User Perceptions and Experiences with Smart Homes - The Smart Home as an Obedient Guard Dog, Disinterested Cat, Ambitious Octopus or Busy Beehive

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ABSTRACT
We investigated people's experience with living in shared smart homes, involving both smart home initiators and maintainers (primary users) as well as other inhabitants (secondary users). Through a cultural probe study with 35 participants from 16 shared homes and follow-up interviews with a subset, we gained insights into people's understanding of smart home technology, their ideas for the future, their experiences with the technology, and how they relate to their smart home. Our findings highlight how the role taken (primary or secondary user) influences how smart homes are experienced and understood in everyday life, and how 'smartness' is defined. The study further investigates how people describe their smart home 'as a living being', yielding a wide range of animal metaphors, that reveal character traits that people associate with smart home technology.

CCS CONCEPTS
• **Human-centered computing → Empirical studies in HCI**; **Empirical studies in ubiquitous and mobile computing**; • **Social and professional topics → Gender**.

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KEYWORDS
smart homes, user roles, relationship, primary user, secondary user, shared household

1 INTRODUCTION

Smart homes, defined as integrated living spaces that use common communication systems to ensure economical, safe, and comfortable operation through intelligent functionality and flexibility [27], have become an integral part of modern living environments. The global market for smart home technology (SHT) is growing rapidly, indicating its potential for ubiquitous integration into everyday life [24]. This growth is reflected in a projected 46% increase in global smart home users from 2023 to 2028 [1].

Correspondingly, the academic community devotes increasing attention to the concept of the smart home, its technological functionalities, and its broader social and individual implications, reflecting increasing industry investment in the sector [28]. Geeng and Roesner suggest that a space equipped with electronic devices for domestic usage enables automation, remote control, or sensing to achieve security, energy efficiency, and a reduction of mental load [18]. While early research focused primarily on users' motivations and concerns regarding smart home adoption [4, 9, 32, 54], recent studies have begun to explore the lived experiences of smart home residents and acknowledged different user roles individuals assume in shared households [3, 20, 50, 56]. However, as Marikyan et al. (2019) note, current research often fails to capture the multifaceted nature of smart homes, resulting in unbalanced representations of their implications, functionalities, and target user demographics [28]. How residents relate to such devices in their everyday lives,

how they perceive automated actions by Internet of Things (IoT) devices, and how they feel about the relationship between themselves and their smart home were hardly investigated.

In our research, we aimed to gain a deeper understanding of individual users' perceptions, attitudes, and interactions with smart home technologies in shared living spaces, in particular, how they experience their smart home. To understand how individuals perceive their smart home, their purpose, and the relationship they have with them, we employed cultural probes [17] that were distributed to participants living in shared smart home households, followed by semi-structured interviews with a subset of the participants. The cultural probes consisted of a notebook with various tasks to reflect on and describe their experience of living in a smart home that the participants filled out over a time frame of around 2 weeks. With these probes, we paid attention to capturing the perspectives of both the primary users (the person who purchases, sets up, and primarily controls the technology) and secondary users (everyone else in the home) regarding their smart home environment.

Our contribution is insights into how individuals relate to their smart home, what purposes they see in using the technology, and how they look towards the future. By analyzing the perspective of primary and secondary users, we identify differences and potential tensions in shared households. Further, knowledge of how people perceive and relate to their smart home can inspire future designs that align with users' mental models of the system or aim at building a mutual understanding of a system across user groups and ultimately support users in shaping their smart home collaboratively.

2 RELATED WORK

2.1 Motivations and Expectations for Smart Home Usage

There are various reasons for individuals to purchase and set up smart home devices. Strengers et al. analyzed the experience of smart home early adopters along Intel's Ambient Computing vision, the '3P's': 'Protection', 'Productivity', and 'Pleasure' [48]. They found that different households emphasized different aspects, such as security or having 'peace of mind', keeping organized and coordinated, energy efficiency, the 'show-off factor', and identified gendered design challenges [48]. Woo and Lim noted that motivations to acquire SH devices vary, from creating more convenient routines, saving energy, child care, health care, security measures, and support of family communication, to monitoring purposes [55]. A survey with 234 future smart home users (thus not actual users) found that the participants expect the smart home technology (SHT) to improve the quality of life and enhance the safety and security of residents, while simultaneously being concerned about increased dependence on technology and privacy [44]. Another online survey found that users focus on perceived benefits, such as performance and compatibility, and tend to neglect privacy and security risks [52].

