Exploring Social Acceptability and Expectations in Communal Use of Smart Home Devices

Research Report

Summary
This report documents an effort to explore communal use in smart homes with a factorial vignette survey based off a qualitative analysis of semi-structured interviews. While the highlights of the survey have been published previously [16], this paper reports on the full survey. Scripts to build and deploy the survey are available on GitHub. Note, that the survey was an early exploratory effort to get an overview of the space, and that this report is not peer reviewed.
On a personal note: This research was conducted in early 2018. As a result of an early analysis of the data, I decided to focus my research efforts on a more naturalistic perspective later that year. In 2019, I revisited the analysis to salvage any useful information [16]. This report documents the full data set and was written in 2020. It also highlights some of the shortcomings of the chosen approach and motivates a change of perspective (more on that in my PhD thesis). Young PhD researchers be encouraged that not every experiment or study will work out, but will offer a great learning opportunity.

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1 Introduction

In a previously published paper, we drew on a survey of domestic use of smart home devices to explore notions of social acceptability and expectations for different devices in different social situations. This report expands on our prior work [16] in two ways: (1) it provides more detail from participants' comments on previously reported data; and (2) it provides previously unpublished sections of the survey that make first steps towards understanding social norms around smart device use.

In the following, we first present our interview methodology and related findings; secondly, we briefly summarise our survey methodology and report on survey findings relevant to the revised teams; and thirdly, we discuss insights from interviews and the survey to unpack elements and to start laying out a research and design framework of communal use. We will conclude with implications from this scoping exercise that provide direction for focus and methodology of our subsequent studies.

2 Background

Prior work focuses on individual experiences, perceptions, and attitudes in relation to smart home technology use. Singh et al. [22] research individuals' perceptions and attitudes toward smart home technology. Their participants perceive benefits of comfort, safety, and improvement of life, but also raise concerns of autonomy and privacy. Forlizzi and DiSalvo [9] find some behavioural changes are intended or anticipated by participants, whereas other changes appear unintentional and incidental. The introduction of new technology challenges and changes traditional gender roles [13]. Hargreaves, Wilson, and Hauxwell-Baldwin [14] show how inhabitants negotiate the use of devices and navigate conflicts, while routines keep changing and evolving.

Some devices, like thermostats or home security systems, are designed for administration by an individual, while they provide functionality to all householders. Other devices were designed with a single user in mind, but are indeed used by many [11]. Members of communal settings establish their own ways to share resources and responsibilities; 'taking care of internet-connected devices' is consequently not a responsibility assumed by each user equally [7, 27, 19, 14, 11]. Different household members do not share the same attitude, knowledge, and preferences, but they use and manage technology in their own ways. These differences influence the use (or non-use) of technology and can lead to tensions between householders [14, 18, 11].

The use of ubiquitous technology in homes, then, is inevitably communal, requiring an understanding of individual and communal practices to design adequately [7, 4,

8, 27, 5, 6]. Future smart homes should empower inhabitants communally "to take an active part in controlling their set-up, evolution and destruction" [21]. We need to understand the intricate ways in which smart home technology can fit with communal everyday work practices [21, 25].

In our prior work [15], we explored technology use in the home, reporting on four themes. In *dealing with technology*, illustrated how people sought informal support within their social relationships, and how those providing support considered their own skill and expertise, and projected these considerations together with character traits and aptitudes on supportees. We similarly found that decisions and arrangements for *sharing personal devices* were rooted in these aspects. Although participants were less inclined to share devices considered personal (e.g., saying there were too individual), there were exceptions to this rule. Our findings also illustrated how *using shared devices* was deeply rooted in similar aspects, subject to the social nature of the home. We reported on smart home devices not necessarily designed for communal use but had communal impact; different household members developed different practices. Households coordinated using shared devices through implicit consideration of personal characteristics or negotiation of needs and demands. The last theme showed how accommodating for *guests and visitors* posed new kinds of challenge for smart home owners, and that the group of users in the home is a fluid concept.

3 The Survey

We sought to understand how the natural order of the home was reflected in participants' orientation towards *smart* (internet-connected) devices in the home, and which aspects and qualities of the home's social nature in light of a particular device would surface when participants encountered and navigated unfamiliar situations, not in isolation as an individual but in consideration of their social group.

3.1 Survey Development

Our goal was to elucidate decision-making in relation to social and technological facets of responsibility and etiquette around smart device use in the home. We aimed to relate participant situational preferences from the vignettes to demographic information and attitudinal differences. The relevant parts of the survey outlined below match with data points and insights in the previously mentioned themes: the social organisation of shared use between household members (Theme 3 '*using shared devices*' and sub-themes) and the coordination with the outside world (Theme 4 '*guests*

and visitors'). An overview of survey questions and related insights in relation to our revised themes can be found in the appendix (see Table 4).

As to what these social aspects and qualities ought to be, we used anecdotal evidence to inspire our vignettes: (i) responsibility for the home's infrastructure and the installation of devices or is shared by inhabitants (or landlords); (ii) people living in the home are to some extent responsible for the well-being of cohabitants; and (iii) they express feelings of duty of care towards visitors or guests coming to their home. When people visit each other's home, etiquette—specific to culture and social context—provides a framework for expectations and behaviour. As an example, people inform their guest about the customs of their household: Please use the downstairs bathroom; please take your shoes off; or—as one of our participants suggested— they will explain how to handle an unfamiliar smart home system; anecdotally, 'please don't use the light switches in kitchen or living room'; 'please don't play around with the smart home control'; and 'be aware, Alexa might be listening to you'. To get a better understanding of the prevalence and nature of 'etiquette' in this context, we took inspiration from the literature on norms from social psychology to explore the relationship between notions of appropriateness (personal normative beliefs and empirical and normative social expectations), factual beliefs and preference (the disposition to choose in a specific way all things considered [2]). In the wider context of Bicchieri's work, the belief/preference model ties into the theory of social norms, which is concerned with understanding motivations for collective patterns of behaviour ("why do people do what they do?"). The theory builds on the understanding that some patterns of behaviour stem from conditional preferences.

The survey (Table 1 and Table 4 in the Appendix) asked respondents for information on all their cohabitants (age, sex, occupation, relationship with the respondent) and which smart home devices they owned. To gauge attitudes toward internet-connected technology, we asked for respondents' agreement with value-laden statements from our interviews. The main survey had three parts: (A) unpacking the social context of roles and responsibilities in setting up and maintaining devices through five vignettes with different versions (factors included type of technology, the social relationship, and *physical location*; (B) three scenarios of problems with device usage asking the participant how they would solve adoption challenges; and (C) two scenarios to explore moral and normative aspects of disclosing the use of smart cameras and voice assistants.

Once the survey was designed inspired by this anecdotal evidence, three human-centred-computing researchers from our department commented on possible biases

Survey Outline

Context and Background

(i) Device Ownership – which of the following devices do you own?

(ii) Attitude – how much do you agree with each of the following statements?

(iii) Household – Please introduce your own household using nicknames for each person living with you

Part A – Social Context (aspects of roles and responsibilities, norms, skills and knowledge, character traits)

(i) (a) Who would configure the system?; (b) Are there other household members who could configure the system?; (c) How is the system going to be used?

vignettes: (1) system: security, lights, thermostat

(ii) Going on vacation – How should Peter and Paula arrange for house-sitting?;

vignettes: (1) social: friend, colleague; (2) aptitude: good/bad with technology; (3) distance: next door, across town

(iii) Choosing a house sitter – (a) How important are the following traits in choosing a house sitter? (b) Please rank the traits in importance.

vignettes: same as in (ii)

(iv) Adjusting smart home system – How would you recommend Grace and Oliver accommodate for their guests?

vignettes: (1) duration: weekend, week; (2) social: niece/nephew, mum/dad, close friends, colleagues

(v) Responsibility toward cohabitants – How important is it for them to make sure that adults in the house ...

vignettes: (1) devices: security, light, thermostat, voice assistant, television (2) social: partner, housemates, parents

Part (B): Adoption Challenges (attitudes and preferences)

(i) How can the inhabitants make the smart light system work?

