ADOPTION AND ACCEPTABILITY OF SMART DEVICES FOR THE HOME

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Abstract

There are expectations that the market for smart home devices in Europe will triple by 2023. If this growth is to be realised, it is important for providers to understand the considerations and issues for adoption and acceptance of such technologies. In this paper, we address this by reporting results from a nationally representative survey of a sample of 2101 British consumers to measure adoption rates through *experience of use* and acceptability attitudes, through *trust, risk awareness, satisfaction* and *intention* to use smart home devices in the future. We interrogated the survey responses based on key influential demographics such as gender, age and education. Overall, we found that males have a slightly more favourable attitude towards smart home devices than females, that younger people are more likely to hold favourable attitudes towards smart home devices than older people, and that people with primary and secondary education levels are the least interested in smart home devices. It was also ascertained that trust was negatively correlated with being female, and positively correlated with age and education. For education, higher trust was linked to lower risk awareness. This research outlines social divides in smart home devices adoption and raises questions about what kind of business models or policy interventions may be required to level these adoption challenges.

1 Introduction

The market for smart home devices in Europe is expected to triple by 2023 [1], hence governments and the private sector have an interest to ensure the adoption of this technology happens smoothly, so they can affect innovative changes to society. These 'change agencies' often seek to target those user segments that promise to pose less resistance to the technology [2]. Such an approach facilitates adoption success, albeit at the expense of other, more resistant segments, meaning that not everyone may be able to benefit from the innovation brought about by the technology and potentially fostering a 'technological divide' amongst the population. Eventually, with the introduction of new policies and business models, this divide may diminish over time, but by the time this happens, the late adopters will not have had the opportunity to influence the innovation' s development. Hence, in addition to favouring an 'exclusive' adoption, this approach favours short-term, economically motivated gains and may ignore many of the wider – and less well understood – societal effects of the innovation. As this logic is inherent in recent Internet of Things adoption studies [3], [4], [5], IoT has unsurprisingly attracted criticism from consumer groups [6]. Instead, since the IoT is the convergence of ideas and technologies developed from a number of viewpoints [7], its adoption and acceptability are expected to be complex and must take account from several interests, including - but not only - its contribution to the global market. In order to promote a more 'balanced' take on the adoption of IoT, we have conducted a study on *both* the adoption *and* the acceptability of smart home devices.

Amongst the different application domains of IoT, we have focussed on the smart home, since this is a category of IoT technology that is already available to purchase on the market, including high street retailers, and is the most easy-to-influence area for society as a whole (rather than logistics or transport, for example).

We have identified the key concepts that have framed our study, specifically the perspectives of adoption and acceptability. Adoption can defined as a process "starting with the user becoming aware of the technology, and ending with the user embracing the technology and making full use of it" [8]. Everett [9] has visualised this process as a normal, bell-shaped curve describing the frequency of distribution of the

innovation across the population. This curve rises slowly initially, when there are very few adopters ('Innovators' and 'Early Adopters'), then accelerates to a peak as the 'Early Majority' join, and then increases slowly with the addition of the 'Late Majority' and 'Laggards'.

On the other hand, acceptability is "the degree of primary users' *predisposition* to carry out daily activities using the intended device" [10]. Predisposition is a subjective state that can be further unpacked with reference to 'judgements'. Technology acceptability is a judgment that defines, or better, prescribes, the way in which the technology examined *ought* to be desirable, either instrumentally or morally [11]. Using this notion, acceptability can relate to the desirability of the technology.

A key aspect of the acceptability of a technology is trust, and there exist a number of studies of trust in the smart home carried out external to the academic context [12]. Some of these studies yield notable results, for example, the recent study by TechUK [13], in which they recruited a sample of more than 1000 British consumers. However these studies are not grounded in relevant theory and their statistical significance is unclear. The study we have conducted seeks to address this gap by providing a theoretically-grounded and statistically rigorous, joint adoption and acceptability study of smart home devices, which includes trust as a measure.

2. Methodology

To ascertain what makes the smart home acceptable in the opinion of both experienced and prospective IoT users, we conducted a nationally representative survey of a sample of 2101 UK consumers, 2033 of which were recruited based around the following representative quotas (see Fig 1). Using a quantitative survey, we measured smart home device adoption rates through the variables of *experience of use* and *functionality usage* [14]. Also, we measured attitudes through the variables of *satisfaction* [15], *intention to use* [16] smart home devices in the future, and *trust*. We defined trust as the belief that an entity will act cooperatively to fulfil a client's expectations without exploiting its vulnerabilities [17]. Particularly, we measured trust in relation to its integrity component [18], that is, the belief that the trustee (for example, the smart home device manufacturer or service provider) is honest towards the consumer.