While a lot of studies investigated people's expectations for SHT, there appears to be far less research on the experiences of actual SH inhabitants. Oliveira et al. compared initial expectations with experiences after 1 year with 15 volunteer homes [34]. Expectations of improved comfort and convenience were largely met, especially for homes with varied routines. While the devices soon 'faded' into the background and were not visually obtrusive, usability issues persisted. The effort and time required for maintenance shows that technological proficiency is a major factor for advanced usage [34]. Woo and Lim also emphasized the effort behind maintaining a self-managed smart home by describing a 'life cycle' from initial installation of devices, set up and implementation, troubleshooting, over a phase of routinization, to the removal of rules or entire devices [55].

Several researchers highlight that arguments, such as saving energy or improving home safety, often are used as excuses for setting up Do-it-Yourself (DIY) SH technology that for some individuals constitutes an enjoyable task in itself [31, 42, 56], resulting in a continued process of expanding the network with new components, setting up and maintaining SHT [31]. Still, there is little evidence that SHT will generate substantial energy savings [21, 49].

SH initiators' effort in troubleshooting, expanding, and maintaining the smart home network turns into an established and recognized household duty in their families, with decreased effort as their proficiency increases and systems become fine-tuned [56]. Research found that currently, it is typically household inhabitants who are experts in technology, automation, or software development, who adopt and implement smart homes at an advanced level [42, 56]. The people doing this 'digital housekeeping' work [51] are referred to as 'primary users' while other inhabitants who do not actively control and the SH are 'secondary users' [20, 23]. In this paper, we adopt this terminology to distinguish between the different roles of our SH inhabitant participants. Furthermore, digital housekeeping work, which includes setting up, maintaining and optimizing the SHT [29, 30, 47], tends to get done by (or assigned to) men [2, 40, 42].

A 9-month field trial with 10 households [21] found that SH technologies are both technically and socially disruptive and require forms of adaptation and familiarization from householders that can limit their use. Learning to use SHT is demanding and time-consuming, with currently very little available support [21]. This is especially true for secondary users. When interviewed about how they experienced the initial phase of living in a smart home set up by their partner as a hobby [42], secondary users shared that they mainly engaged with the smart home in reacting to disruptions of their daily routines. They then started to observe the devices' behavior, shared their complaints with their partner, and started collecting ideas for improvement [42]. A flurry of recent studies investigates the power imbalances that emerge when Smart Home installation and control are taken over by one person, and the gendered nature of this phenomenon [16, 18, 25, 42, 48]. Geeng and Roesner found that the primary user that selects and installs devices usually dominates expertise and control, and identified resulting challenges for cohabitation (e.g., privacy and dependencies for implementation of changes) [18]. Given these points, our study therefore explicitly includes secondary and primary users, to get both individual perspectives. In our study, we focus on understanding how the user roles in shared households shape the expectations and visions for the smart home they live in together.

2.2 People's Relationship with Smart Home Technologies

One of the core features of smart home technology is that once set up, it reacts autonomously, based on the rules programmed. It reacts to sensor events, time of day, calendar entries, and other factors next to explicit user input. Wozniak et al. suggested a service-oriented view on SHT that builds onto the intelligence that humans apply in conducting their everyday life routines [56]. In this definition, they focus on the connectedness of devices and disregarding standalone devices. We used the same lens throughout the conversations with the smart home inhabitants.

Salman et al. categorized smart home devices as a form of autonomous technology, that can be interacted wirelessly with through other devices [41].