(ii) What would you recommend them do to solve the problem with their smart vacuum cleaner?

(iii) What do you suggest John do to solve his problem with the smart socket?

Part (C): Beliefs and Social Expectations

(i) Informing about smart security cameras – (a) four sub-questions on (1) preference, (2) normative belief, and social empirical (3) and normative (4) expectation

vignettes: (1) social: close friend, colleague, neighbour, contractor; (2) placement: 2a. in the hall, the living room, and the kitchen; 2b. overlooking the garden, the driveway, and parts of the street

(ii) Informing about smart voice assistant – (a) Beliefs: How likely is each of the following statements to be true?; (b) four sub-questions on (1) preference, (2) normative belief, and social empirical (3) and normative (4) expectation

Table 1: Survey outline

and the order of questions before we deployed the survey, and one non-expert user completed a cognitive interview [24] of the deployed survey on LimeSurvey (face-validity). We started recruitment via Prolific Academic in May 2018. All our respondents were UK residents, and we collected demographic data using pre-screening filters. Answers below 10 minutes were considered speeders and filtered out. The average time to finish was 15 minutes.

3.2 Participants

3.2.1 Demographics

In the final data set, 40% of our respondents were 18-36 years old, 57% were 37-64 years, and 3% were above the age of 64; 52% of respondents identified as male and 48% as female. Our 850 respondents shared their homes with 1142 cohabitants – median household size of 2 (n=409).

3.2.2 Device Ownership

48.8% of households owned at least one internet connected device out of voice assistant, security systems, lights, sockets, thermostat, or vacuum cleaner (Table 2).

Table 2: Smart device ownership per participant and per device category

combination of different device categories (k) per participant (n)	devices categories (d) across all participants
k=0: (n=435)	
k=1: (n=238)	Voice Assistant (d= 269)
k=2: (n=106)	Lights (d= 143)
k=3: (n=047)	Thermostat (d= 126)
k=4: (n=016)	Sockets/Plugs (d= 74)
k=5: (n=005)	Security System (d= 60)
k=6: (n=003)	Vacuum Cleaner (d= 26)

3.2.3 Attitudes and Social Context

While our respondents mostly maintained a positive attitude towards internet-connected devices, they reported differences with their cohabitants. The majority of our respondents (82.1%) agreed with (b) being interested in understanding benefits and limitations, and 81.7% were (h) willing to use internet-connected technology to improve their lives (Figure 3.2.3). They disagreed with not wanting to use "wifi, computers, and so on" (89.3%). Respondents were split on internet-connected technology being

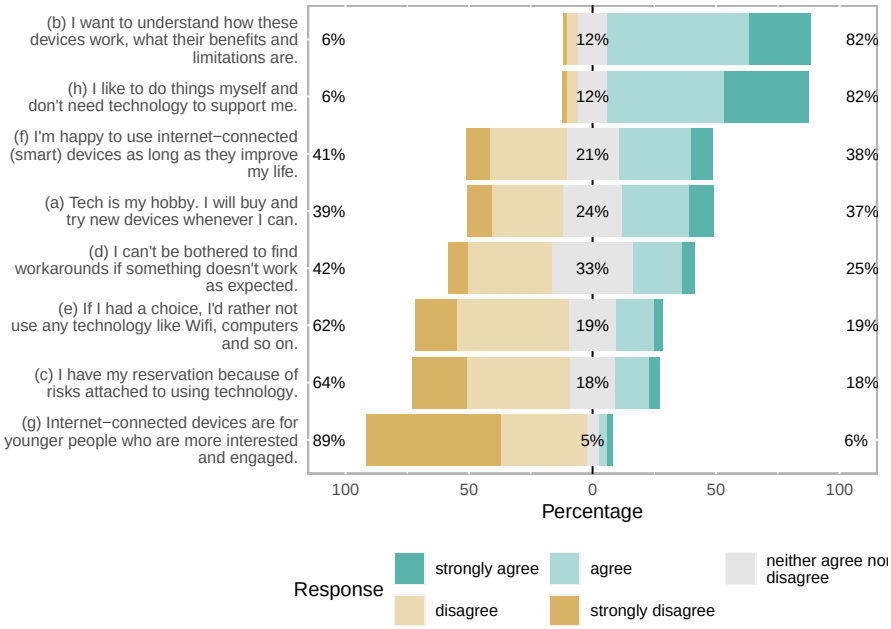

Figure 1: Agreement with attitudes among respondents

their hobby (38.7% disagreed) and on whether they had reservations because of related risks (40.8% disagreed).

We also asked our respondents for the single most fitting statement to describe the attitudes in their households. We split these statements by their sentiment in two groups to highlight the complexity of household attitudes: we consider (a), (b), and (h) to reflect interest and willingness to use technology (positive attitude) while (c), (d), (e), (f), and (g) represent caution and reluctance in some statements (negative attitude). About 76% of all respondents were open or maintained a positive attitude (b: 27%/h: 24%/a: 25% – see Figure @ref for labels) while the remaining 24% expressed some reservations. They considered their cohabitants less positive about devices (a/b/f: 53%) but more reserved (c/d/e/g/h: 47%). This lead to diverse attitudes among our householders. 63.08% of the 2-person households (n=409) shared a positive attitude, 28.85% an identical statement. Among our 3-person households (n=168), in 80.95% at least two inhabitants shared a positive attitude (25.6% the exact same); all three inhabitants shared a positive attitude in 36.31% (2.98% exactly the same).

3.3 Data Analysis

Because of the survey's exploratory nature, we included a comment field for every question in the survey except for Part C. Our first step was always to use descriptive

statistics on the question and to link this information with Thematic Analysis of participants' comments. For survey questions with different vignette versions (factorial vignettes), we took into account the influence of factors on comments[1]. Participants left a total of 749 comments across 9 questions (min. 34; avg. 60; max. 95).

3.3.1 Non-parametric tests

We use the Chi-Squared test as a measure of association between two n-dimensional, nominal, and independent variables. Similarly, we use the McNemar test with Cohen G as effect size for two-two-dimensional, nominal, dependent (paired) variables. The related effect size is Cramer's V. We use the Friedman Test to rank likert-style answers based on participants ratings, and we report Kendall's coefficient of concordance as corresponding effect size; and we use the Conover test with Bonferroni correction for post-hoc comparison of elements.

3.3.2 Parametric tests

In part C of the survey, we use logistic regression to test for effects of independent variables on the dependent preference variable 'would tell about device'.

3.3.3 Effect sizes

We adapt our reporting of magnitudes of effect sizes for behavioural sciences from [3]: (< 0.3) weak; $(0.3 - 0.7)$ medium; and (> 0.7) strong.

4 Results

4.1 Assuming Responsibility

Includes insights from Parts A and B of the survey as they pertain to power dynamics, responsibilities, and relationships in the home.