Variable	Participants no.	Percentage
Gender		
Male	992	49%
Female	1041	51%
Age		
18-24	228	11%
25-34	341	17%
35-49	516	25%
50-64	482	24%
65+	466	23%
Education		
ISCED 0-2	429	21%
ISCED 3-4	820	40%
ISCED 5-6	784	39%

Fig. 1 Quotas composing the nationally representative sample (n = 2023). For ISCED definition, see footnote[1].

Finally, we measured risk *perception*, since risk has been argued to frame a technology's acceptability [19] and hence could influence adoption rates. We did this by focussing on people's awareness of a high-consequence, technology-relevant event such as the launch of the new General Data Protection Regulation (GDPR) on 25 May 2018, which took place whilst our questionnaire was being designed. We also measured risk awareness in relation to *awareness of media reports* of security-related incidents.

With the exception of risk perception and experience of use, all the variables were measured based on a 5 point Likert scale. Of the variables, two (functionality usage and satisfaction) were addressed at people already experienced at using smart home devices (n = 1422). Finally, we have analysed survey responses to these measures based on technology-relevant social factors such as gender [20], age [21], and education [22]. In this paper we report some of the statistically significant results derived using the Chi-squared test.

[1] ISCED 0-2 includes Pre-primary education, Primary Education and GCSE/Vocational GCSE or equivalent (incl. O-levels). ISCED 3-4 includes A-level/Vocational A-level or equivalent (incl. AS-level), Higher Diplomas below degree level/as gateways to degree. ISCED 5-6 includes Postgraduate degree (Master and PhD) and Undergraduate degree.

3 Results

We measured levels of experience of use, functionality usage, satisfaction, and intention to use smart home devices in the future across gender, age and education groups.

3.1 Gender

The study has revealed that males have a slightly more favourable attitude towards smart home devices than females, a finding that is consistent with previously identified gendered attitudes towards computer technologies [23]. However, females have taken up smart home devices more substantially and consistently over the past year (64% of females have experience of using smart home devices versus 56% of males; 32% of females have taken up smart home devices in the past year versus 24% of males). Results for this measure were statistically significant at $p<0.05$. Females are generally more satisfied (mean = 2.83[2]) and more likely to use smart home devices in the future than males (mean = 2.94). This may reflect females' hope that smart home devices will help them to cope with domestic chores, as women are still found to carry out cooking, childcare and housework tasks 60% more so than men [24]. Results for this measure were also statistically significant at $p<0.05$.

3.2 Age

The survey has also revealed that younger people are more likely to hold favourable attitudes towards smart home devices than older people. Younger people tend to be more satisfied (mean = 2.47) than middle aged and older people (mean = 2.75 and 3.20 respectively; see footnote 2). Results for this measure were statistically significant at $p<0.05$. Younger people are also more likely to use smart home devices in the future (18-24 year old mean = 1.97[3], 35-49 year old mean = 2.41, and 65+ year old mean = 2.84). This implies that levels of satisfaction in using smart home devices and intention to use smart home devices in the future are correlated with age. Results for this measure were statistically significant at $p<0.05$.

In terms of experience of use, only 25% of 8–24 year old respondents have no experience of using smart home devices, compared to 34% of 35–49 year old respondents, and 39% of those aged 65 or over. This could be explained through the notion that aging is linked to decreased capability of learning, including learning to use a new technology [25]. Furthermore, 42% of 18–24 year old respondents and 41% of 65+ year old respondents have 2 years or more experience of using smart home devices. Results for this measure were statistically significant at $p<0.05$. This means that young people are an early adopter group, followed by older people, whom might have been not uniformly resistant but selective [26] in the smart home devices they have initially decided to try out.