Nass suggested that relationships between humans and computers, even simple ones, are fundamentally social [33]. Prior work found that voice interaction with conversational agents increases the technology's perceived social agency and that these evoke emotional responses [10, 19]. But the social agency of a technological artifact does not need to be static - depending on context and task, or the outcome of a situation (success or failure), people personify voice interfaces or describe them as objects [36]. Hassenzahl et al. argued that proactive autonomous technology is perceived by humans as counterparts, as another social entity that humans face or encounter, terming this 'otherware' [22]. Elsewhere, this 'experienced sociality' has been described as 'sociomorphing', which captures the fact that people experience autonomous machines as social agents, but compare this to how they interact with animals (and not with human sociality) [43].

So far, concrete examples of this kind of quasi-social relationship have primarily been found regarding people's interactions with robots and voice interfaces. Various studies observed that humans ascribe agency and intentionality even to simple robots, thereby granting the robot a 'proto-social' status [6, 45, 57].

Studies have revealed how families embed interaction with voice assistants into their ongoing conversations while highlighting that these interactions do not follow the rules of human conversations [35]. Desai et al. [14] asked 14 end-users to describe their interactions with voice assistants. Their analysis of the utilized metaphors identified the categories of 'computer, search engine, friend, and silly child', where two of these imply a proto-social relationship. They suggest that voice user interfaces should be designed based on these metaphors that come into play according to context. This points to the value of looking at what metaphors people use to describe such systems.

We can expect people to develop a similar proto-social relationship with their smart home ecology as with other autonomous systems. Yet given voice interfaces are just one potential part of an SHT system (in combination with others, including physical components, with voice interaction as one option amongst others for SH control), we assume their reactions to be different from how people describe their relation with voice interfaces [37].

There is so far very little work on what metaphors people use to describe their smart home technology. Clark et al. presented four different descriptions of hypothetical smart home systems to 1500 Mechanical Turk workers, who responded with desired applications [11]. The four abstractions varied across two dimensions: capabilities (device-centered or data-centered), and level of personification (mediated by agent or un-mediated). The authors distilled in the analysis of the applications the participants wished for metaphors for mental models: an 'island', a 'watchdog', a 'delegate', and an 'assistant'. This study derived metaphors indirectly from participants' ideas for applications but did not investigate metaphors directly. Yet elicitation of metaphors can also help to uncover users' mental models [39]. Similar to the definitions of the 'island' and the 'delegate' metaphor [11], Reig et al. investigated the perception of smart home devices and their connectedness and found that some people perceive multiple devices in a smart home as different interfaces for the same system, while others see them as devices that talk to each other or as independent systems [38].

Furthermore, Weiser and Brown argued that relationships with computers are personal, even intimate [53], which means that individuals in a shared household might perceive the same system very differently from each other. How people describe their own SHT that they set up and are familiar with (as a primary user) or live with (as a secondary user) can thus provide us with valuable insight into how SHT is being experienced and which aspects of SHT behavior and function they perceive as dominant characteristics.

3 A CULTURAL PROBES STUDY WITH SMART HOME INHABITANTS

As part of a project investigating people's experiences of living in smart homes, a cultural probe [17] study was prepared. The overall study was to provide insight into the sharing of smart homes. Thus from each home, at least two people had to participate, and many tasks and interview questions focused on aspects related to shared habitation. A subset of tasks and questions enquired about what people use SHT for and how they perceive this technology. These are the findings that we report in this work.

We recruited participants via a post in a Facebook group for SHT from a smart home provider with a link to a screening questionnaire to identify households meeting the participation criteria: (1) living in a multi-person household with at least two people willing to take part in the study for two weeks, (2) owning at least five devices from at least two different categories (utilities, security, entertainment, or household appliances) and (3) a smart home hub compatible with ZigBee (this was relevant for some of the tasks). Before sending out the final version of the cultural probes, we conducted a pilot study with two households with each two participants. As there were only minimal edits in the cultural probe design and procedure, data from the pilot was included in the analysis with the permission of the participants.

