology. Facilitating conditions refer to one's perceptions about the availability of resources and support [39]. Hedonic motivation is the fun or pleasure one perceives from using a particular technology [39]. Price value refers to the cost/benefit tradeoffs [39]. The last construct, habit, according to Venkatesh et al. is a "perceptual construct that reflects the results of prior experiences" [39, p. 161]. For further information refer to [39]. These theoretical frameworks and models provide some context within which we can further examine and explore the adoption and use of new technologies.

2.3 Smart Home and Smart Living Literature

Much has been written about smart homes and smart living. In this literature, perceptions of smart home devices vary. Several literature reviews have been conducted including those by Alaa, Zaidan, Zaidan, Taal, Kiah [1], Chan, Esteve,

Escribe, Campo [10], Demiris and Hensel [16], and Solaimani, Keijzer-Broers and Bouwman [36]. Alaa et al. [1] provide a review of 229 publications. Demiris and Hensel [16] provide a review of 114 publications. Chan et al. [10] provide a review of smart home projects along with the systems used in the smart homes. Solaimani et al. [36] provide a review of 154 publications. Solaimani et al. [36] identify four domains within smart living literature: organization, finance, service, and technology. Alaa et al. provide a taxonomy of smart home literature and divide the literature into four classes and several subclasses [1].

Several methods have been used to investigate perceptions of smart home technology. Bernheim Brush, Lee, Mahajan, Agarwal, Saroiu, Dixon [7] conducted home visits “in the wild” at 14 homes with at least one smart home device, or home automation device, as they referred to in their work. Bernheim Brush et al. spoke with 31 people in the 14 households. Bernheim Brush et al. found that many households were happy with their experiences with smart home devices. Although these users were happy with their experiences, they encountered challenges including: inflexibility, manageability, security, and high cost of ownership [7].

Balta-Ozkan, Davidson, Bicket, Whitmarsh [6] conducted workshops and expert interviews to understand barriers to the adoption of smart home technologies, specifically related to energy efficiency. Balta-Ozkan et al. found that experts perceive barriers related to complexity, interoperability, privacy, reliability and security. However, Balta-Ozkan et al. found that consumers concerns are related to: cost, loss of control, privacy, reliability, security, trust and utility (or lack thereof) [6].

Rainie and Duggan [34] at the PEW Research Center conducted a survey and online focus groups. Rainie and Duggan state “the phrase that best captures Americans’ views on the choice between privacy vs. disclosure of personal information is, “It depends.”” [34]. Rainie and Duggan [34] surveyed a nationally representative sample of 461 Americans, using parameters from the March 2013 Census Bureau’s Current Population Survey (CPS). This survey included 235 men and 226 women. Two-hundred thirty participants were between ages 18–49 and 231 participants were age 50 and above. Participants were asked to indicate whether or not you would be willing to share information about themselves in exchange for getting something they might need or enjoy [34]. Rainie and Duggan report that 27% of the adults surveyed found a smart thermostat acceptable. Fifty-five percent found a smart thermostat not acceptable, and 17% felt as though it depends [34].

Apthorpe, Shvartzshnaider, Mathur, Reisman, Feamster [3], using a survey based on the Contextual Integrity privacy framework, gathered data from 1731 adults in the United States. Based on the results of their survey Apthorpe et al. [3] concluded that user privacy perceptions are context dependent and diverse in this area. Zheng, Shvartzshnaider, Mathur, Reisman, Feamster conducted 11 semi-structured interviews with smart home device owners [43]. Their work suggests that user opinions depend on perceived benefits [43]. The findings in [43] suggest that users trust manufacturers, but do not take action to verify that they are being protected and that users are unaware of some privacy risks. The findings in Zheng et al. suggest that desires for convenience dictate privacy related behaviors [43].

Lau, Zimmerman, Schaub [29] conducted a diary study and interviews with 17 smart speaker users and 17 non-users. Lau et al. investigated perceptions of benefits, risks and

concerns with smart speakers, such as Amazon Echo. In this study, non-users did not see the purpose or value of the devices and non-users did not trust the device companies [29]. Their findings suggest that users of the smart speakers did not fully understand privacy risks, expressed few privacy concerns and were mixed on their level of trust in the companies [29]. Lau et al. suggest “people are choosing to trade privacy for convenience” [29]. Lau et al. provide recommendations to device manufacturers, regulators and policy makers to address privacy protections and data practices [29]. Nikou [32] conducted a survey of 156 individuals in an attempt to understand what influences intentions. Their findings suggests that perceived usefulness, attitudes towards technology and social influence impact adoption decisions [32].

