"We Just Use What They Give Us": Understanding Passenger User Perspectives in Smart Homes

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With a plethora of off-the-shelf smart home devices available commercially, people are increasingly taking a do-it-yourself approach to configuring their smart homes. While this allows for customization, users responsible for smart home configuration often end up with more control over the devices than other household members. This separates those who introduce new functionality to the smart home (pilot users) from those who do not (passenger users). To investigate the prevalence and impact of pilot-passenger user relationships, we conducted a Mechanical Turk survey and a series of one-hour interviews. Our results suggest that pilot-passenger relationships are common in multi-user households and shape how people form habits around devices. We find from interview data that smart homes reflect the values of their pilot users, making it harder for passenger users to incorporate their devices into daily life. We conclude the paper with design recommendations to improve passenger and pilot user experience.

CCS Concepts: • **Social and professional topics** → User characteristics; • **Human-centered computing** → **User studies**; **Ubiquitous and mobile computing design and evaluation methods**.

Additional Key Words and Phrases: smart homes, pilot users, passenger users, user experience, mixed-methods study, domestication theory, internet of things

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1 INTRODUCTION

Off-the-shelf smart home devices like the Amazon Echo smart speaker and the Philips Hue light bulb have become increasingly popular in the last few years. These Internet of Things (IoT) devices act as modular components that users can install themselves. To further customize their homes, users can specify device behavior by creating "if-then" rules, or "routines" for their devices. A user might, for example, have their smart security camera turn on if nobody's home, or have their smart light bulb slowly dim if its bed time. Taken together, these design features afford users fine-grained, automated control over their smart devices.

But what happens when only some of the users in a household exercise this control? Set-up and customization takes time, and as Davidoff et al. point out, users desire control over their lives, not their devices [13]. Past studies have observed that the work of setting up and configuring smart devices is not always distributed evenly, separating users who add new smart functionality to the

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home from users who make use of existing functionality [17, 24, 30, 40]. We use the term *pilot user* to refer to the former class of users, and *passenger user* to refer to the latter.

Although past work has noted that conflicts can arise between pilot and passenger users, it remains unclear what, if anything, passenger users want out of their smart home devices, and how they build habits around them [17]. In this study, we investigate pilot-passenger relationships through the lens of domestication theory, which emphasizes the work users do to "tame" new technology and build habits around it [19]. Domestication theory tracks how a household's values, beliefs, and shared identity shape the way its members incorporate technology into daily life. Using this framework, we seek to answer three research questions:

> **RQ1a**: How do pilot and passenger users differ in their approach to domesticating their smart home devices?
> **RQ1b**: How do relationships between pilot and passenger users affect the domestication process?
> **RQ2**: How are device set up and routine creation responsibilities shared between household members?

To answer these questions, we conducted 24 one-hour interviews with participants from 12 different households, and a 178-person Amazon Mechanical Turk (AMT) survey. In the survey, users answer a series of questions about household structure and device usage patterns, helping us answer **RQ2**. The interviews helped us answer **RQ1a** and **RQ1b**, as more nuanced data was needed to understand how pilot and passenger users domesticate their smart devices. During the interviews, participants were asked how and why devices were set up in their home, how they learned what the devices in their home could do, and how their habits formed around devices.

Our survey findings suggest that pilot-passenger relationships are relatively common, with just over half of multi-user, multi-device households surveyed containing both pilot and passenger users. Survey data further suggests that just under half of multi-user households have multiple pilot users, indicating that users do share device management responsibilities. As a result, we believe it is more helpful to think about the pilot-passenger classification on a spectrum – in a household where device management responsibilities are shared, users may act as a pilot for some devices, and a passenger for others. Our interview results suggest that pilot users invest time and effort into setting up their devices to be beneficial to the passenger users in their home. Additionally we found that pilot users serve as the primary source of information about devices for passenger users, and that passenger users typically knew less about their devices than pilot users. While we found many cases in which passenger users found uses for their devices that they valued, these users still lagged behind the pilot users in incorporating devices into their daily habits. Ultimately, the pilot users we interviewed typically domesticated smart devices to meet their own needs first, and to meet the passenger users' needs second.

Our paper concludes with a discussion on the dynamics of pilot-passenger relationships. We propose design recommendations for intuitive controls to help connect passenger users with device features that suit their habits, and give passenger users more control of the data they share with their devices.

2 RELATED WORK

In this paper, we rely on two main areas of prior research: prior studies on user experience with smart home devices, and the domestication theory framework.

2.1 User experience with smart home devices

Many of the early user studies on smart homes highlighted the unique challenges multi-user households pose to designers [13–15, 22]. Davidoff et al. conducted an ethnography of double-income families, finding that "enrichment activities" for children, like piano lessons or cross country meets, largely shaped household schedules [13]. These highly variable enrichment activities made it difficult for families to adopt rigid routines for their smart devices. On the whole, these works highlight that smart homes require a level of "social awareness" in their design. In other words, smart home systems should adapt to their occupants' flexible routines [13], handle multiple potentially conflicting commands [14], and facilitate the construction of a shared household identity [14, 22].

More recent qualitative user research has focused on the design implications of power imbalances found in many households (e.g. parent-child relationships) [4, 17, 30, 31, 40]. Some of these studies noted the frequent presence of a lead user or "driver" in smart households [17, 30, 40]. These drivers acted as a sort of system administrator for their household, taking more responsibility for the acquisition, set up, and control of devices in the home.

Although household members were fairly comfortable with the imbalance in power in most of these studies [17], there is some evidence these imbalances can play a role in domestic abuse cases [5, 28]. In 2018, the New York Times published findings from a series of interviews with domestic abuse victims, lawyers, shelter workers, and emergency responders. Interview participants indicated that abusers often revoked the victim's ability to control smart devices in the home, and used smart locks or cameras to isolate and monitor them [5]. While these cases may be extreme compared to other households, they highlight that smart home infrastructures and design inherently empower some users over others, and how dangerous that can be.

Other past work has found that power imbalances between smart home stakeholders were often accompanied by differing views on privacy [10, 11, 17, 24, 27, 36, 42]. Lau et al., found that users who set up smart speakers in their home often had greater awareness of privacy settings than other household members. Ur et al., found differences in privacy expectations between teens and their parents [36], and Mare et al. found similar misalignments between AirBnb hosts and their guests [27]. Geeng and Roesner suggested user access control systems as a way to manage these misalignments [17], and Zeng and Roesner prototype and evaluate one such system. [42].

While the above studies focused primarily on dynamics between users, others work has evaluated the usability of specific smart device features. Voice assistants are one such feature, and have been the subject of many recent papers. Although voice assistants can be frustrating for users when they malfunction, they show promise as means for controlling devices, especially in social situations [2]. Yuan et al. investigated how voice assistants helped people in formulating queries [41]. Luria et al. evaluated voice assistants against wall-mounted touch screens, mobile apps, and social robots, finding that voice assistants reduced situational awareness and sense of control in participants [25]. White highlighted what he called a skill discovery problem in voice assistants. Because voice assistants lack proper affordances, White found that most users only end up using a handful of the features available to them [39].