4.1.1 Attending new systems

The survey comments resemble notions from our interviews on considering personal characteristics for sharing. Respondents' considerations included the nature of the system itself, the ability, and the aptitude of individuals. In fact, often more than one inhabitant was considered able to set up the system: "I would want to be responsible for setting up the system. Although my son would be equally capable and wanting

[1] After all, we are approaching this research from a pragmatist, relativist stance

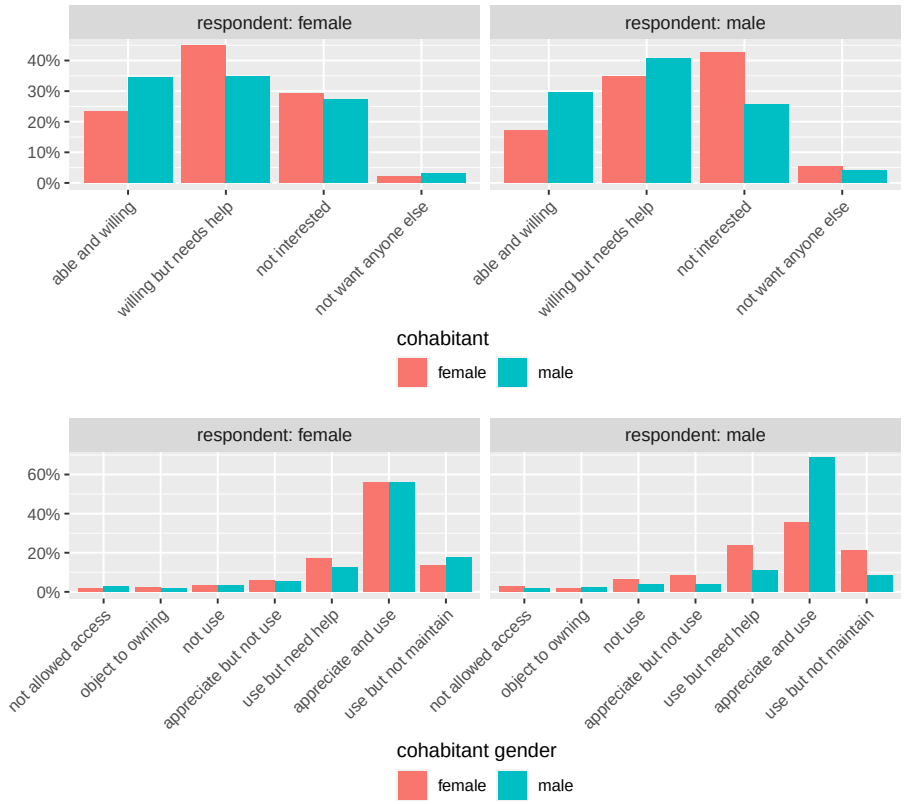

Figure 2: Gender perceptions of system configuration and use

to do it." (PS-716). The majority (62.7%) of our respondents would set up an internet-connected system (lights, thermostat, or security system) themselves or would trust close family members with the setup (25.5%).

Among those setting up systems were 40.5% male and 35-64 years old, of which 63% were respondents and 33% cohabiting family members. The majority of *other* cohabitants were considered willing to attempt the configuration (25.7% equally able and willing / 38.5% willing but needed help). Most of these people were female and immediate family members; and younger people were generally perceived as more able and willing than middle-aged cohabitants.

4.1.2 Usage expectations

There was a general expectation that people would find ways to make use of a system, and if individuals should struggle respondents trusted in the individual ability to overcome issues, and sometimes they suggested strategies that could support those struggling. These findings are supported by prior research. For example, Zeng, Mare,

and Roesner [27] report on an instance where cohabitants were excluded from access to the heating management because of disagreements, and Hargreaves, Wilson, and Hauxwell-Baldwin [14] illustrate challenges of learning how a smart home system works.

The more, the better Our respondents expected most of their cohabitants to make use of an internet-connected system. Comments like "the more i use the system the better; i and others would get use to it" (PS-793) revealed thoughts on administrators' role and ability in helping others getting used to a system; and indeed most inhabitants would use a system (85.6%). The majority of 70.0% was considered able to use a system independently (15.7% with help only), and the majority of those considered not interested in configuring a system in the first place (31.5%), was anticipated to use the system later on (60.2%).

Gender effects in perceived attitude and aptitude A closer look at questions (A.i.b+c) suggested this expectation was influenced by the respondent's and the cohabitant's gender (Figure 2). Females were considered less able and willing to configure a system by male than by female respondents. In turn, male respondents considered their male cohabitants more likely to be self-sufficient in using the system than their female cohabitants, while female respondents considered their male and female cohabitants equally self-sufficient. According to our female respondents (24.12%), female non-administrators were more capable and willing than according to our male respondents (17.24%); and female non-administrators were more likely to be willing but needing help in the eyes of our female respondents (44.73%) than in the eyes of our male respondents (35.64%). According to our male respondents, female non-administrators were more likely to be not interested (41.95%) than according to our female respondents (28.95%).

'Old habbits die hard' Respondents expected cohabitants to make some efforts in adapting to a new system (Figure 4 and Figure 3), some assuming they agreed to obtaining the system in the first place (per the comments). It was the cohabitant's responsibility to learn use of the system – the economic value of the system was mentioned in some comments explicitly to this extent. Others suggested talking to the individual for guidance and considering their aptitude and competence when doing so. If any of these systems would not work for their partners, some comments suggested getting rid of them entirely.

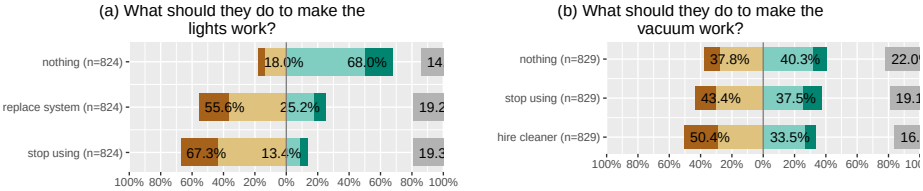

Figure 3: Inhabitants struggle to make use of smart systems. The smart light system in (a) requires not to use existing wall-mounted light switches but other means (e.g. smart phone app)—Friedman, Kendall W ($X^2(4, N = 824) = 325.77, p < 0.001; W = 0.099$) – post-hoc conover test significant ($p < 0.001$) for all group wise comparisons; and the vacuum cleaner in (b) only works if the floor is kept tidy—Friedman, Kendall W ($X^2(4, N = 829) = 382.66, p < 0.001; W = 0.115$) – post-hoc conover test significant ($p = 0.005$) for 'all group wise comparisons 'nothing'/'stop using' over 'hire cleaner'

When introducing new smart technologies to the household, old habits could challenge the adoption of new technology (Figure 3). Habits of using light switches were believed to be changed more easily ((a) nothing 68%) than those of cleanness ((b) nothing 40.3%); and respondents agreed more with stopping to use a vacuum cleaner (37.5%) than smart sockets (13.4%).

Through their comments, our respondents suggested a number of different strategies including role modelling and training, communicative approaches, and, what is effectively, forcing the use of the system ("Educate the Muppet that can't get it right" (PS-1184)). Many comments suggested to mark existing light switches as not to be used by displaying instructions or fixing the switch in "on" position. Others offered to train users, and to designate a person that could be in charge of training. Another, much less mentioned, solution could be to sit down and discuss the issues (mediation).