In an attempt to further understand perceptions and use of smart home technologies, research groups have designed, constructed and studied smart homes [27, 28]. Many including Nikou [32] have investigated adoption of smart home technologies using some of the frameworks discussed above. Others have conducted focus groups [13, 15], interviews [3, 17, 43], surveys [5, 17, 22], observational studies and home visits [7] and mined publically available information from consumers [8]. Some have utilized multiple research methods [6, 29, 41]. The methods used in this study are described in the following section.

3 Method

A survey instrument was used to gather data. The survey was developed after a review of the literature and consideration of the theoretical frameworks described in the previous section. The survey contains questions and statements similar to those used elsewhere, such as [17]. There was a tradeoff between the length of the survey instrument and the number of items that could be addressed.

The survey gathered demographic information, familiarity with smart home devices, ownership of smart home devices and perceptions of a few specific smart home devices. The survey included a summary of three smart home devices: Amazon Echo, Nest thermostat, and Ring doorbell. The summary included information about functionality and price. This information was gathered from the product pages on the manufacturer websites. The survey asked for an indication of the extent of disagreement or agreement with 14 statements for each device with the following Likert-type responses: strongly disagree, disagree, neither disagree nor agree, agree and strongly agree. The survey contained statements such as: I feel that the Ring doorbell (or a similar video doorbell) would be useful. Each time that a device was listed in the survey it was listed with (or a similar <fill in the blank> device) where fill in the blank contained a brief description of the device. The survey also included open-ended questions.

The survey was distributed on paper. The survey was administered in multiple sections of an introductory computer science course at a liberal arts college in the fall of 2017. The survey was distributed in one class session. Participation was voluntary and students received no remuneration. Students took approximately 25 min to complete the survey.

Data from the completed surveys was entered into an excel spreadsheet. The data was checked twice for accuracy. Prior to analyzing the pilot data the data was examined for missing responses. Seventy-six participants completed the survey. Of those 76 participants, 18 of them did not complete the entire survey. Sixty-eight of the 76 participants responded to all questions. Instead of selecting a method such as replacing missing values with the mean, incomplete survey data was not used in this analysis. Therefore this analysis includes data only from the 68 participants who answered all the questions. To simplify reporting in this paper, strongly disagree and disagree have been combined into disagree and similarly strongly agree and agree have been combined. For simplification and readability in the reporting of the results, percentages have been rounded at two decimal places. The results of this research are discussed in the next section.

4 Results

Sixty-eight college students responded to all the survey questions. The data from the 68 participants is included in this analysis. The majority of the college students, 80.9%, were between the ages of 18 and 21. Most students, 64.7%, identified as male and 73.5% Caucasian. All of the 68 participants owned a smartphone and most reported using their smartphone extensively: 42.65% for more than 5 h a day; 45.69% for 3–4 h a day and 11.76% for 1–2 h a day. All but one of the participants owned a laptop or desktop computer. Many participants, 70.59%, also owned a gaming console.

Most of the participants, 95.59%, used social media or were a member of more than one social network, with Facebook, 77.94%; Instagram, 73.53%; and Snapchat, 80.88%; being the mostly frequently used. Many participants, 57.35%, reported using the Internet 5 or more hours a day; followed by 36.76%, reported using the Internet 3–4 h; and 5.89%, for 1–2 h a day. Approximately two-thirds, 66.18%, of participants reported mostly using their smartphone to access the Internet, followed by laptop, 17.65%; desktop, 11.75%; and gaming console, 4.41%.

Almost all the participants were familiar, to some extent, with smart home devices: 7.35% extremely familiar; 20.59% familiar; 35.29% somewhat familiar; and 26.47% slightly familiar. While some participants, 10.29%, indicated they were not at all familiar with smart home devices. Most of the participants, 76.47%, did not own a smart home device or live in a residence with a smart home device. Of the 16 participants, 23.53%, who owned or lived in a residence with smart home devices, most (11 participants) only had one smart home device. The most commonly reported device was the Amazon Echo, followed by the Nest thermostat. One participant lived in a residence with more than 5 smart home devices. This participant reported that a family member who worked in a technology related field. Four participants had 2 smart home devices in their residences, which included WeMo outlets, Philips Hue lightbulbs, and Bluetooth deadbolts.

The survey included several questions about perceptions of smart home devices. Participants were asked if they thought three smart home devices would be useful. More than half of the participants agreed that the three smart home devices included in the survey would be useful, as seen in Fig. 1. However, many were unsure about the usefulness of the devices and more than 10% of the participants did not feel that the devices would be useful.