End-user programming tools [9, 37, 40] have also been the subject of recent work. Woo and Lim conducted a longitudinal study on user-created routines, finding that users spent a lot of time refining routines after deployment, and that users frequently abandoned routines. They further suggested that users be provided an evaluation channel for routines set up by other household members [40]. Other studies have found that new users were able to quickly learn how to formulate "if-then" statements to achieve desired behavior, but struggled to debug these statements once they were written [9, 26, 37].

2.2 Domestication theory

The domestication framework was first put forward in the early 1990s, and can be seen as a response to prior work on innovation diffusion [19, 32]. Rather than thinking of new technologies as having fixed attributes for consumers to decide over, domestication theory highlights the active role consumers play in constructing meaning for new devices. Domestication theory emphasizes the process of "taming" that occurs as a household learns to incorporate a new technology into their daily routines [19, 34]. Silverstone, Hirsch, and Morley, describe four integration phases for such technologies: appropriation, objectification, incorporation, and conversion [34]. These phases capture how devices are brought into the home, adopted into daily life, and used to facilitate the construction of a shared household identity.

(1) *Appropriation*: During this phase, the new technology first enters the home. It is worth noting that the decision to acquire a new technology can itself be a part of a household's identity construction.
(2) *Objectification*: The technology is then physically placed in the home environment. Decisions in placement can reveal the values household members place upon the new technology. For example, a personal computer could be placed in a common area of a home (e.g. a living room), or a more private space, like a bedroom. Where a household chooses to place a new computer can be an indication of how the household views ownership of the device. Importantly, there is no "correct" or "intended" location for the device to be placed. Once the technology is made available, consumers shape how it is to be used.
(3) *Incorporation*: Over time, the technology becomes integrated into the daily routines of the various household members. The moral economy of the household plays a strong role in determining this. Consider, for example, a household with a single income earner and a stay at home partner. While one user might find themselves using a virtual assistant to check their schedule in the morning, another may use it to assist in various household chores, reinforcing their respective roles in the household.
(4) *Conversion*: Finally, conversion refers to the role the new technology plays in the household's representation of itself to the outside world. Discussing the purchase of a new exercise bike with co-workers, for example, may signal health and wellness as household value.

Both Hargreaves et al. and Nyborg discuss domestication theory in the context of smart home technologies [20, 30]. Hargreaves et al. found that the task of domesticating smart home technologies is extremely burdensome for many families, in part because the disruptive nature of the technology requires that existing household devices be re-domesticated [20]. For example, the introduction of a smart grid might cause a household to rethink how they utilize energy-consuming devices. As a result, their participants often ended up with minimal use for their smart home technologies. Nyborg, conversely, found that the flexible nature of smart grid technology resulted in many households having a "lead innovator" [30]. These users undertook much of the domestication work discussed by Hargreaves et. al upon themselves. Because these users often played an out-sized role in determining how the technology would be used, there was often a power imbalance between lead users and other members of the household.

3 METHOD

To answer our research questions, we conducted a mixed-methods study. The study consisted of two complementary components. To answer **RQ1a** and **RQ1b**, we conducted a series of semi-structured 60-minute interviews with members of 12 different households recruited via Reddit posts and a post in a public Facebook group. We used an online survey with participants recruited from Amazon Mechanical Turk (AMT) to answer **RQ2**. The interviews were conducted between late May and

early July 2020 over video calls. The survey was administered in late August of 2020. All procedures of this study were approved by our institution's Institutional Review Board (IRB).

3.1 Interview Procedure

We recruited 24 participants across 12 different households. Participants had to be at least 18 years old and own at least two types of smart home devices to participate in the interviews. These inclusion criteria were chosen to assess patterns in the pilot-passenger relationship beyond a single type of device. In formative work for this project, we discovered that interviewing households that only possessed one device type did not surface dynamic relationship patterns. For the purposes of our study, we define a smart home device to be one that is primarily situated in the home and that can interact with other devices wirelessly or can operate autonomously. Almost all of these devices are also considered IoT devices. Where possible, we attempted to recruit multiple members of the same household, though there were two households with only one participating member.

To capture experiences across households with varying numbers of pilot and passenger users, we asked participants beforehand if they had installed devices or created routines before in a brief "pre-survey" done before the interviews were conducted. Participants who indicated that they had either installed a device or created a routine were considered pilot users, while participants who had not were considered passenger users. Due to the COVID-19 related closure of public spaces and statewide bans on gatherings, participants were recruited entirely online across a number of smart home related subreddits and Facebook pages [1]. When possible, we obtained permission from community moderators before posting.

At the start of the interview, participants explained their interpretation of the term "smart home." If their definition differed from ours, we clarified the discrepancy. Participants then sketched their home's floor plan and placed their smart devices and household members in it, indicating which devices different household members used. Based on an earlier study using similar methods, we included the sketch task to prepare participants to think about their relationship with the devices and people in their home [18]. The sketches also served as a reference point during and after the interview. After completing the sketches, participants were asked a series of questions crafted to gain an understanding of the role passenger and pilot users played in the appropriation, objectification, and incorporation phases of domestication described by Silverstone, Hirsch, and Morley [34]. Although we believe it is important to understand how smart devices influence a household's self-presentation to the world, we leave investigation of the conversion phase of domestication to future work, as we believe it merits its own study. To address the appropriation and objectification phases, participants were asked how different household members contributed to purchasing decisions and about decision processes regarding where devices were placed in the household. To understand the incorporation phase, participants were asked questions on how they learned about device capabilities and how habits formed around their devices.

Household members were interviewed over separate, hour-long Zoom calls. We interviewed household members separately to capture the differences in knowledge about the smart home setup between users. Additionally, we anticipated that joint interviews might place extra pressure on participants to speak positively about their smart devices.

Interview participants received a $20 gift card as compensation for their time. All interviews were recorded for later analysis. 15 of our participants were pilot users, while nine were passenger users. Ten participants were female; 14 were male. Participant ages ranged from 19 to 67, with

[1]We made posts on the following subreddits: r/GoogleHome, r/SmartHome, r/SmartThings, r/AmazonEcho, r/ifttt, r/homeautomation, and r/samplesize. We also made a post on the Facebook group "SmartThings User Group (not the 'Strict' Group)"

an average age of 33.6. 22 of the participants were White and two were Asian. While most of our participants resided in the US, four lived in Canada, and two lived in Australia. Due to technical issues, one interview recording with a pilot user was lost. Consequently, results from this interview are not presented in this paper.

In this paper, interview participants will be referred using a letter, to denote their household, and a number to distinguish them from other household members. For example, A1 and A2 are two participants from the same household, while A1 and B1 are two participants from different households.