> Personally i would have made sure that this situation didnt arise. if one was left at home then i would suggest he asks his partner who is out of the house to put the lights on remotely and then to download the app so that he could do it himself in future (PS-770)

> The perfectly adequate switching system with switches in each room is fully functioning but the others want to play with remote control devices instead of raising one hand and using one finger once in a while. When you enter a dark room, turn the light on. When you leave switch it off. Simple. Anything else is superfluous and as the scenario shows, potentially confusing and counterproductive. (PS-1158)

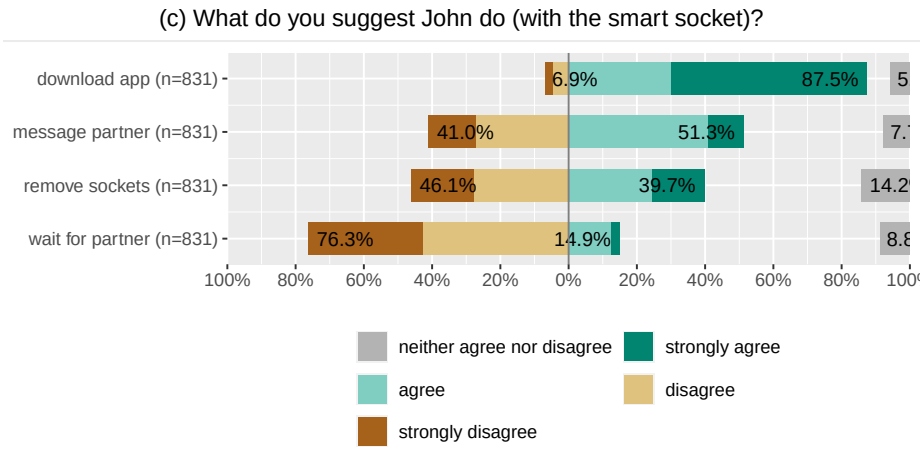

Figure 4: A light is plugged into a smart socket which requires the use of an app. Respondents recommend downloading the app over messaging the partner, removing the sockets, and waiting for the partner to return—Friedman, Kendall W ($X^2(4, N = 831) = 298.21, p < 0.001; W = 0.09$) – post-hoc conover test significant ($p < 0.005$) for all group wise comparisons

These findings corroborate with Geeng and Roesner [11] who find that smart home drivers are ordinarily man, gaining power and agency through their technology work. Strengers et al. [23] support this sentiment by highlighting that many of the technology drivers are hobbyists and mescaline identifying. However, Rode and Poole [20] suggest that men and women are co-constructing the gender and technical identities, and that "digital chivalry" does not imply competence; they similarly illustrate situations in which women decide not to show high levels of self-efficacy. These insights are likely to affect our findings reported above.

4.2 Being Responsible

4.2.1 Relationships and hierarchies

More specific relationship deliberations included: *Keeping on par* – *Partners* should generally consult each other on matters of new devices while sharing access to any existing device; and all items (see Figure 5) ranked high (>75% agreement) across all technologies with almost no significant differences. *Being considerate* – Respondents presented with the *housemates* scenario challenged whether devices were shared by emphasizing the importance of location (shared or private area). Respondents commented, regardless of their location, it was “courtesy to consult” (PS-817) flatmates on issues they could be affected by to avoid “violations of trust” (PS-835); housemates shared “responsibilities and costs” (R61). Particularly, voice assistants and television

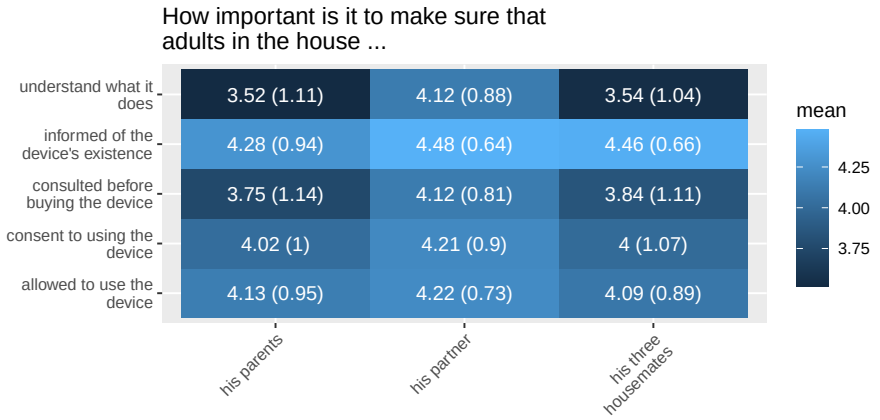

Figure 5: Mean (standard deviation) of agreement with steps to introduce a smart voice assistant to the household when living with parents, partner, or three housemates. Results show importance of informing everyone whereas opinions on need to be accountable to parents and housemates vary more than for partners

required consideration of location as an indication to whether these devices were shared or not. There seemed to be uncertainty whether and to what extent the smart voice assistant in the scenario was a shared device (54.3% agreed and 33.3% were uncertain whether to allow use). *Being responsible* – These considerations were amplified in the *parents* scenario with stronger expressions of preference. Respondents expected individuals to involve their cohabiting parents closely in the procurement of any security, light, or thermostat system (>75% agreement for all items). In case of security and light systems, it was impossible to operate them without parents' approval. Strong comments surfaced in relation to voice assistants and referred to discomfort with the devices' presence due to privacy concerns, in one comment explicitly linked to the respondents' responsibility as a parent. The comments and scores suggested television (63.3% allowed use) and voice assistant (51.3% allowed use) could also be personal devices, and parents did not need to be allowed access.

These findings corroborate with insights from prior research revealing strong moral imperatives with regards to managing shared technology in the home [12], and our participants comments are partly resembling Garg and Moreno [10] participants' considerations of appropriate placements; and also Lau, Zimmerman, and Schaub [17] suggestions of consulting cohabitants on the use of voice assistants.

4.2.2 Balancing needs and demands

Respondents considered trust and respect—explicitly or implicitly through established close relationships—as qualities of relationships; they referred to ability and skills

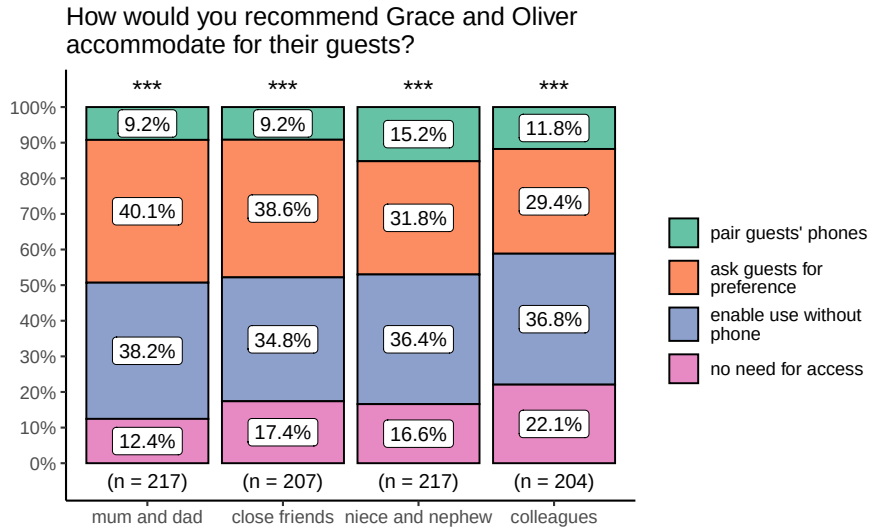

Figure 6: Overview of vignette SC25 for different social relationships (length of stay aggregated). Respondents were asked to recommend adjustments for a smart home setup that relied on inhabitants' phones for control and information.

when sharing access to internet-connected devices with their guests. Some explicitly highlighted the need to balance obligations of hospitality with their own security and privacy needs by considering responsibility and trustworthiness in their guests (Figure 6).