35 individuals (15 female, 20 male) were recruited from a total of 16 different households, with two or a maximum of three participants per home that returned the filled-out cultural probes. In each household, one participant assumed the role of a primary user, and the other(s) assumed the role of a secondary user. Their relationship varied, with most being a couple, and a few being parent(s) with their child. All participants lived at least a year in a smart home, two households used their SHT already for 8 years. The number of devices installed in a home ranged from 11 to 57 (based on a floor plan in which they visualized the location of the devices). In

the follow-up interviews, some participants shared that the real number must be much higher (up to more than 100 devices).

Before conducting the study we created an information sheet in consultation and approved by our corporate data officer, which informed participants about the study purpose and data handling (according to GDPR), as well as a declaration of consent, in which the participants could also indicate if they were willing to participate in a follow-up interview. Our institutions have no ethical approval process, but great care was taken to make sure we collect and process the data correctly. Participants were informed they could drop out of the study at any point without explanation or consequences and could work on the tasks at their own pace. We chose the research approach purposely (cultural probe method over an extended period, combined with follow-up interviews at a later point) to ensure that participants retain sovereignty of their own data and have time to reflect on their answers to correct or hold back information. In a few households, participants asked their children to take part in the study as well. The children were provided with their material for the cultural probes but we did not investigate or inquire private aspects of their experiences. To ensure all criteria regarding data protection concerning minors are met, we consulted again with our corporate data officer. For organizational communication about the study and informed consent, we addressed the legal guardian of the child as a proxy. We further emphasized that children's participation is voluntary and that we do not expect them to fill out all tasks thoroughly. This applied to both the cultural probes and follow-up interviews.

3.1 The Cultural Probe Tasks

The cultural probe kit contained a notebook for each person in the household, with descriptions for each task and blank spaces for answers, as well as a pen, floor plan, overview paper, and other materials. For some tasks, there was an additional paper with instructions or templates to fill in. The participants were asked to perform nine tasks in total, each on a different day within at least two weeks. Some tasks were done individually, others collaboratively, and a few asked participants first to do something alone and then get together to discuss.

For the sake of space, we here focus on those tasks relevant to this article and only give a summary for the others. The first pages of the notebook asked participants to describe themselves in a template and to provide demographic information including name, age, household members and their relations, how long they have been living in a smart home, what hobbies they have, and what their favorite application is. In the following, we report insights from the following tasks:

Task 0: Define: Since there are different views on what a "smart home device" is, it would be interesting to know how you would define it. Your answer may provide an insightful and distinctive perspective. How would you characterize a "smart home device"? (done individually)

Task 1: Locate: Use the floor plan and stickers to locate the devices in your household, and connect the devices as they are connected in the home network (done individually).

Figure 1: Cultural Probe Box with the materials sent to participants.

Task 2: Characterize: Imagine your smart home was a living being, what would it be? (first individually, then discussed with co-inhabitant involved in the study)

Task 8: Simple and difficult devices: Describe the easiest and hardest devices to handle and explain why. (first individually, then discussed with co-inhabitant)

Task 9: Future visions: Look at pictures that show what people in the past thought the future would look like and write down or sketch out how you think your smart home could look and function in 30 years. (first individually, then discussed with co-inhabitant)

The 'definition' task at the beginning of the cultural probes served to gain an understanding of potential differences and how participants draw the boundaries for 'smart' devices. After they provided their point of view, we provided them with our definition of a smart home device to create a shared understanding for the following tasks. We defined a smart home device as being 'mainly located in the home and being able to interact wirelessly with other devices, operate autonomously, via a smartphone app, voice assistant or other devices.' As examples, we listed smart thermostats, smart lighting, smart security cameras, smart door locks, smart sensors, smart speakers, etc. The 'locating' task was designed as a warm-up task, which helped secondary users gain an overview and start a conversation with cohabitants. The 'characterize' task was intended to be creative and fun, to add variety to the tasks, and to enhance engagement. It furthermore aimed to get people thinking about their smart home on a more associative and emotional level. It is reminiscent of popular psychology quizzes that ask people 'If I were an animal I would be ...'. Earlier research has also argued for investigating what metaphors people use to talk about technology (in this case voice interfaces) to inspire design [14]. Moreover, Darling [12] has argued to think about robots (another autonomous technology) in analogy to our relation to animals and pets. We here hoped to elicit responses that would give us insight into the subjective experience of what it was like living in - or with - a smart home. In the analysis, this task helped us to identify the role distribution in the shared household. The 'ease of use' task was to identify participants' preferences and aversions for particular devices of their smart home. The collaborative aspect of this task served to make