3.2 Survey Procedure

The online survey was administered in two stages: a short survey to screen for inclusion criterion and demographics, and a main survey containing questions about household structure and device usage patterns.[3]. Out of the participants who completed the screening survey, we selected a subset balanced for race/ethnicity, age, and gender, and sent the main survey to any members of this subset who matched our inclusion criterion (owned more than one type of smart device).

In the screening survey, we asked 1,400 participants to supply their basic demographic information and to indicate the types of smart home devices they owned from a list. Device types included things like smart locks, smart light bulbs, etc. The provided list contained 13 types of devices as well as a write-in "Other" option and a "None" option. The screener also included a short attention check in which we asked participants to re-enter whether they owned a smart lock or a voice assistant. If the responses did not match their previous response, they were excluded from further participation in the study. The screening survey took participants an average of one minute to complete and they were compensated $0.25 for their time.

Given the list of respondents from the screening survey, we used quota sampling to select a subset of 471 potential participants balanced for age, gender, and race/ethnicity. We balanced our participant pool using these three dimensions for the following reasons: 1) past work indicated that age has a strong negative correlation with technology adoption [38], 2) the findings of Blythe et al. suggested that gendered design decisions may impact the adoption of domestic technology [4], and finally, 3) Pew Research analysis of US census data showed that non-White Americans are significantly more likely to live in multi-generational households [12].

After applying our inclusion criterion, 280 potential participants remained. All 280 were given access to the main survey on AMT and 195 responded. In the main survey we asked our participants questions about device installation and routine creation to assess whether they were pilot or passenger users. Participants were also asked whether they lived alone or with other people. Participants who indicated that they lived with others were then asked to indicate their relationship with the other members of the household, and to similarly indicate whether other household members had installed devices or created routines. Participants specified the same information for non-household members, if applicable. Participants who, despite their screener responses, indicated they owned one or zero types of smart device were excluded, leaving us with 178 responses. Participants were paid an additional $0.90 for completing the main survey, and took an average of 6.5 minutes to complete it.

Our initial pool of 471 potential respondents, was relatively balanced compared to US national demographics, but Asians are somewhat over-represented in our sample, while participants who identify as Hispanic, Latino, or Spanish are under-represented. The 195 participants who completed

[2]This interview recording was lost due to technical difficulties. As such, it is not included in the qualitative analysis portion of this paper

[3]In order to reduce our participants' incentives to answer unfaithfully [33], the participants in the screening survey were initially not told about the existence of the main survey.

Table 1. Summary of interview participants. Participants labelled "Mostly Passenger" are those whose pre-survey response indicated that they had not set up a device or created a routine before, but whose interview answers indicated that they had set up a few of the devices in the household.

PID	User Type	Relationship	Devices
A1	Pilot	Fiance of A2	3 smart bulbs/strips, 2 Chromecast,
A2	Passenger	Fiance of A1	1 door sensor, 1 smart switch,
			1 voice assistant
B1	Mostly Passenger	Wife of B2	4 voice assistants, 3 smart plugs,
B2	Pilot	Husband of B1	1 camera sensor, 1 Chromecast,
			1 smart thermostat
C1	Pilot	Fiance of C2	7 smart bulbs, 5 voice assistants
C2	Pilot	Fiance of C1	
D1	Pilot	Husband of D2	4 voice assistants, 3 smart plugs
D2	Passenger	Wife of D1	
E1	Pilot	Brother of E3, Son of E2	6 smart bulbs, 4 voice assistants,
E2	Passenger	Mother of E1, Mother of E2	3 smart TVs, 1 smart thermostat,
E3	Pilot	Brother of E1, Son of E2	1 camera sensor
F1	Pilot	No other users in study	5 voice assistants, 3 smart bulbs,
			1 smart garage door,
			1 fan controls, 1 smart speaker,
			1 smart doorbell, 1 smart sprinkler
G1	Pilot	Fiance of G2	3 smart bulbs, 3 voice assistants,
G2	Passenger	Fiance of G1	2 smart thermostats, 1 smart TV
H1	Pilot	No other users in study	4 voice assistants, 3 smart bulbs,
H2[2]	Pilot	Husband of H1	smart thermostat, 1 smart kettle,
			2 smart TV/display
I1	Pilot	Brother of I2	3 voice assistants, 2 smart bulbs,
I2	Passenger	Brother of I1	2 smart plugs, 2 Chromecast,
			1 smart IR hub, 1 smart kettle,
			1 switchbot
J1	Pilot	Husband of J2	11 smart bulbs, 2 voice assistants,
J2	Passenger	Wife of J1	1 smart TV, 1 smart vacuum
K1	Mostly Passenger	Wife of K2	27 smart bulbs, 4 voice assistants,
K2	Pilot	Husband of K1	10 outdoor smart lights,
			3 smart cooking-ware,
			3 smart timer,1 smart thermostat
L1	Pilot	Husband of L2	3 voice assistants, 2 light bulbs,
L2	Passenger	Wife of L1	1 smart TV, 1 smart door,
			1 smart router

Table 2. Comparison of our 178 main survey participants to US Demographic Data [6–8]

Demographic Category	% of our sample	% of US Adults
Race/Ethnicity		
Non-Hispanic White	70.1%	60.1%
Black	10.2%	13.4%
Asian	11.3%	5.9%
Hispanic, Latino, or Spanish	4.5%	18.5%
American Indian or Alaska Native	0.6%	1.3%
Native Hawaiian or Pacific Islander	0.0%	0.2%
Multi-racial	3.4%	2.8%
Age		
18-29	19.2%	21.09%
30-39	21.5%	17.31%
40-49	18.1%	15.80%
50+	41.2%	45.30%
Gender		
Man	48.0%	48.73%
Woman	52.0%	50.77%
Non-binary	0.00%	N/A
Education Level		
Some high school	1.5%	7.25%
High school graduate (or equivalent)	7.4%	28.64%
Some college, no degree	9.1%	18.53%
Associate's degree	10.8%	9.67%
Bachelor's degree	46.0%	20.62%
Graduate or professional degree	25.0%	11.63%

the main survey were demographically similar to the initial pool, though a higher proportion were Non-Hispanic Whites. The main survey respondents were highly educated compared to the US population, and over half had completed or were in the process of completing a Bachelor's degree. This is consistent with past findings that AMT workers skew higher in education level compared to the general US population [23]. This discrepancy may also partially result from our inclusion criterion, as past work has found that college graduates are more likely to own smart devices [1].

4 INTERVIEW RESULTS

Our interview data revealed that pilot-passenger user dynamics played a key role in shaping how households domesticated new smart home devices and routines. We focus primarily on how these dynamics impacted the appropriation, objectification, and incorporation phases described by Silverstone, Hirsch, and Morley [34]. We separate our results into three sections and discuss the role pilot and passenger users play in each. First, we look at how households determine which devices and routines enter their home. Second, we cover how knowledge about new features propagates between household members. Finally, we discuss the incorporation of devices and routines into daily habits.