In this scenario (Figure 6), some features of a smart home system relied on inhabitants' phones for control and information. The owners considered adjustments to accommodate for their guests. Respondents were most likely to "strike the balance" by enabling the system for use without a phone (36.57%), followed by asking guests for their preference (35%); 17% thought there was no need for access, and 11% agreed to pair their guests' phones. Respondents preferred *colleagues* not to have access to their systems (58.9%). The comments showed different attitudes, ranging from disapproval of having to make any adjustments ("none of this should be necessary" PS-734) to considerations of tech-savviness and system security ("giving access might compromise security" PS-436). As relatives, *nieces and nephews*, "shouldn't be held responsible" (PS-315) or be burdened with the system. While the younger relatives were considered tech-savvy enough to handle the system, respondents expressed concerns with regards to responsible use: They were not old enough to be trusted (PS-359). Respondents suggested implementing guest features for longer stays so that the system could be adjusted while security was maintained. While more likely to pair their phones

(15.2%) or ask for their preferences (31.8%), most respondents preferred adjusting the system (36.4%). *Close friends* should not be bothered, and a balance between being polite and needs of security had to be found ("educate them and adjust" PS-809). One respondent commented that "asking for preference was mindful of guests privacy" (PS-637). *Parents*' needs were more important than the inhabitants', and the preferred way to accommodate them depended on what they were comfortable with [26].

> My daughter and her husband are both IT specialists so have a very automated system.. they control a lot of things via their phones and internet but if anything doesn't work as expected then I ring her or she rings me frequently anyway and I can override the controls and reset the heating etc manually .. *I am shown how to do this and have a book with instructions* in for all aspect of household management. When they are in America on holiday it I could be there for a month and have not had any problems so far as the equipment is reliable (PS-1209, emphasis added)

Some of the recommendations considered tech savviness of guests, but also a need to keep parts of the home secure and private. 40.1% recommended asking the parents for their preference, closely followed by 38.2% recommending to enable the system to be used without a phone. While privacy issues surface and are somewhat recognised (see norms), they are not very salient when considering other's use of a system – less than 5 comments included the word 'privacy'.

4.2.3 Relying on other people

Priority of protecting home The general consent across all vignettes was that internet-connected technology could add another layer of security to the home (Figure 7), and therefore using remote monitoring in addition to asking a trusted person would be better (>68%); and further comments pointed out asking a friend in addition might be useful in case technology failed. Opposing this view of added security, respondents' comments were in disagreement whether using remote monitoring could provide peace of mind or would undermine the quality of vacation when checking the phone too many times. Though, this was overpowered by the intention of most respondents to use the system.

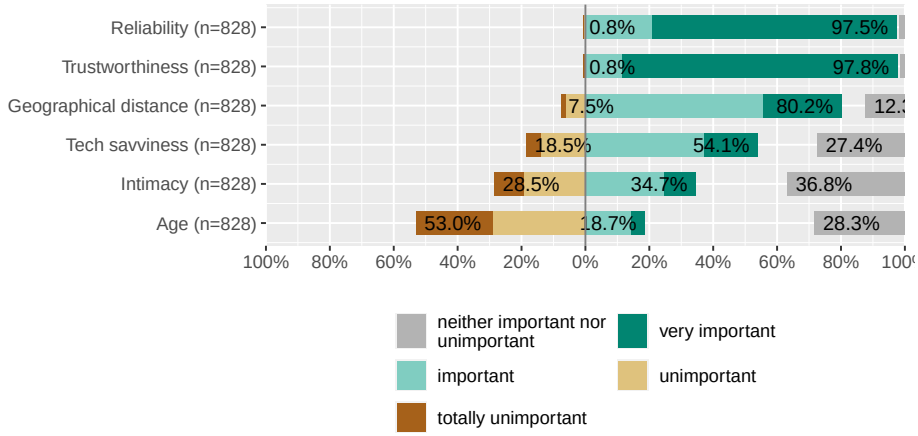

Figure 7: Importance of factors when choosing a house sitter. A Friedman test with Kendall W for effect size revealed significant difference between ratings for factors considering effects of raters ($X^2(5, N = 828) = 2489.9, p < 0.001; W = 0.602$). A post-hoc conover test showed significant differences (p<0.005) for all group wise comparisons. A separate ranking question confirmed the order of items with the same significance.

Don't burden people Participants also pointed out that the complexity of the system could cause some issues, in case Anna (the housesitter) was required to use the system – one of them assumed the system would be reasonably easy to use and therefore should not cause complications. They provided solutions for different situations, e.g. the housesitter could be asked not to touch the system—if there was a need to mention the system in the first place. Others suggested educating the house sitter about the system.

Not fair to ask On the other hand, some people felt it was inappropriate to ask a housesitter that was potentially unfamiliar or uncomfortable with using technology to take over responsibilities that required usage of technology. They did not want to overburden someone in such a situation. One respondent mentioned effects on the housesitters privacy about which they should be informed.

Although participants considered technology aptitude (being good vs. being bad) in answering the question ($X^2(3, N = 845) = 11.459, p = 0.009; V = 0.116$), it was not a primary concern (Figure 7); if a lack of aptitude should cause problems, they suggested strategies to overcome it. There was overwhelming agreement among respondents that reliability and trustworthiness (PS-1240 "trust is the key") were the most important factors, followed by geographical distance, tech-savviness, intimacy, and age (Figure 7). Although being considered as the least important, age could also

be seen as an indicator for maturity and the agency to handle any kind of problems as they arise, and in some cases also as an indicator for tech-savviness.

> If a person is very old or young, they might struggle with any problems that arise from either the tech or with making decisions if there is a burglary or other problem, so while geographic location is quite important, it is less so than age. (PS-214)

However, tech-savviness was generally seen as more important than age and intimacy, although some respondents hoped the system wouldn't require much interaction. "If the person is tech savvy then age shouldn't come into it" (PS-639)

4.3 Appropriate Conduct

Apthorpe et al. [1] explored privacy norms were not home devices using a factorial vignette survey and building on contextual integrity. Their survey of 1731 American adults comprehensively reports on factors impacting an individual's perception of privacy norms. We were interested in understanding how perceived social obligations could lead to social action. Related uncertainties of whether "being a good host" or "responsible individual" required smart home device owners to disclose beliefs were discussed by our interview participant (PI-032) and also explicated by some of our survey respondents' comments.