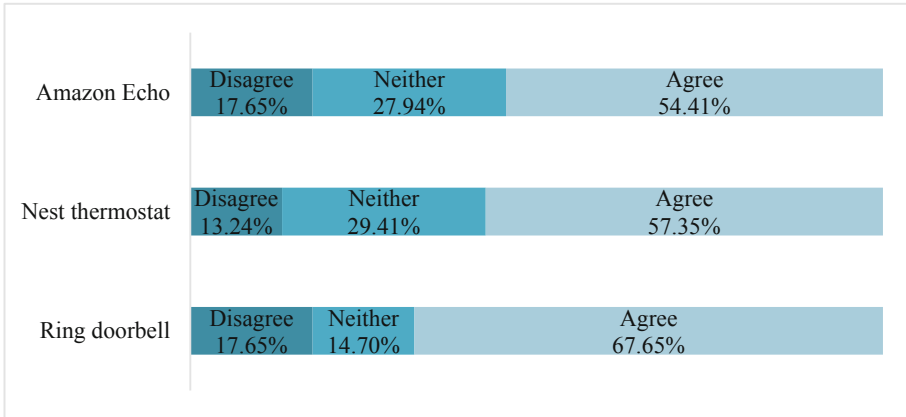


Fig. 1. Responses to: I feel <device> would be useful

Participants were asked about possible advantages of each smart home device including: convenience, comfort, security, and saving time and money. More than half of the participants agreed that the three devices would provide convenience as seen in Table 1. More participants agreed that the Nest thermostat would provide convenience, as compared to the Amazon Echo and the Ring doorbell.

Table 1. Responses to: I feel <device> would provide convenience

	Disagree	Neither	Agree
Amazon Echo	7.35%	25.00%	67.65%
Nest thermostat	10.29%	14.70%	75.00%
Ring doorbell	8.82%	19.12%	72.06%

Participants had varying levels of agreement about smart home devices providing comfort and security. In terms of comfort, 61.76% of participants agreed the Ring doorbell would provide comfort, compared to 47.06% for the Nest thermostat and 26.47% for the Amazon Echo. Participants had varying perceptions about smart home devices providing security. Many of participants, 73.53%, agreed that the Ring doorbell would provide security, 16.18% were unsure and 10.29% disagreed. Very few participants felt as though the Amazon Echo and Nest thermostat would provide security, only 5.88% and 2.94% respectively agreed that these devices would provide security.

Participants were also asked about their perceptions of the smart home devices saving them time and money. Participants had varying levels of agreement as seen in Tables 2 and 3. More than half of the participants agreed that the Amazon Echo and

Nest Thermostat would save them time. Many did not feel as though the devices would save them time and many were unsure.

Table 2. Responses to: I feel <device> would save me time

	Disagree	Neither	Agree
Amazon Echo	23.53%	22.06%	54.41%
Nest thermostat	26.47%	22.06%	51.47%
Ring doorbell	39.71%	23.53%	36.76%

Many participants did not feel as though the smart home devices would save them money and many participants were unsure. Of the three devices, more participants agreed that the Nest thermostat would save them money, compared to the Amazon Echo and the Ring doorbell as seen in Table 2.

Table 3. Responses to: I feel <device> would save me money

	Disagree	Neither	Agree
Amazon Echo	64.70%	20.59%	14.71%
Nest thermostat	22.06%	44.12%	33.82%
Ring doorbell	76.47%	16.18%	7.35%

Participants were asked about potential concerns of each smart home device including: cost, ease of use, interoperability, level of control, privacy, reliability, and trust. Cost was a concern for many participants as seen in Table 4. More participants agreed that they were concerned about the cost of the Nest thermostat and the Ring doorbell when compared to the Amazon Echo. For some participants cost was not seen as a concern in making a decision to use a particular device.

Table 4. Responses to: I feel cost would be a concern in deciding to use <device>

	Disagree	Neither	Agree
Amazon Echo	47.06%	13.24%	39.71%
Nest thermostat	22.06%	26.47%	51.47%
Ring doorbell	20.59%	22.06%	57.35%

More than half of the participants agreed that privacy would be a concern in deciding to use a smart home device as seen in Table 5. Almost 80% of participants agreed that privacy would be a concern in deciding to use the Amazon Echo. Over 60% of participants agreed that privacy would be a concern in deciding to use the Nest thermostat and the Ring doorbell. Some participants were not sure if privacy would be a concern and some did not feel as though privacy would be a concern.

Table 5. Responses to: I feel privacy would be a concern in deciding to use <device>

	Disagree	Neither	Agree
Amazon Echo	11.76%	8.82%	79.41%
Nest thermostat	20.59%	16.18%	63.24%
Ring doorbell	14.71%	20.59%	64.71%

More than 60% of participants agreed that trusting an organization with their usage information would be a concern in deciding to use a particular smart home device as seen in Table 6. Less than 15% of participants did not feel as though trusting organizations with their usage data was a concern and some participants were unsure.