the participants reflect on their distinct perspectives based on the roles assumed. Asking participants about 'future visions' was to understand their hopes and fears for the development of SHT, and how they perceive their own agency in shaping the future. This task was thought to inspire, illustrating utopias and dystopias.

Other tasks (not analyzed for this paper) focused on the different roles that inhabitants in a smart home will take on, in particular on differences between those that set up, administer and maintain the devices and the overall smart home environment (primary users) and the other inhabitants (secondary users), which also concerns their differences in attitudes towards specific devices, on experiences setting up devices, their frequencies of interaction with devices, and on how to assist people such as a house sitter with gaining an overview that allows them to control the smart home.

3.2 Follow-up Interviews

The follow-up interviews were conducted after an initial analysis of the cultural probes, which provided topics for the interviews and questions for clarification regarding household-specific responses. We first asked about the participants' experience of the cultural probe study, addressed open questions from their side, and clarified aspects regarding their completed cultural probes, to understand their responses better. Then we discussed how they cope with gaining and keeping an overview of their smart home. We asked how communication about smart home technology takes place, how they deal with changes and malfunctioning, how they reflect on implemented functionalities, and how they plan and envision growing their smart home in the near future.

We conducted the interviews online with a video call in Microsoft Teams (with a GDPR-compliant instance with servers based in Europe) and recorded the conversation with the participants' informed consent. 14 individuals from 8 different households participated in the follow-up interviews. For households where several people participated, all individuals joined sitting together in front of one device for the video call. In such households, towards the end of the conversation, we asked the primary user to leave, so we could talk to the secondary user(s) alone.

3.3 Data Analysis

For data analysis, we utilized Thematic Analysis [8]. The initial steps of digitizing the returned probes, as well as the initial deductive coding of the cultural probe tasks, contributed to familiarization with the data. Then, we approached the data inductively, and coded data in various iterations, using Miro-boards and MAXQDA. Starting to code the cultural probes provided the first insights and topics to discuss in the follow-up interviews, which were then conducted in parallel to the further cultural probe analysis. Next, we transcribed the interviews, first automatically with the caption feature of Adobe Premiere Pro, and then manually, correcting any captioning errors. Finally, all data were analyzed within one MAXQDA project. Again, we assigned the first codes deductively based on the structure of the cultural probe tasks or respectively the interview guide, to familiarize ourselves more intensively with the data. In the next step, we applied more granular inductive coding to support a comparison of secondary and primary users' experiences and form initial topics discovered in the data. The data was analyzed in

several iterations by two of the authors, developing the codes first individually, and then aligning with each other in iterations. The themes were then created by one person and reviewed in discussion together.

As the findings reported here were part of a larger project, in the following, only those themes relevant to the focus of this paper are presented, supported by direct quotes that stem from the listed cultural probe tasks, combined with data from the follow-up interviews. Participants are indicated through a participant ID, which consists of the household ID they belong to, and the role assumed: P for primary user, S for secondary user (numbered if there were two secondary users) (e.g., H1P is the primary user of household 1, H2S2 is the second secondary user of household 2).
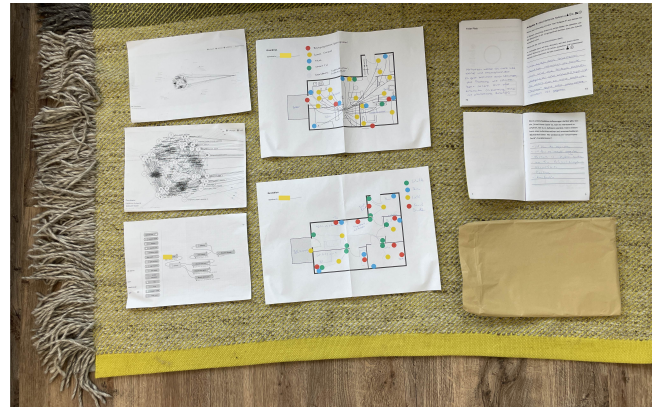