3.3. Education

When it comes to education, we found that the less educated the population is, the less likely it is to hold favourable attitudes towards smart home devices (with the exception of when it comes to trust, see below). In our discussion, we refer to ISCED 0-2 as 'up to secondary education', to ISCED 3-4 as 'post-secondary education', and to ISCED 5-6 as 'tertiary education'. In regard to experience of use, there is a higher percentage of respondents with education up to secondary level (39%) with no experience of device use than respondents with the same experience and post-secondary and tertiary education (29% and 32%). Also, post-secondary and tertiary educated respondents (42% and 40% respectively) tend to have 2 or more years of experience than those with secondary education (34%). Results for this measure were statistically significant at $p<0.05$. We can explain this finding through the fact that educationally-enhanced cognitive abilities aid adaptation to change [27], including the change caused by new technologies. Consistent with this idea, we found that people with primary and secondary education levels are the group who have shown the least interest in smart home devices.

Of note is that fact that people with post-secondary education have been smart home's early adopters and the group that has adopted the technology the most over the past year, i.e. the early majority. This could mean that the adoption process has already passed its initial stages, hence people with tertiary education may have been, but are no longer, smart home innovators.

[2] Average level of agreement to satisfaction statement "I find that my smart home devices exceeded my expectations", where 1=strongly agree, and 5=strongly disagree. n=1422.

[3] Average level of agreement to intention to use statement "I intend to use or continue using smart home devices in the future", where 1=strongly agree, and 5=strongly disagree. n=2101.

We also found a positive correlation between levels of education and intention to use smart home devices in the future, (tertiary education mean = 2.37, post-secondary education mean = 2.41, up to secondary education mean = 2.68, see footnote 3). Results for this measure were statistically significant at a level $p<0.05$. Also, people with tertiary education report using more smart home device functionalities than other education groups (up to secondary education mean = 3.16, post secondary education mean = 3.04, tertiary education mean = 2.96; see Fig. 3). This suggests that future intention to use smart home devices may be linked to a more thorough and effective use of IoT. Our findings also suggest that people with tertiary education have the highest rates of satisfaction (mean = 2.85) as compared to people with up to secondary education (mean = 2.86) and people with post-secondary education (mean = 2.91) (see footnote 2). Findings for this measure were not statistically significant, however, more comprehensive use of IoT might potentially be linked to higher levels of satisfaction, in addition to future intention to use, as outlined earlier. This may suggest that the use of smart home devices is not as intuitive as the industry might wish.

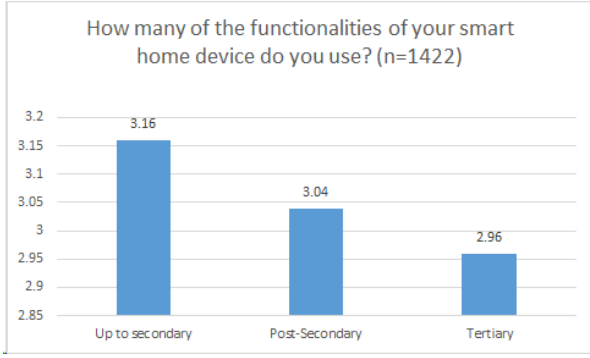

Fig. 3 Average amount of functionality usage according to Education (1=all of them; 5=none); *significant at $p < 0.05$

3.4 Trust

Finally, we measured trust levels across gender, age and education groups, and contextualised these results within levels of risk awareness. Overall, trust was negatively correlated with being female, particularly when it comes to trust in privacy, (females mean = 2.26[4], males mean = 2.31, where 1=strongly agree; 5=strongly disagree). This finding was not significant at $p < 0.05$. We found that trust in the integrity of smart home devices was positively correlated with age and education. Younger people and people with primary and secondary education levels were found to have more trust in smart home devices (18-24 year old mean = 2.84, 35-49 year old mean = 3.17, 65+year old mean = 3.40; up to secondary education mean=3.09, post-secondary education mean = 3.25, tertiary education mean=3.26; where 1=strongly agree; 5=strongly disagree). Results for this measure were statistically significant at $p < 0.05$ for both age and education.

Notably, higher levels of trust for younger and less educated respondents occur in the context of equally higher levels of security self-efficacy for these groups (Fig. 4), meaning that they feel more confident about understanding the security settings of their devices than older and more educated demographics. Results for this measure were significant at $p < 0.05$. For people with up to secondary education, who have the highest percentage of 'no experience of device use', this heightened confidence in security self-efficacy may be just related to lack of knowledge about security issues to IoT.