Table 6. Responses to: I feel trusting an organization with my usage information would be a concern in deciding to use <device>

	Disagree	Neither	Agree
Amazon Echo	11.76%	16.18%	72.06%
Nest thermostat	13.24%	25.00%	61.76%
Ring doorbell	14.71%	13.24%	72.06%

More than 60% of participants agreed that not having full control of a smart home device was a concern in deciding to use a particular smart home device as seen in Table 7. Some participants were unsure and less than 20% of participants did not see this as a concern.

Table 7. Responses to: I feel not having full control of <device> would be a concern

	Disagree	Neither	Agree
Amazon Echo	17.65%	13.24%	69.12%
Nest thermostat	13.24%	11.76%	75.00%
Ring doorbell	14.71%	20.59%	64.71%

Some participants agreed that ease of use would be a concern in deciding to use a smart home device as seen in Table 8. Some participants were unsure and many participants did not perceive ease of use to be concern in deciding to use a particular device. Participants were also asked about interoperability and reliability. Less than half of the participants expressed that interoperability with other devices would be a concern in deciding to use a particular device. Approximately half of the participants agreed that reliability would be a concern in deciding to use a particular smart home device.

Table 8. Responses to: I feel ease of use would be a concern in deciding to use <device>

	Disagree	Neither	Agree
Amazon Echo	41.18%	23.53%	35.29%
Nest thermostat	42.65%	35.29%	22.06%
Ring doorbell	35.29%	32.35%	32.35%

Participants were also asked if they would use the devices, responding to statements such as: I would use the Nest thermostat (or a similar thermostat). Less than 40% of the participants indicated that they would use each of the devices as seen in Fig. 2. Most of the participants indicated that they would not use the devices or they were unsure.

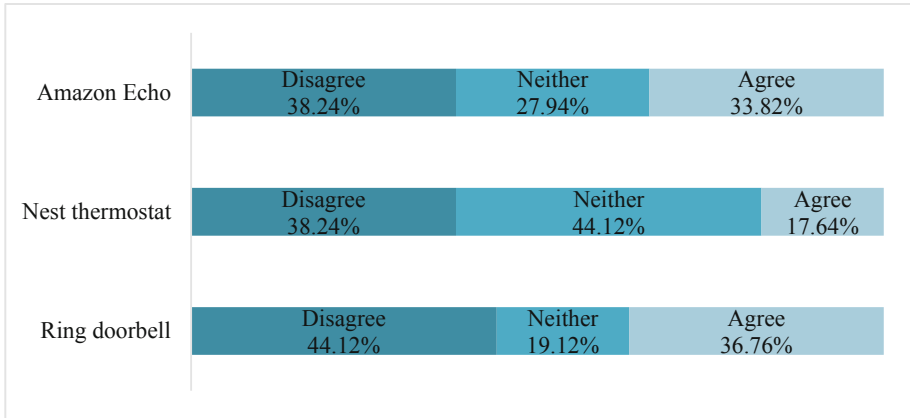


Fig. 2. Responses to: I would use <device>

The survey also included open-ended questions. For each of the three smart home devices included in the survey, participants were asked: What information, if any, would you need before deciding to use this technology? Participants had more questions and comments about the Nest thermostat, followed by the Ring doorbell and then the Amazon Echo. Many participants indicated that they did not need any further information. The most common responses for all three devices included questions of comments about where and how their data would be stored, used and shared. There were 37 responses related to data storage, access, and usage. Examples of comments include: What does Nest do with my location data? What information, if any, Nest will keep a record of? Where is the information stored and who can access it? If they record my voice without me knowing and who can access my data that the company receives... Do they save my voice recordings!?! and What information it is taking from me personally and does it save pictures of people at my door?

Following questions and comments regarding how data is stored, used and shared, the next largest category included questions about the functionality of the devices. Examples include: Does it need to be always plugged in in order to be used? What happens if a leaf blows by? Do I get a pop-up message from the motion sensors every time? and How do people ringing the doorbell know if they are being filmed?