Figure 2: Exemplary returned probe including two floor plans, two filled-out booklets, and additional information provided by the primary user.

4 INSIGHTS ON THE RELATION TO THE SMART HOME

Throughout the cultural probes and interviews, participants provided information on how they define a smart home, and how they feel about their relationship to the technology. We gained insights into the goals they pursue with purchasing SHT and for what purposes they use connected devices predominantly. Further, we understood their visions for the future, to which some look forward and some voice concerns.

4.1 Defining Smart Home Technology - 'Smartness' as a Vision Not Yet Achieved

The cultural probes had asked how participants define SHT and we had also delved deeper into this in the interviews. Smartness was related to connectivity, remote access, prediction of user needs, and automation. A surprising insight was that, especially for primary users, 'smartness' only appears to be partially achieved, and that current smart home usage does not yet fulfill their criteria for real smartness. The most dominant characteristic of a smart home, according to our participants, is its connectedness; that it *"can be combined with other devices"* (H12P). Many users understand SHT as a tool to achieve multi-modal interaction, specifically remote

access and voice control. *"Through our smart home, we can control everything by voice or on the move with the app"* (H10S1), *"A device that I can operate in different ways (app, switch, sensor) and that is networked in the household"* (H15P).

Some users would expect from a smart home that most events occur automatically after they define the conditions once. *"[A smart home device] can be set up in such a way that, in the best case, everything is triggered and controlled without me having to do anything. Regardless of whether it's via time control or other triggers."* (H10P), *"Once set up, it does the thinking for me."* (H8S). A few participants mentioned that a smart home constantly senses and collects information to predict their actions and needs: *"A place that 'knows' me and can 'cater to' or take into account my requirements, respectively a device, tool, intelligence that learns from when/how I do things"* (H11P), *"It should know by itself what I want without me having to do anything additionally"* (H10P).

In the interviews, several primary users emphasized a vision of implicit interaction with a smart home via automation, as in the previous participants' quote on SHT 'knowing by itself what I want'. Some commented on features used by their cohabitants, specifically children, and argued that accessing a connected device through a provided user interface is not yet characteristic for smart homes: *"Sure, they give the commands 'Play me the song, play this music story and these things', but that's pretty much it. So the children use it a lot, but it's not exactly a smart home."* (H14P). H10P said about his daughter: *"She mainly uses the Echo here as a speaker to listen to her music or to switch lights on and off. Real scenarios or automation, how they always work specifically, that's not really her thing yet, but I think that will come naturally with age"*. Smartness occurs according to H14P rather invisibly or automatically without human intervention: *"it's the things that run by themselves. Ultimately, the roller shutter switches have two functions: on the one hand, they really do function as ordinary switches on the wall [...] but the variant where the shutters also close because the temperature is too high or something like that is more likely, or that's definitely part of it. It's this smart, intelligent thing. For example, we have a rainwater cistern, the domestic water system is now also connected to it [...] it's just a switch, but the smart thing is that it always shuts off after an hour after being switched on, for example, in case you forget and leave it on overnight"*.

The definitions provided about smart home technology in the cultural probes concern mostly remote access and rule-based connectivity. From the perspective of primary users, however, 'smartness' seems to begin with automation; once set up, the home acts on its own. In conversation, they argued that what they currently have installed at home, and what the secondary users interact with and see as smart, does not yet align with their definition. Primary users consider their current implementation only as the foundation and infrastructure to build their vision. They seem to consider explicit interactions, even if the switch press is replaced with a voice command as not 'smart' yet. In this sense, using connected devices, including voice assistants controlling the music or shutters is not yet 'smart' from the primary users' point of view.