4.1 Determining What the Smart Home Can Do

To understand how pilot-passenger user dynamics affect the domestication process, we began by investigating how the functionality of the smart home was determined – that is, how did pilot and passenger users negotiate which devices and routines would enter the home?

4.1.1 Pilot users determine what the smart home can do. In the majority of the households we studied, the pilot users described themselves as the driving force behind device acquisition and routine creation (N=8). A1, for example, described himself as "the controller of the smart home," stating that "Everything we have I have set up, I have tinkered with. […] I have got to where I think its a good working condition." K2 similarly said "I'm more of the instigator with the devices. And so I'm the one that does most of the research and […] spends time on forums and Reddit and […] and do most of the programming of it and she just sort of uses them." This result is consistent with previous studies that suggested that pilot users largely determine how the smart home is set up [17, 30, 40].

Despite this, we find that passenger users often still took part in discussions about new devices. Passenger users' concerns about new devices usually pertained to shared household resources like money (N=6) and space (N=4). For example, E1, a pilot user, describes discussions he had with his mother and father (passenger users) and his brother (pilot user) when considering new devices to add to the household:

> My dad kind of stays out of it unless it's costly. Just because the technology's more everyone else's thing. My mom and my brother are kind of the two decision factors. He's like […] what it can do for us, compatibility, kind of thing. My mom was like the cost […] and then I'm like, right under them in the middle […] talking to either of them.

A2 similarly noted about her fiancé that "usually, it's him coming to me with an idea" and that "money is a big factor." A few participants also mentioned some discussions about privacy prior to acquiring new devices (N=3). G2, a passenger user, said that she was "pretty adamant about […] we don't need cameras inside the house." Most of the pilot users felt the need to discuss new plans with the passenger users in their household (N=6), though some of these discussions were a courtesy more than anything else (N=2).

Even when passenger users voiced minimal concerns, several pilot users indicated that they wanted to set up the devices to benefit passenger users (N=7). Attitudes on this varied, however. Some took an active approach, and specifically tried to find routines and devices that would please the other household members (N=3). A1 described what he called a "wife approval factor," and said that "The more things I make that can make her life just a little bit more convenient is gonna help." In some cases, this process can be quite labor intensive, as F1 describes:

> Honestly most of the design was setup to simplify the few smart things that I enjoy to make it so that they can use it. […] I had 13 years working for a corporation doing home theaters […] And I found the biggest thing was that there was always one person in the house […] that knew how to work everything, and if that one person wasn't home, there were entire rooms of electronics that didn't get used […] so I tried to make sure that this house wasn't going to be that way. That they can use everything in the house. Flawlessly.

Others took a slightly more hands off approach (N=2). K2 said that he "assumed that as long as it […] works properly, then we'd both probably use it the same way." I1 similarly stated that when purchasing a new device, he is "not really thinking about anyone else" and that "I just sort of think this is cool. […] Let's get some automation happening."

4.1.2 Trust, apathy and apprehension in passenger users. Passenger users expressed a number of reasons for playing a minimal role in device acquisition and routine creation. Many expressed a lack of tech-savviness relative to the pilot user in their household (N=5). D2, a passenger user, described the pilot user in her household as "more of the tech savvy one." I2 similarly felt that "its more of a hobby of his [...] to connect up the house" when comparing himself to his pilot user. However, despite their personal disinterest in new technology, passenger users often stated that they trusted the pilot user in their home to select devices and create routines that would be beneficial to the whole household (N=4). L2 noted that the pilot user in her household "debugs things before [they're] put to use," and that "he's really good at researching and [...] figuring out what's best."

Some passenger users also stated that they felt satisfied with their current habits, and did not need to incorporate devices into them (N=4). G2 said that she preferred to "go about how [she's] always done it." These passenger users felt the benefits of home automation were limited. A2 summarized this sentiment saying "In my opinion I don't need an automated light when I can just get up and use the light switch. It's not that big of a deal to me."

However, there were a few cases where people who were initially passenger users ended up exhibiting more pilot user-like traits. Although H1 said that her husband did all the device set up, she ended up creating more routines than her husband. When describing why she became more invested in the devices, H1 said that she tries to "find more usage" for her devices because she felt like "they can do more" than how her husband was using them. B1, another passenger user, had brought up the idea of getting a Google Hub for their home, as she felt that it would be helpful for cooking, stating "if I was trying to follow a recipe [...] I would be able to just see it on the Google Hub." In this case, B1's interest was driven by her positive experiences using Google Mini's in the kitchen to set timers while cooking.

4.1.3 Collaboration amongst multiple pilot users. Households H, C, and E gave us some insight into how households with multiple pilot users functioned. We observed a range of behaviors here. In some cases, these households displayed collaborative processes for device acquisition (N=2) and routine creation (N=1) between pilot users, while in other cases the opposite was true (N=3). Compared to households with a single pilot user, C1 and C2 described a planning process for new devices that was more reciprocal. C2 described it as follows:

> We were both on computers the entire time and like for sharing all of this through our chat [...] when Google announced the [...] Hub or whatever [...] So we're discussing all of the pros and cons of what we want and things like that. We started exploring the website to see what's compatible with it, what can be done, what can't be done.

C1 and C2 often acted collaboratively while setting up routines as well. C1 described the process of working together to debug routines, saying "we try to like just sit down with [...] the routine. [...] Okay, is it set that way? [...] I think we should set it that way." This is in contrast with household H, where H1 handled most of the routine creation, while her husband drove the device acquisition.

4.2 Learning what the smart home can do

Given the role pilot users played in introducing devices and routines to the home, we now focus on understanding how passenger users learn about new functionality available to them.

4.2.1 Knowledge flows from pilot to passenger users. Our findings suggest a stark difference between the knowledge acquisition processes of pilot and passenger users. Most of our pilot users used external resources to learn about their devices (N=8). J1, a pilot user, said that he "dove deep" into doing his own research. Another pilot user, D1 similarly described himself as "tapped in to [...]

tech blogs." For pilot users like J1 and D1, these resources helped them to domesticate their new devices.

On the other hand, passenger users were much more likely to learn about the devices from another household member, either through a direct explanation from a pilot user (N=8), or by observing their pilot user's usage of devices (N=4). For instance, J2, a passenger user, felt like explanations from the pilot user in her household were helpful for her, saying "he went around and he just showed me how to do everything. So it wasn't anything difficult." Smart home related mobile apps were frequently introduced to passenger users by pilot users (N=4). Although a few preferred not to use these apps even once they were installed (N=2), more expressed relative comfort with their apps (N=3).