The next most frequently occurring responses were indications that they would not use the smart home device. There were 18 responses that specifically mentioned that they would not use a device. Three participants wrote comments indicating that they would not use each of the smart home devices. There were nine other participants who indicated that they would not use one of the devices. Examples of these comments

include: I would not use it, Not going to use it, so none, and I'd never use it. Some responses indicated that they would use a particular technology, but would not buy it, for example: I would use it but I wouldn't buy one for privacy reasons. Responses also indicated a need for further explanation of the benefits of smart home devices and/or a lack of understanding about the utility of the smart home devices. Examples of comments include: What would be the benefit? Using the internet yourself takes 5 s, I feel like it is useless; Don't be lazy, walk to your door; and Seems pointless. Responses also included cost concerns, privacy concerns, security concerns, reliability concerns, installation and maintenance concerns/questions and a desire to read reviews or talk with people who have used a particular device, among other things. A discussion of the results is included in the following section.

5 Discussion

This research contributes to smart home research by providing some insight into college students' perceptions of smart home devices. Considering the expectations about the rate at which sales of smart home devices are predicted to continue to grow [4], this population will likely be a target population in the sales of smart home devices. This research suggests that there are many potential issues to be addressed. It is possible that some people are not ready for this paradigmatic shift inside their homes. A brief discussion of the results is included here.

Approximately half of the college students surveyed expressed that they believe the smart home devices are useful. However, most of the college students did not express a willingness or desire to use the devices. The results of this study suggest that the perceived benefits of the three smart home devices varied. This is not surprising considering the differences among the smart home devices. Many of the students surveyed agreed that there were potential benefits, but also had concerns about using the devices.

Convenience was one of the benefits that the college students recognized with each of the smart home devices. Previous research with other populations also found a desire for such convenience [29, 34, 43]. TAM [14] suggests that perceived usefulness and perceived ease of use determine behavioral intent to use a technology [14]. The findings in Nikou [32] also suggest that perceived usefulness is one factor that influences smart home technology adoption decisions. In this research more than half of the surveyed college students perceived some usefulness for each the smart home devices. It appears as though this is one area that might require further attention from smart home device manufacturers and researchers.

In this research, the college students surveyed were more concerned with trusting organizations with their data and potentially not having full control of the devices, compared to the other concerns. Most participants were also concerned about privacy, reliability and cost. Ease of use and interoperability were not as concerning to as many participants. Privacy and trust were concerns among the college students surveyed in this research, as well as concerns with a lack of perceived utility and/or lack of understanding about the smart home devices. Some researchers have examined smart home devices with a particular focus on privacy. Apthorpe et al. [3] based their work

on the Contextual Integrity privacy framework. It appears as though examining smart home device acceptance, adoption and use with a focus on privacy might provide further insights.

Approximately a third of the college students surveyed were concerned with ease of use. Seeing as how the college students surveyed are digital natives, it is not surprising that many of them are not as concerned with ease of use. However, this requires further investigation. Considering that most of the participants did not own any smart home devices it is not surprising that they are not (yet) concerned with interoperability of devices. Cost was a concern for many of college students surveyed. Venkatesh et al. [39] suggest there is a complex relationship between price value, hedonic motivation and habit. The sentiment of “it depends” seen in previous research [34] seems to be the case in this study also.

Although there are many frameworks that focus on understanding technology acceptance, adoption and use, and frameworks that focus on privacy, it is possible that we currently do not have a framework that is most appropriate for understanding the acceptance, adoption and use of smart home technologies. Further work is needed in this area to understand these complex relationships.

6 Conclusion

There are many advantages and potential advantages of smart homes devices. There are also disadvantages and concerns with the use of such devices. This study extends previous research by gathering college students' perceptions of smart home devices. This group has not been studied as extensively as other populations. Approximately 90% of the college students surveyed were familiar, to some extent, with smart home devices. Approximately 75% of the college students surveyed did not own a smart home device or live in a residence with a smart home device. The results of this study suggest that many of the college students surveyed perceived some usefulness and potential benefits of smart home devices, but they also had many concerns. Less than half of the college students surveyed indicated a desire to use the three smart home devices mentioned in this research. Further understanding younger adult perceptions, expectations, and concerns may assist device manufacturers, researchers, and potential users of such devices. In an industry that is predicted to continue to rapidly grow, it appears as though we still have many questions to answer and many issues to address. Further work is needed.

7 Limitations and Future Work

A survey is only one of many ways to gather perceptions. The sample population in this research is limited to college students in a particular course. This gathered perceptions about a few specific smart home devices and did not encompass all types of smart home devices. All of these limitations are acknowledged. The goal of this research was to work towards an understanding of college students' perceptions of smart home devices and to further refine the survey instrument for future use with a larger population.

Based on the results of this survey, modifications were made to this survey. After further refinement we intent to gather feedback from a larger group of college students. We are also expanding the list of smart home devices included in the survey. As this work continues we may begin to understand more about the complexities in the acceptance, adoption and use of smart home technologies, and the frameworks through which we can further understand these complex relationships.

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