To understand normative and structural effects on disclosure preference, we applied logistic regression. Our variables include the outcome variable ("tell about the …" [No:0, Yes:1]) and normative belief ("it's right to tell" [No:0, Yes:1]), empirical expectation ("most people would tell" [No:0, Yes:1]), and normative expectation ("most people think it's right to tell" [No:0, Yes:1]) as independent variable. We further included demographic variables age [18-34, 35-64, 64+], sex [female:0, male:1] and device ownership of a range of smart devices (lighting, thermostat, security system, socket, voice assistant, vacuum cleaner) [ownership per device – no: 0, yes: 1]. As reference points and to explore the emerging influences of social and technological factors, we asked these questions in two different scenarios of disclosing the existence of devices to visitors:

- *smart security cameras* (Table 5) – additional independent variables included location [outside: 0, inside:1] and social relationship [contractor, neighbour, colleague, close friend] installed to either overlook areas inside or outside the house to be disclosed either of close friend, colleague, contractor, or neighbour

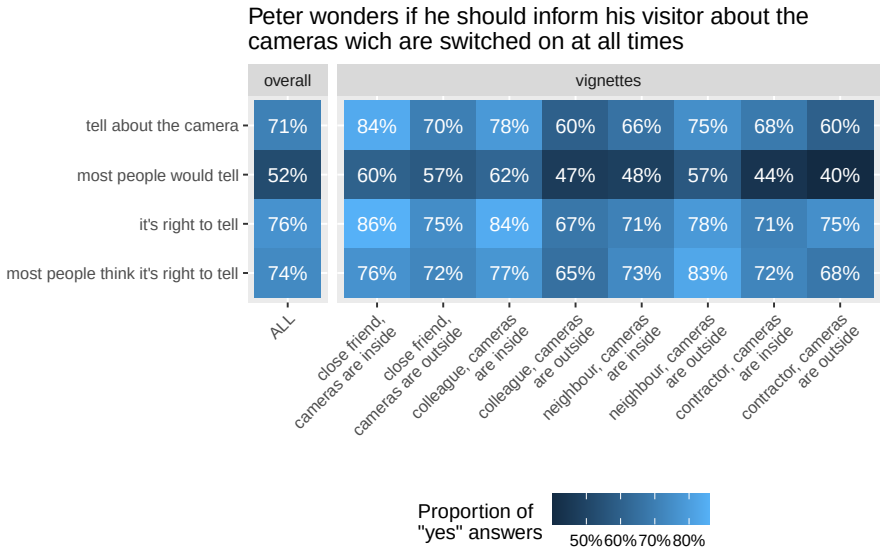

Figure 8: Respondents' believes with regard to appropriate conduct. All subquestions (y axis) had to be answered with either 'yes' or 'no'. The heatmap shows the proportion those answering 'yes'.

- *smart voice assistant* (Table 6) – additional independent variables included four belief questions answered on a 5-point scale for agreement: the voice assistant (i) 'only listens when talked to'; (ii) 'lessons but Amazon would not be interested'; (iii) 'what harm could it do'; and (iv) 'that is a reasonable thought'

4.3.1 Security Cameras

Across all vignettes in the camera scenario (Figure 8), about three out of four people said they would inform about the camera (71%), believed it was right to do so (76%), and also believed that most people thought it was right to (74%). However, they did not actually trust most people to tell (52%). About half of all respondents (49%) agreed with all four sub-questions, indicating they perceived a social obligation on which they preferred to act.

Our analysis (Table 5) showed the preference to tell a guest about the camera was positively associated with the expectation that most people would do the same ($p<0.001$; OR: 27.1; CI 95%: 11.4, 74.6) and the normative belief that it is right to inform people ($p<0.001$; OR: 538; CI 95%: 176, 2065); effects of social normative expectations were weak (*$p=0.052$*; OR: 0.41; CI 95%: 0.16, 0.97) People aged between 35 and 64 were significantly more likely to inform others than people aged 18 to 34 ($p=0.014$; OR: 2.32; CI 95%: 1.20, 4.63). There was no significant effect of gender. Interactions between

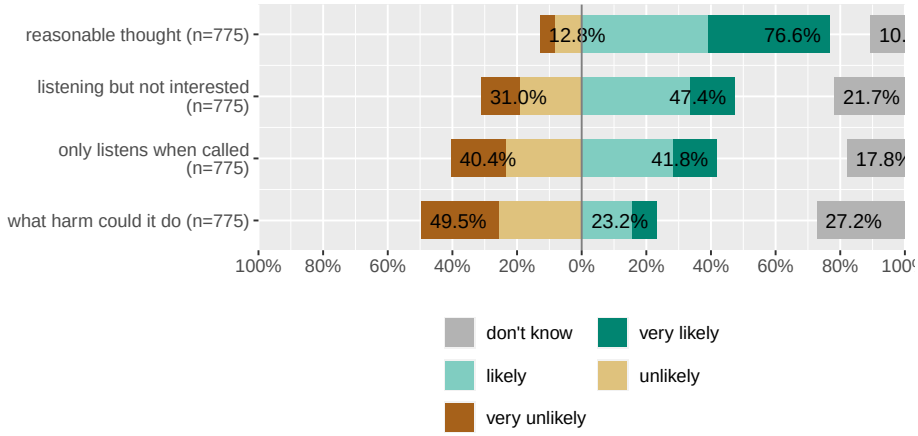

Figure 9: Likelihood of each of the following statements on *a smart voice assistant listening at all times* being true—Friedman, Kendall W ($X^2(3, N = 775) = 425.4, p < 0.001; W = 0.18$) – post-hoc conover test significant ($p < 0.005$) for all group wise comparisons

vignette factors (baseline *contractors outside*) showed that people were significantly more likely to mention inside cameras to contractors than outside (p=0.019; OR: 5.05; CI 95%: 1.39, 21.1); they were more likely to mention outside cameras to neighbours than to contractors (p=0.014; OR: 2.32; CI 95%: 1.20, 4.63); and they were significantly more likely to mention inside cameras to a friend (p=0.019; OR: 5.05; CI 95%: 1.39, 21.1). There were no effects of device ownership.

4.3.2 Voice Assistant

A majority of our participants agreed that smart voice assistants might be listening at all times (Figure 9). As to what the implications of that possibility could be, there was much less agreement; though, many felt it was potentially harmful.

Scores for voice assistants were significantly lower (Figure **??**). Only two out of three people intend to disclose the presence of the voice assistant, and the same number thought it was right (66%). significantly less believed most people would tell (53%) and that most people thought it was right to tell (57%). Overall, 44.68% of all participants perceived a social obligation to disclose the voice assistant. There were significant effects of social empirical expectation (p<0.001; OR: 24.9; CI 95%: 12.6, 52.5) and normative beliefs (p<0.001; OR: 32.7; CI 95%: 16.8, 67.1), and there was no significant effect of the belief questions (Table 6).

However, there were some effects of device ownership (Table 3). While owning smart lighting (p=0.014; OR: 0.33; CI 95%: 0.13, 0.79) or thermostats (p=0.003; OR: 0.26;

CI 95%: 0.1, 0.62) had a negative effect on disclosure preference, owning a security system (p=0.009; OR: 4.3; CI 95%: 1.45, 13.2) or voice assistant (p=0.033; OR: 2.22; CI 95%: 1.08, 4.7) had a positive effect on disclosure preference.

4.3.3 Comparison

We can assume that people who agreed with all four sub-questions would say a social norm exists. In the camera scenario, more respondents agreed with all four subquestions (49.08%) than in the voice assistant scenario (44.68%), and normative beliefs had much stronger effects than for voice assistants (Table 7). This suggests a difference in perceived social obligations between cameras and voice assistants. Reducing both scenarios to the same independent variables (cameras/voice assistant inside and disclosing to a close friend), our analysis (Table 3) suggests that there is indeed a more widely adopted understanding of appropriate behaviour around cameras than voice assistants.

	camera | voice	No	Yes	Significance Test
(1) It's right to tell	No	63.64	36.36	*
	Yes	24.36	75.64	
(2) Most people think it's right	No	75	25	***
	Yes	34.78	65.22	
(3) Most people would tell	No	70.59	29.41	*
	Yes	38.18	61.82	
(4) I would tell	No	61.54	38.46	***
	Yes	31.58	68.42	

Significance codes: 0 '***', 0.001 '**', 0.01 '*', 0.05 '.' 0.1

McNemar's Chi-Squared Test
(1) $X^2_{McNemar}(1) = 9.78, p = 0.002; \widehat{g}_{Cohen} = -0.33, CI_{95\%}[-0.49, -0.16], n_{pairs} = 89$
(2) $X^2_{McNemar}(1) = 12.45, p < 0.001; \widehat{g}_{Cohen} = -0.33, CI_{95\%}[-0.47, -0.18], n_{pairs} = 89$
(3) $X^2_{McNemar}(1) = 3.90, p = 0.048; \widehat{g}_{Cohen} = -0.18, CI_{95\%}[-0.35, -0.01], n_{pairs} = 89$
(4) $X^2_{McNemar}(1) = 12.45, p < 0.001; \widehat{g}_{Cohen} = -0.33, CI_{95\%}[-0.46, -0.19], n_{pairs} = 89$

Table 3: Comparison of perceived social obligations to disclose the presence of cameras or voice assistants to friends who come to visit one's home.