While on the whole passenger users learned about their devices through the pilot users they lived with, there still were a few instances where passenger users indicated learning about their devices from external sources (N=2). G2, a passenger user, described learning about some features through emails sent to her by the device manufacturer, and felt that many features were common knowledge.

We also found a few instances in which the flow of knowledge reversed, and a pilot user learned about device functions from a passenger user (N=2). G1 said his fiancé would "every once in a while come across a [Reddit] post" describing a new feature for one of their devices. F1 also remarked that his nine-year old daughter often discovered features before him, since she was "more apt to try things."

4.2.2 Knowledge gap between pilot and passenger users. Despite the flow of information from pilot users to passenger users, a number of our passenger users still felt that the pilot users knew more about the devices in their home (N=5). Passenger users would turn to pilot users for help when they had problems with their devices (N=3). E2, for example, felt that the pilot users in her household were more "in tune to what the possibilities are." In some cases the gap in knowledge between pilot and passenger users could be a source of frustration. A2, who felt this way, noted: "I get frustrated easily because I really don't know the basis of them [...] So if it's wrong, all I can do is complain about it. He's like, 'hang on, let me fix it.' And I just don't have the inclination to go learn about it either."

4.3 Using the smart home

In the previous sections, we described that pilot users tended to have a greater degree of control over the smart devices and that knowledge about the devices tended to propagate from pilot users to passenger users. In this last section, we investigate how pilot-passenger user dynamics shape the habits that form around smart home devices.

4.3.1 Devices are less of a habit for passenger users. In most of our pilot-passenger user households, we found that passenger users felt their usage of devices was quite different from their pilot users' (N=6). Passenger users described this difference in a few ways. Some felt like they used devices less frequently (N=5) while others described feeling like they used more "basic" features (N=3). A number of passenger users also felt that using the devices in their household came more naturally to the pilot users (N=3). I2 referred to his brother as having "more fluency" when it came to using devices. E1, a pilot user, noted that his father was less fluent using devices as well, going so far as to say that "sometimes if I know that there's something he'll need [...] I will sort of do the command for him. Just to get it out of the way." But not all passenger users felt like they were missing out on something. A couple of our passenger user participants described the pilot user in their household as more dependent on their smart home devices (N=2). E2 described these differences between her and her sons, saying "I don't think that they understand that we could live without it."

Taken together, our results suggest that pilot users are more generally more successful in developing habits around their smart home devices. In the remaining sections we will explore why these differences in habit formation occur.

4.3.2 Passenger users benefit from external triggers. For many of our pilot users, setting up the smart home was a hobby or passion project (N=9). None of our passenger users expressed a similar sentiment. Additionally, as mentioned earlier, many of our passenger users expressed satisfaction with their current daily habits (N=4). As a result, these passenger users were not looking for ways to augment their lives. I2 describes this feeling, saying:

> I think it's one of those things where you don't know something's more convenient thing until you do it. So until I see someone else do it, I think I'm happy with the level of convenience I have already. [...] I'm not searching for the next best thing until I see it and I go, 'Oh, that's great.' And then I'll start doing it.

What I2 describes is the need for some kind of external trigger to prompt device usage. For him, observing the pilot user in his household served as an external trigger. Another passenger user, J2 recounted an incident in which an external trigger prompted her to use a device, saying "the other day I needed to know a measurement when I was cooking, and I did ask Google because my hands were dirty." In this case, J2's dirty hands served as an external trigger, prompting her to use the Google Home in new way.

This need for an external trigger was not exclusively a passenger user phenomenon. G1, a pilot user, said that he and his fiancé used to often forgot to use their smart home devices. He described this, saying "whenever we went over to do something that we could have done with the Google Home, we reminded each other to use the Home. You know, we spent money on this thing, so why not use it and get the most out of it."

One set of features that seemed to suffer from a lack of external triggers were the voice match features offered by several popular voice assistants. A number of our passenger users who had not used the voice match feature mentioned that: 1) their voice assistants had a hard time recognizing their speech, 2) they were aware that their voice assistant had a training process they could complete to improve accuracy, and 3) doing so would probably help them (N=3). All three users described the feature as something they had just not yet gotten around to using. D2 said "I haven't gone through it. I probably should, because then my life would be a lot easier and we wouldn't be fighting with our devices." K1 contrasted herself with her husband, who had gone through the voice training process saying "He's better about caring about fixing the issues, whereas I'll just turn it off if it's not listening to me."

4.3.3 The smart home reflects the values of the pilot users. As stated earlier, many pilot users said they tried to take into account the interests of passenger users when setting up their smart home. Despite this, passenger users often found that devices were configured in ways that did not suit their needs. A2, for example, primarily used the smart speaker in her home while cooking. However, because her first smart speaker was placed in the living room, she would have to "yell from the kitchen for [her] timers or music," making it more difficult for her to use it the way she wanted.

In other cases, passenger users could not find a way to utilize a device in their home. I1, a pilot user, placed a SwitchBot (a smart button pusher) on top of his household's garage door controller. I1 felt this placement of the device was useful, saying "My father in law sometimes comes over [...] mows the lawn out the back. If none of us are home and he's over, he just gives us a ring and says 'yeah, here to mow your lawn.' We can open the garage from anywhere in the world." I2, however, who was not responsible for letting I1's father-in-law into the garage, did not see a use for the SwitchBot. When describing why he did not use this SwitchBot, I2 said "If I'm going to open the

garage, I'm probably going to walk through the garage anyway. So I'm going to be right next to [the garage controller]. I've never really needed to open it up when I'm not there."

For other passenger users, certain routines set up in the household ended up being a source of inconvenience. D1, a pilot user, largely stopped trying to set up routines, as they were often disruptive for his wife. As he describes:

> I think she would get annoyed with the rigidity [...] So I'd like to turn on the lights, start music, read my calendar first thing in the morning, but if it didn't sync up with her work schedule, then it was a it was a pain.

In all three cases, devices were utilized in ways that did not suit the needs of the passenger users in the home. This is not inherently a problem, but these instances demonstrate that devices are often set to benefit pilot users first, and passenger users second.

4.3.4 Habits form around household roles. Despite some of the above difficulties, we did observe several cases in which passenger users found specific uses for their smart devices they really valued. Many of these uses were tied to a passenger users' household responsibilities (N=5). J2, for example, had a set of cameras in her home that she used to check on her kids while she was at work. Compared to other devices in her household, J2 said she was more willing to learn how to use the cameras in her home "because it involves [her] kids." E2 said the Google Hub in her home was the first device that "actually made a difference" and that she was "constantly using it." E2, the primary cook in her household, found the Google Hub's screen particularly useful for her, as it allowed to "actually see the timer" she set while cooking. Though E3 said that the Hub was his idea to add to the home, the fact that it matched E2's unique role in the household led E1 to say that it was "mainly her who used it."

5 SURVEY RESULTS

In this section we describe results from our survey, which we use to understand the prevalence of pilot-passenger relationships, and add to the generalizability of some of our interview findings.