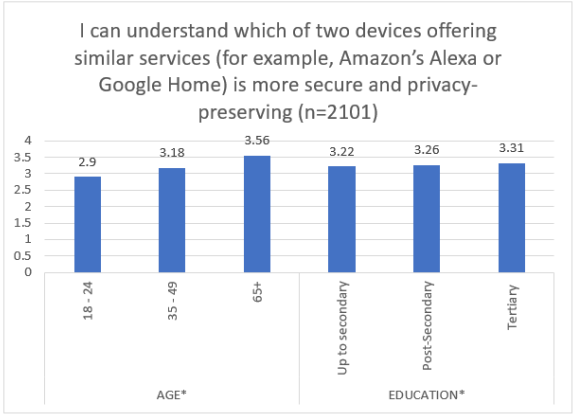

Fig. 4 Age and Education average agreement with security self-efficacy statement, (1=strongly agree; 5=strongly disagree).

To support this argument, we found that people with up to secondary education were found to be least aware of media reports of smart home security-related incidents (see Fig. 5). Results for this measure were significant at $p < 0.05$.

[4] Average agreement with trust statement "I think the likelihood of the security of smart home devices being compromised and resulting in a privacy/data breach is high", where 1=strongly agree, and 5=strongly disagree. n=2101.

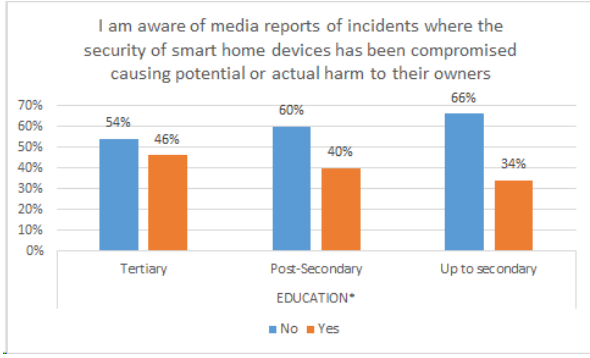

Fig. 5 Awareness of media reports of security-related incidents for the Education segment, n=2101.

Also, the higher levels of trust in smart home devices for younger and less educated respondents may be related to lower risk awareness of privacy issues. For example, there are more respondents aged 18–24 (33%) who are unaware of GDPR and its implications, than those aged 35–49 or 65 and over (both at 13%). (See fig 6). Furthermore, a lack of awareness of GDPR decreases with education (up to secondary education 20%, post-secondary education 18%, tertiary education 13%) (see Fig. 6). Results for both these measures were significant at $p < 0.05$.

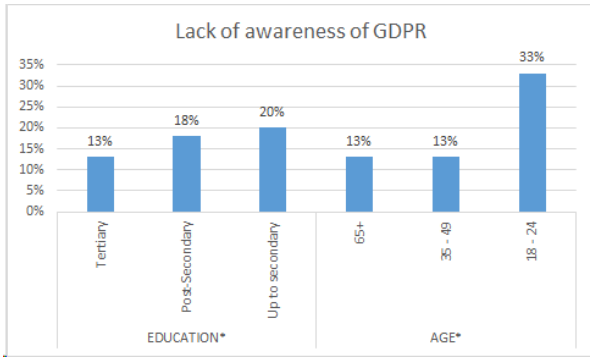

Fig. 6 Lack of awareness of GDPR for the Age and Education segments, n=2101.

4 Summary and Conclusions

Our results suggested that, despite the slightly more negative attitudes to technology, females are constituting smart home device's early majority of adopters, hence they may be more predictable smart home users in the years to come.

With regard to age, we found that younger people are more likely to hold favourable attitudes towards smart home devices and constitute the innovators/early adoption group. Older people have also been early adopters, however the rate of their adoption of smart home devices, and perhaps their interest, has more recently dropped.

Finally, we found that higher education levels correlate with favourable attitudes towards smart home devices and acceptability. People with primary and secondary education are the least interested in adopting smart home devices, and showed a lack of awareness of IoT security issues.

This research provides a rationale for new business models or policy interventions to level some of the social divides that have been highlighted through our analysis of the survey. Smart home devices may need to be designed such that their use is more intuitive, for example, to encourage greater functionality usage and related satisfaction of use; or IoT literacy campaigns might be targeted at the less-well educated members of the population to increase interest in using IoT in the future; or risk awareness campaigns may be launched to engage with those groups who are least aware of security and privacy issues. Interventions to increase trust levels in female users, or re-new male interest in a saturated smart home device market may also be required. For the IoT to be as useful to society as is hoped and promised, it is vital that the process of adoption is as inclusive as possible.

5 Acknowledgements

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