Apthorpe et al. [1] suggested that greater exposure to smart home devices will increase acceptability of information flows around the device, and reported smart device ownership (one or more devices) had positive effect on acceptability. Our findings cautiously suggest that exposure to devices (or maturity of device categories) also has an impact on perceptions of social obligation and possibly action; novel and

immature products bring about greater uncertainty as to what constitutes appropriate behaviour. Furthermore, the effects of particular kinds of ownership attest to the complexity of exposure, in that those of our participants not having been exposed to voice or video interfacing devices, but other smart home devices were less inclined to disclose the presence of a voice assistant than vice versa.

5 Limitations

We report on participants' self-reported behaviour and participants' observations of other household members[2]. These other household members might hold different perceptions of these practices. While this allowed us to also learn about participants' preferences, goals, and motivations, further observational research is needed. ethnographic study of home technology use can help verify and expand our findings.

We studied technology use with an online survey and by recruiting from an online platform. Our results confirm that our respondents are rather technology astute. Secondly, our results are exploratory, and confirmatory follow-up studies would be needed to assess the replicability of specific findings. Thirdly, we excluded "prefer not to say" as answer option from the presented results, leading to smaller sample sizes.

Our findings might also have been influenced by social desirability biases when asking about recommendations for problem-solving and appropriateness of actions. Given the exploratory nature of this work, we acknowledge these limitations and suggest the use of normative and best friend techniques for future work.

The survey consists of three almost distinct sections that explore attitudes, planned behaviours, and expectations. These sections are not interlinked or interlink-able (as the futile efforts in the Appendix 7.3 show). However, our findings yield interesting and promising insights, suggesting more deeply exploring any one of these sections in future research might worthwhile.

The survey design is much more inspired than empirically grounded in qualitative data from a previous study (see 7.1 and 7.2). Hence, this survey was purely and fully exploratory in nature. More theorising based would be necessary and can be the foundation of a thematically-informed, confirmatory survey in the space of communal use and the smart home.

[2]We interviewed two couples as separate individuals to get both their perspectives.

6 Concluding Remark

This report has merely illustrated attitudes, expectations, and planned behaviours. In other words, what might be happening in terms of situated and socially embedded communal use of smart home devices.

Among the insights, notions of acceptability and responsibility are the most interesting aspects from a communal perspective. To understand how communal use is embedded in the social nature of the home, how it evolves, and how acceptability and responsibility are socially co-constructed by household members and others outside the home, more research is needed. Because of the complexity of the problem space, we suggest reducing technical and social variety by focussing a few of smart (internet-connected) *off-the-shelf devices* and plan on deploying them to families as part of a 6-months ethnographic interview study.

APPENDIX

7 Exploring communal technology use in the home

7.1 Allocation by Theme

- Theme 1 Dealing with Technology–Old and New
  - *(A.i) Device Usage – roles and responsibilities of configuration and use*
- Theme 2 Sharing Personal Devices
- Theme 3 Using Shared Devices
  - Theme 3.1 Navigating communal use
  - Theme 3.2 Usage Practices
  - Theme 3.3 Managing failure
  - Theme 3.4 Considering Cohabitants
    - *(A.v) The Acceptance Factor – negotiating device procurement and intended usage in social context; importance of involving others in process through*
    - *(B.i-iii) Adoption Challenges - shoe-horned, life-styled, limited: navigating the user/social and technical contexts of adoption*
- Theme 4 Guests and visitors
  - *(A.ii, iii.b+c) Using Home Security Systems – impact of a smart security system on social relationships and agency: preference of having a house sitter and/or remote monitoring*
  - *(A.iv) Hospitality – accommodating guests and trade-offs between social and technical contexts: adjust system to follow social norms (allowing access or not inconveniencing others)*
  - *(C) Beliefs and Expectations – Exploring responsible disclosure in terms of social norms and mental models of smart security cameras and voice assistants*

7.2 Survey Outline

Table 4: Survey outline and grounding

Topic	Outline	Type	Vignettes	Theme Allocation Key takeaways
Context and Background **Participant and household demographics**				
The Smart Home	Consent form for participants	Check boxes	n/a	n/a
(i) About Smart Homes	Primer to educate people about smart homes – we introduce device briefly in so far relevant for the survey	none/ informative	n/a	n/a
(ii) General Attitude	General attitude – with regards to internet-connected devices in the home extracted from interviews Items: hobby, interested, younger people, independent, benefit, cautious, technophobe, utility/opportune	5-point likert for agreement	none	***Methodology*** - participant demographics
(iii) The Household	Household social structure – who (age, gender, profession, relationship, attitude) is living in the household; add a line for each household member	text/ drop-downs	n/a	***Methodology*** - participant demographics
(A) Social Context **Roles/responsibilities, relationships, norms, skills/knowledge, character traits**				
(i) Device Usage - internal	Social structure: responsibilities/roles and system life-cycle (1) who takes over responsibility of configuring the system, (2) who else could configure the system, and (3) how will these systems be used by all residents	single choice comment	(1) devices: lights, security, thermostat	***Theme 1*** dealing with technology old and new setup is family business males are administrators gender effects—perception of females struggling the more the system is used, the better
(ii) Using Home Security Systems - external	Norms, relationships, agency and tech knowledge—impact of a smart security system on social relationships and agency: preference of having a house sitter and/or remote monitoring Choices: ask/don't monitor, don't ask/monitor, ask/monitor, none	single choice comment	(1) social: friend, colleague (2) geographic distance: next door, across town (3) skill: good / not good with technology	***Theme 4*** guests and visitors belt and braces (more is better) piece of mind vs independence don't burden people not fair to ask
(iii.a) Using Home Security Systems - external	Relationships and character traits – values of social relationships pertaining to device usage: how much do people value which character traits when delegating device usage in social context Factors: trustworthiness, reliability, intimacy, geographical distance, tech savviness, age	5-point likert for importance comment	Same as (15 SC)	***Theme 4*** guests and visitors trust is key, tech-savviness is important (more than age)
(iii.b) Using Home Security Systems - external	Relationships and character traits (cont'd) – values of social relationships pertaining to device usage: how people rank the importance of character traits	Ranking 6 factors from (17 SC)	Same as (15 SC)	