5.1 Household structure

For this analysis, participants were classified as pilot users if they had even minimal involvement in device set up or routine creation. Thus, we expect our estimates for the number of passenger users in our sample to be conservative.

Of our 178 survey participants, 36 lived alone while 142 shared a household with other users. Unsurprisingly, of those who lived alone, almost all were pilot users (N=33). The remaining three were passenger users who had a non-household member set up devices. Amongst respondents who lived in multi-person households, 124 were pilot users, while the remaining 18 were passenger users. 57 of these pilot users indicated that they were the sole pilot user living in their household, while 67 indicated living with at least one other pilot user. All 18 passenger users who lived in a multi-user household indicated living with a pilot user. Consequently at least 52% of our respondents in multi-user households lived in a household with at least one pilot user and at least one passenger user (n=75).

5.2 Sharing device administration

Figure 1, shows how participants shared device administration responsibilities with other household members as well as with non-household members. We identified a few hotspots on this chart. The leftmost boxes in the third and fourth rows represent the 12.86% of participants that did not set up devices or routines. These users would be classified as passenger users. The top and bottom right corners show the 30.71% of the participants that were solely responsible for device management

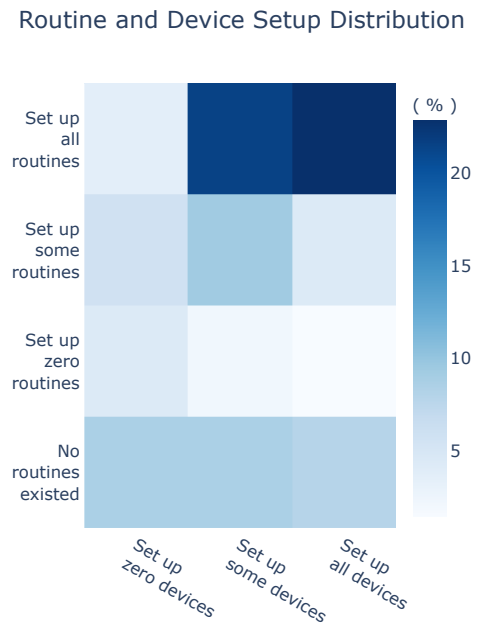

Fig. 1. The distribution of shared device management responsibilities across our multi-household participants. Note that the fourth row corresponds to users who lived in households where no routines were created, while the third row corresponds to users who lived in households where routines were created, but who had not created routines themselves. The first squares in the 3rd and 4th rows from the top indicate a cluster of participants (12.86%) that maps to our definition of passenger users. All other users are considered pilots. The dark colors in the top right (22.86%) and bottom right (7.86%) demonstrate the pilot users who handle all device management in their home (30.71%).

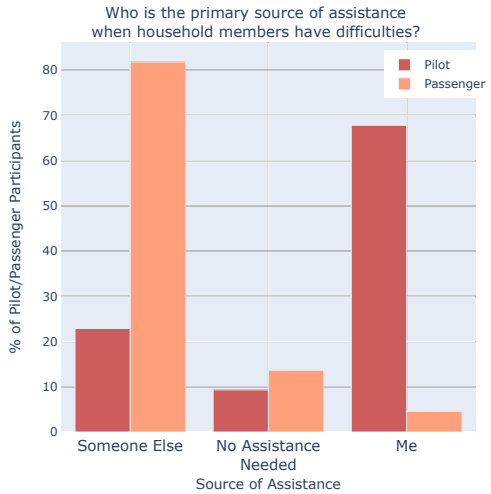

Fig. 2. Respondents perceptions of who provided the primary source of device-related assistance in their multi-person household. We see more than 80% of passenger users consider someone else to be the primary source of assistance, while almost 70% of pilot users identify themselves as the main source.

in their home (22.86% in the top right box and 7.86 % in the bottom right). The remaining 56.43% of users shared device management with responsibilities with others (possibly including non-household members). Our results suggest there are relatively few users who create routines without having installed devices. These users accounted for 13.83% of all routine creators. In contrast, users who had installed devices but never created routines accounted for 25.69% of all device installers.

5.3 Other Pilot-Passenger Attributes

We also used our survey to add generalizability to two of our interview results. Namely, we asked survey respondents how they learned about the smart devices in their home and which user acted as the primary source of device-related assistance in their household.

Figure 3 shows the percentage of pilot and passenger users who selected each knowledge acquisition channel listed in our survey question. 58.47% of the pilot users utilized online resources

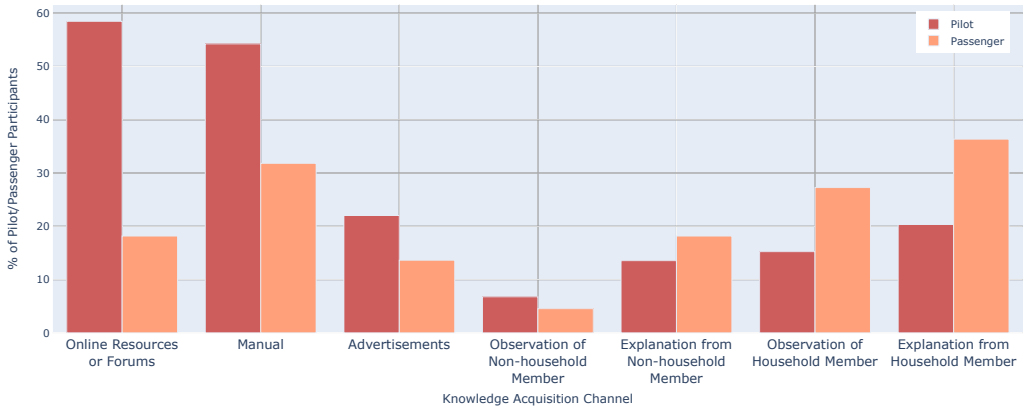

Fig. 3. This graph visualizes where pilots and passengers acquire information for their smart devices in multi-user households. A trend appears to the left showing that more pilot users consumed their knowledge from external resources and passenger users consumed their knowledge from internal household resources.

to acquire knowledge compared to 18.18% of passenger users. 54.24% of the pilot users consulted product manuals compared to 31.82% of the passenger users. On the other hand, 36.36% of the passenger users gained their knowledge via explanations from other household members compared to 20.34% of the pilot users. Similarly, 27.27% of the passenger users gained their knowledge from observing other household members compared to 15.25% of the pilot users. This supports our interview results, demonstrating that pilot users tend to learn from external resources, while passenger users tend to learn from other household members.

This finding is further supported by Figure 2, which displays the distribution of participants' responses when asked who served as the primary source of device-related assistance. We found that less than 5% of passenger users felt they were the primary source of assistance, while 67.8% of pilot users felt they were the primary source of assistance.