Table 4: Survey outline and grounding

Topic	Outline	Type	Vignettes	Theme Allocation Key takeaways
	Ranking: Trustworthiness, reliability, intimacy, geographical distance, tech savviness, age	comment		
(iv) Hospitality - external	Norms, relationships, and tech knowledge – accommodating guests and trade-offs between social and technical contexts: adjust system to follow social norms (allowing access or not inconveniencing others)	Single choice	(1) duration: weekend, week	***Theme 4*** guests and visitors
	Choices: adjust for non phone use, pair phones, leave choice to guests, no need to give access		(2) social: niece/nephew, mum/dad, close friends, colleagues	responsibility and trustworthiness
		comment		– balancing security and privacy with hospitality (ease of use, comfort), and showing trustworthiness by allowing access; prioritisation of others' needs » training/coaching privacy salience – not a lot
(v) The Acceptance Factor - internal	Accountability & communication – negotiating device procurement and intended usage in social context; importance of involving others in process through	5-point likert for impor-tance	(1) devices: security, light, thermostat, voice assistant, television	***Theme 3.4*** considering cohabitants
			(2) social: partner, housemates, parents	keeping on par; being considerate; being responsible;
	factors: understanding/explaining, consulting, agreeing/consenting, allowing use, informing about existence	Ranking of factors		
		comment		
	(B) Adoption Challenges **Attitudes and preferences**			
(i) Smart Lights	shoe-horned, life-styled, limited: navigating the social and technical contexts of adoption Choices: Replace original system, wait to get used to it, stop using it	5-point likert for agree-ment comment	none	***Theme 3.4*** considering cohabitants old habits die hard role modelling and train-ing strong sentiments surface (comments)
(ii) Housekeeping	Adoption challenges (cont'd) - shoe-horned, life-styled, limited: navigating the user/social and technical contexts of adoption Choices: Replace original system, wait to get used to it, stop using it	5-point likert for agree-ment comment	none	- expectation of efforts by cohabitants (sunk costs)
(iii) Light Systems	Adoption challenges (cont'd) - shoe-horned, life-styled, limited: navigating the user/social and technical contexts of adoption	5-point-likert for like-lihood	none	

Table 4: Survey outline and grounding

Topic	Outline	Type	Vignettes	Theme Allocation Key takeaways
	Choices: message partner, download app, remove sockets, wait	comment		
	(C) Beliefs and Social Expectations **Mental models and social norms**			
(i) Smart Security Systems 17	Social norms – attempting social understanding of the right and wrong (norms) Questions: would you tell, think it's right to tell, most people would tell, most people think it's right to tell	Yes/no 4-questions - social norms	(1) social: close friend, colleague, neighbour, contractor (2) location: hall/living room, garden/ driveway/ parts of the street	***Theme 4*** guests and visitors appropriateness, factual beliefs, and preferences - generally association of preference with normative belief and social expectation čameras (more prevalent than voice) - desire to ground appropriateness in familiarity grounded in social relationships - more prevalent among middle-aged people v̌oice assistant - no association of disclosure with beliefs - association with normative belief and empirical expectation - device ownership associated: lights and thermostat negative
(ii) Social Norms - Smart Voice Assistant	Mental model and social norms – what is peoples' perception of smart voice assistants, and how does that relate to social norms? Options 5 likert: Alexa only listens when called, listens but Amazon not interested, what harm could it do, reasonable thought that it's listening Norm questions: would you tell, think it's right to tell, most people would tell, most people think it's right to tell	5-point likert for like-lihood Yes/no 4-questions - social norms	none	security and voice positive

7.3 Regression Models

7.3.1 Smart Security Cameras

Characteristic	OR[1]	95% CI[1]	p-value

Most people would tell			
No	—	—	
Yes	27.1	11.4, 74.6	**<0.001**
It's right to tell			
No	—	—	
Yes	538	176, 2065	**<0.001**
Most people think it's right			
No	—	—	
Yes	0.41	0.16, 0.97	*0.052*
Age			
18-34	—	—	
35-64	2.32	1.20, 4.63	**0.014**
64+	7.55	0.52, 153	0.2
Sex			
female	—	—	
male	1.46	0.75, 2.86	0.3
Location * social			
Inside * close friend	6.43	1.70, 29.4	**0.010**
Outside * close friend	2.29	0.70, 8.18	0.2
Inside * colleague	1.89	0.62, 6.05	0.3
Outside * colleague	1.36	0.45, 4.23	0.6
Inside * neighbour	2.36	0.75, 7.91	0.2
Outside * neighbour	3.60	1.09, 13.2	**0.042**
Inside * contractor	5.05	1.39, 21.1	**0.019**
Outside * contractor			

[1]OR = Odds Ratio, CI = Confidence Interval

Table 5: Results of logistic regression for smart security cameras with preference of disclosure as outcome variable.

7.3.2 Voice Assistant

Characteristic	**OR**[1]	**95% CI**[1]	**p-value**
Most people would tell			

No	—	—	
Yes	24.9	12.6, 52.5	**<0.001**
It's right to tell			
No	—	—	
Yes	32.7	16.8, 67.1	**<0.001**
Most people think it's right			
No	—	—	
Yes	1.42	0.72, 2.77	0.3
Only listens when talked to	1.13	0.89, 1.44	0.3
Listens but Amazon not interested	1.22	0.96, 1.56	0.11
What harm could it do	0.99	0.79, 1.25	>0.9
Reasonable thought	0.87	0.65, 1.16	0.3
Age			
18-34	—	—	
35-64	1.05	0.58, 1.88	0.9
64+	2.01	0.36, 18.8	0.5
Sex			
female	—	—	
male	0.84	0.46, 1.50	0.6

[1]OR = Odds Ratio, CI = Confidence Interval

Table 6: Results of logistic regression for smart voice assistants with preference of disclosure as outcome variable.

7.3.3 Camera vs Voice Assistant

	camera			voice		
Characteristic	**OR[1]**	**95% CI[1]**	**p-value**	**OR[1]**	**95% CI[1]**	**p-value**
Most people would tell						
No	—	—		—	—	
Yes	29.8	12.2, 87.1	**<0.001**	32.6	15.5, 73.9	**<0.001**
It's right to tell						
No	—	—		—	—	
Yes	989	263, 5242	**<0.001**	56.6	26.3, 132	**<0.001**

Most people think it's right						
No	—	—		—	—	
Yes	0.39	0.14, 0.97	**0.054**	1.14	0.55, 2.31	0.7
Age						
18-34	—	—		—	—	
35-64	2.88	1.42, 6.03	**0.004**	0.96	0.52, 1.79	>0.9
64+	14.2	0.73, 413	0.2	5.85	0.79, 63.1	0.11
Sex						
female	—	—		—	—	
male	1.31	0.62, 2.76	0.5	0.90	0.47, 1.71	0.7
Owns smart lights						
No	—	—		—	—	
Yes	1.23	0.45, 3.63	0.7	0.33	0.13, 0.79	**0.014**
Owns smart thermostat						
No	—	—		—	—	
Yes	1.33	0.50, 3.87	0.6	0.26	0.10, 0.62	**0.003**
Owns smart security system						
No	—	—		—	—	
Yes	0.42	0.11, 1.78	0.2	4.30	1.45, 13.2	**0.009**
Owns smart socket						
No	—	—		—	—	
Yes	0.45	0.14, 1.50	0.2	1.54	0.49, 4.87	0.5
Owns smart voice assistant						
No	—	—		—	—	
Yes	1.87	0.80, 4.61	0.2	2.22	1.08, 4.70	**0.033**
Owns smart vacuum cleaner						
No	—	—		—	—	
Yes	4.95	0.65, 60.0	0.2	0.75	0.14, 4.41	0.7

[1]OR = Odds Ratio, CI = Confidence Interval

Table 7: Results of logistic regression for Aggregate for camera (all vignettes) and voice assistant (no vignettes) with preference of disclosure as outcome variable.

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