6 DISCUSSION

In this section we highlight what our quantitative results tell us about the prevalence and fluidity of pilot/passenger relationships, and contextualize our qualitative results in the appropriation, objectification, and incorporation phases of domestication. We conclude this section by putting forward a set of design recommendations to improve passenger user experience. We choose to focus our recommendations on improving passenger user experience, as such users have been overlooked by many past studies. Our recommendations do not necessarily aim to convert passenger users into pilot users. Device set up and routine creation require time and energy that some users would probably be happy to delegate to others, and the pilot-passenger user dynamic allows passengers to achieve this. Rather, our design recommendations are intended to connect passenger users with the features of their devices that best suit their needs.

6.1 Pilot and Passenger User Prevalence

Our quantitative results suggest a few things about the prevalence of pilot and passenger users across household structures. First, they indicate that pilot-passenger user relationships are fairly common. At least 50% of our survey respondents who lived with other people were in a home with both a pilot user and a passenger user. Second, our results suggest that pilot and passenger

categorizations may be fluid. Of the pilot users we surveyed who lived in multi-user households, 56% indicated that they shared device management responsibilities with other users. These pilot users would have set up some, but not all, of the devices and routines in the home. As such, they might act as a pilot for some devices and as a passenger for others. Although we still believe the pilot and passenger user classifications to be helpful to understand user dynamics in the home, the prevalence of households in which device management responsibilities are shared should discourage us from taking an overly binary view of the two terms. Instead, it would be more helpful to understand these categories as existing on spectrum.

Its worth noting, however, that our survey participant pool is heavily skewed towards pilot users, as just around 10 percent of our respondents were passenger users. This is to be expected, to some extent, as for the purpose of quantitative analysis, we adopted rigid and conservative criterion for classifying a participant as a passenger user. We present two additional explanations for this skew. One possibility is that passenger users are less likely to use MTurk. Past work indicates that AMT users are more technically savvy on average [23], which may make them more likely to be pilot users. Additionally, children cannot complete HITs on MTurk, and appear to be a common category of passenger user from our interviews. Second, there may be some self-report bias in our data. Respondents may have overstated their involvement in device configuration while understating the involvement of others. Although these factors limit the conclusions we can draw from our data, our results nevertheless suggest that passenger-pilot relationships are relatively common amongst households with multiple device types. Future quantitative studies should consider targeting passenger users directly to get a better sense of their habits.

6.2 Pilot Users, Passenger Users, and Domestication

Our interview results demonstrate that pilot and passenger users differ dramatically in their approaches to domesticating their smart devices. Below, we summarize these differences for the appropriation, objectification, and incorporation phases of domestication.

6.2.1 Appropriation. When it comes to adding devices to the home, the pilot users we interviewed typically acted as the main driver or instigator, bringing forward ideas to discuss with the other members of their household. In a few cases, pilot users would purchase smart devices without discussion with other household members, though this appeared to be uncommon. Discussions were most often about whether a certain device would be worth the cost, though topics like privacy and device placement did also sometimes occur before purchase. Several pilot users noted that they tried to find devices that would be useful to the whole household, not just themselves. Passenger users, perhaps unsurprisingly, tended to play a more passive role. Still, we found that they did weigh in on purchasing decisions, especially where it pertained to the household's finances. In explaining their decision to play a more passive role in this process, passengers typically cited indifference towards augmenting their lives with more devices and trust in pilot users to make good purchases. In a few cases, passenger users would themselves initiate discussions around purchasing new devices, typically after having a positive experience with a previously purchased smart device.

6.2.2 Objectification. Oftentimes pilot users proposed purchasing a new device with a specific use-case for the device in mind (e.g. purchasing a smart plug to automate a particular lamp). In these cases, passengers were less likely to weigh in on where devices should be placed in the home. However, passenger users typically had equal voice to pilot users in determining where more general-purpose devices were placed (e.g. smart speakers). It was fairly common for both passenger and pilot users to describe these decisions as "obvious" and not requiring much discussion.

6.2.3 Incorporation. Once devices were placed in the household, our interview results indicate that passenger users are slower to incorporate the devices into their habits than pilot users, despite enjoying many of the features they discovered. We found three reasons for this. First, many of our passenger users indicated that they were satisfied with their current habits and were not seeking out new uses for their devices. When these passenger users did adopt new habits, they were often prompted to do so by an in-the-moment external trigger, like a suggestion from another household member.

Second, our interview results show that passenger users rely on pilot users for information about device capabilities. As White argues, smart home devices lack the signifiers necessary to convey these capabilities to users directly [39], so passenger users are largely dependent on their pilot users. This was supported by our survey results, which indicated that pilots were far more likely to use external resources to learn about their devices, while passengers were more likely to learn from other household members.

Finally, because passenger users played a minimal role in the appropriation and objectification phases of domestication, the physical and digital configuration of the smart devices could itself become a barrier to adoption. We observed a few cases in which devices were placed in areas of the house where only the pilot user could benefit from them. In other cases, pilot users created routines that were disruptive for passenger users. A2, for example, was no longer able to use the physical light switches in her home, as they disrupted the routine her fiancé set up for their smart light bulb. In cases like these, routines became more of an annoyance for passenger users than a convenience, making them less inclined to use smart devices in the future.

6.3 Design Recommendations

6.3.1 Personalized Feature Recommendations, with Caveats. Feature recommendation for smart home devices has been explored in several past papers [3, 29, 39]. Our findings suggest that a feature recommendation system would benefit passenger users in particular, who are reliant on pilot users for information about the smart home. However, because passenger users are not actively seeking new ways to use their devices, we argue that the context in which feature recommendations are provided is important. Many smart home systems today send emails to users containing feature recommendations, or display recommendations periodically on smart screens. These recommendations are easy to miss, and are distant from the moment a user would actually need to use the feature. Instead, we argue for "just-in-time" feature recommendations that appear when users are in the middle of using their devices. This allows the recommendations to more effectively mirror the in-the-moment external triggers that our interview results suggest are most effective in reaching passenger users. For example, if a user asks the device to read them a children's story, it would then be appropriate to tell them that the device can also sing them a lullaby While a few smart home systems offer these features, we believe more should follow suit and extend the range of situations in which recommendations are offered. Of course, inaccurate recommendations can be frustrating to users, so providing users the ability to opt out of suggestions is important [16].

We do want to attach some caveats to these feature recommendations. Smart home devices have access to a lot of data they can use to improve the quality of feature recommendations. They could look at calendar events to deduce that a user is in a business meeting. They could look at voice logs to determine what time a user typically wakes up. However, because some passenger users have limited mental models of smart home systems, using all of this information during an initial interaction may be off-putting. Past work has demonstrated that even when accompanied by explanations, users can find recommendations that draw on highly specific personal information "creepy" [16, 35].

To avoid violating trust, initial recommendations should be made based on information that the user clearly understands they are providing. This is one of the advantages of supplying recommendations based on a recent user request. As trust is built, the user can then be prompted to opt in to supplying more information to the system. Users should also be provided an "off-ramp" accompanying each recommendation, allowing them to opt-out of having personal information used for future recommendations. Future work should address how best to inform passenger users about the data being collected about them, as their minimal involvement in device set up and configuration could make this challenging.

6.3.2 Make Important Settings Accessible to Passenger Users. A few of our passenger users noted that the pilot user in their household introduced them to smart device-related apps. However, some of these passenger users indicated that they still did not feel comfortable using the apps. This is problematic, since many smart home systems keep privacy settings and parental controls hidden away in a mobile app. These features are relevant to passenger users, but our results suggest that passenger users do not discover them on their own. This is supported by similar findings from Lau et al. [24].

Drawing on results from Hsu et al., we argue that to reach passenger users, these settings need to be accessible from multiple interfaces [21]. If a user primarily interacts with their device through voice commands, they should be able to access these settings from the voice interface. Prompting users about these settings situationally can improve awareness as well. For example, if a user is having trouble getting the voice assistant to recognize what they are saying, giving them the option to set up voice match in the moment may help them feel more in control of the situation. Any prompts to use these features should be accompanied by an explanation of why using the feature will help. Although making control settings available to passenger users is important, future work should investigate how household members can retain the ability to prevent certain individuals from making changes to settings, like a guest or a child. Zeng and Roesner propose access control systems as one way to address this [42]. They suggest four possible models for access controls that enable users to control who can modify important settings – role-based, location-based, supervisory, and reactive. Its worth noting, however, that their study also found that users made limited use of access control settings. Most commonly, this was because social mechanisms were sufficient for preventing unwanted settings changes.

6.3.3 Utilize Mixed Voice-Visual Smart Displays. The above design recommendations create a lot of information that needs to be conveyed to users during an interaction. This has two problems. First, while we want people to use these recommendations, we do not want to waste their time with features or settings they are not interested in. Second, conveying such information through a voice interface risks overloading the user with information. We believe mixed voice-visual smart displays are a solution to these problems. Displaying feature recommendations on a screen would prevent overload, while still allowing users to issue voice commands. Additionally, Luria et al. conducted a comparison of several interfaces for controlling smart devices. They found that although participants appreciated the hands-free control afforded by voice assistants, they had a hard time recalling previous actions taken through voice interfaces when compared to smart displays. This suggests that smart displays may be particularly advantageous for control settings, which require the user to access and modify multiple pieces of state. Future work should investigate whether a mixed voice-visual interface can successfully combine the strengths of voice controls and smart displays. Push notifications to a user's phone are another mixed voice-visual solution, but they are intrusive and consume the limited space on a phone screen.

6.4 Other Future Work

Although the focus of this paper was on better supporting the needs of passenger users, we note that there are a few potential areas where pilot users could be better supported as well, and encourage future work to address some of these issues. Several of our pilot users felt they put a lot of effort into managing their devices, and that the passenger users in their home were the beneficiaries of this effort. A1 described this, saying "[my fiance] has nothing to do with setting things up, and we both prefer it that way. She wouldn't know where to start, nor would she want to. So I do all the setting up, and she reaps the benefits." By engaging with the smart home less, passenger users actually retained more control over their lives. Although most of our pilot users said they were happy to handle device management, this could be a source of resentment in some households, especially as the number of smart devices increases.

A few of the pilot users we interviewed shared administrative responsibilities with other members of their home. Our survey results supported this, with just under half of our pilot users indicating that they lived with another pilot. While it is unclear from our study whether sharing device management responsibilities actually reduces workload for pilot users, one area for future work is in developing device management interfaces that better support cooperation and delegation across multiple users.

Additionally, several of the pilot users we interviewed expressed interest in configuring devices and routines to better benefit the passenger users in their home. Future work should investigate how to better support this interest. One possible option might be to provide passenger users with some sort of evaluation channel for devices and routines set up by the pilot user. This evaluation channel should require minimal effort from the passenger user. Even something simple, like allowing the user to say "thanks" when a routine runs that they like, can provide pilot users with valuable feedback. Another option might be to provide the pilot user with usage statistics for the different devices and routines they have set up. One challenge here is providing pilot users with these statistics, while still preserving privacy for the passenger users in the household.

7 LIMITATIONS

7.1 Survey limitations

There were several limitations to our survey methodology. First, to keep the number of quota categories manageable, we were only able to distinguish between White and non-White participants, rather than balancing based on more fine-grained racial or ethnic categories. These constraints also limited our ability to adjust for other factors that could influence technology usage, like income and level of education. Second, our methodology relies on the assumption that users can accurately self report their device usage habits of themselves and others in their household, which may not be true in practice. Third, AMT users are often technically savvy, and may not be representative of smart device users [23]. Finally, our survey only captured a snapshot in time of a household's current usage patterns, meaning we did not have a sense of whether users evolved from pilot users to passengers or vice versa. Further research studying the pilot-passenger phenomenon should be done using observational and longitudinal data.

7.2 Interview limitations

Although participants spanned a range of ages and were fairly balanced in terms of gender, they were overwhelmingly White, introducing some bias in our data. This was likely due to demographic bias in the Reddit userbase. Many of our participants came from r/GoogleHome subreddit on Reddit, biasing the brands of devices they owned. Though the core capabilities of most smart home hubs are similar, there are still some differences between devices. In spite of this, participants owned a wide

range of devices, though almost all participants interviewed had some kind of voice assistant present in their home. Additionally, we were not able to interview any households in which all members were passenger users. In such a household, a non-household member would have had to have set up the devices in the home (e.g. a child or grandchild who does not live in the home). Further, although children were present in many of the households we interviewed, we never interviewed children directly, relying instead on parents to describe how their children interacted with devices. Additionally, all of the households we interviewed contained a heterosexual couple and at most a few other immediate family members. Future work should consider how passenger-pilot dynamics might play out in a more diverse set of household structures. Finally, because we chose to recruit from enthusiast forums, the households we selected may be biased towards containing at least one "super user." This may have overemphasized some of the differences between pilot and passenger users in our interview data.

8 CONCLUSION

Pilot-passenger user dynamics are key to understanding how users domesticate their smart home devices. Through a series of 24 interviews and an Amazon Mechanical Turk survey, we identify several ways in which pilot-passenger dynamics can both advance and hinder the domestication process. On the one hand, passenger users often feel less comfortable with technology and trust the pilot users in their home to manage devices. The pilot users we interviewed enjoyed setting up devices and were happy to take on this responsibility. On the other hand, passenger users depend on their pilot users for information about devices, limiting their ability to discover new features. Pilot users, meanwhile, have to deal with complex device management systems while trying to understand how best to support their passenger users. We argue that designers and researchers should develop smart device management systems that acknowledge pilot-passenger user dynamics and make it easier for both groups of users to fit their devices into their lives.

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