4.2 Purposes of SHT: Protection, Productivity, and Pleasure

Many definitions of SHT that participants provided in the cultural probes contained aspects regarding what purposes a smart home device fulfills from their perspective. The stories they shared in the follow-up interviews completed this picture. Overall, the goals achieved with SHT align with the 3P of 'Protection', 'Productivity', and 'Pleasure' discussed by Strengers et al. [48]. As overall purpose, the smart home *"simplifies day-to-day tasks"* (H14S2, H9P, H4S, H1S), *"helps with the 'house organization'"* (H14S1), *"makes everyday life easier by automating decisions and carrying out actions"* (H16S) and *"supports in the daily 'doing' and takes on tasks independently"* (H13P). The most common use case was to monitor devices to provide information about the house or appliances, for instance, when laundry is finished (H10S1, H14P, H6P), if windows are still open (H14P), fire and water damage alarms (H14P, H6P) or when the doorbell rings (H2P). In doing so, SHT primarily increases the comfort of activities instead of taking them over ('Productivity'). Accordingly, some secondary users did not initially consider the smart home necessary. *"At the beginning, I always said we don't need it, I can manage just fine, but once you have it, it's a relief"* (H14S1). *"And then at the beginning I was thinking like: do I really need that or do we need that? [...] And then it just so happened that when he did it and he applied it, I kind of like surprised like I actually - It's actually good now"* (H11S).

Next to facilitating household chores, SHT is used to save resources (also 'Productivity'): *"Well, almost everything that is on standby is switched to switchable sockets, simply to save energy. And this is mostly done via either Alexa or Google Home"* (H4P). *"I also have a heat pump and warm water control depending on the presence of people, which in turn I have linked to the consumption of watts at certain sockets"* (H2). For some people, this covers also 'Pleasure'. For instance, H11P enjoyed the technical challenge and monitoring energy consumption, initially checking the data daily: *"How much power did the heat pump use? [...] I also added additional sensors via this Home Assistant, because the manufacturer didn't intend for the end customer to be able to see whether it was doing what it was supposed to do at the time it was supposed to make optimum use of it in combination with the PV system. That's when the technical interest in connection with the hobby was there"*. Setting up a smart home often accompanies other major changes within a household (e.g., installing a heat pump, renovations (H6), or moving to a new home (H4, H12)).

For secondary users, 'Pleasure', for example about light settings, seems to enhance the openness to SHT. *"At first, she was against the whole smart home thing, and then at some point more and more was added. And then the lamps were suddenly cool, which weren't so nice before because they're so colorful and everything"* (H12P). However, discussing inhabitants' relation to the smart home with them revealed that the categorization in the 3Ps seems to be subjective: for example, cameras that seem to be sold for 'Protection', actually provide 'Pleasure': *"It's just a curiosity function, that's all it is. I wouldn't exactly say that we live in a neighborhood at risk of burglary"* (H6P). *"Well, the whole house is full of cameras, but not because of thieves or anything like that, because once they're inside*

it's too late, but because of the cats. And when we're on vacation, we watch them and what they do" (H12P).

Similar to what has been found in prior research, several participants underlined that setting up SHT is a leisure activity for the primary user and thus, rather tolerated than required from the perspective of secondary users [42, 56]. Asking H1S what the smart home is for her, she laughed: *"My husband's hobby? I'm glad that he's happy about it. And he's always doing new things. And everyone needs something to do, he enjoys it"*. H6P described that his partner accepts the smart home, arguing *"according to the motto, 'Let the boys have fun'. That's his hobby"*.

Still, our participants reported using SHT to provide and convey safety and security for the home (H12, H6, H14). *"So the alarm system is more for reassurance because I work shifts [...] it's just a better feeling for her when she switches on the alarm system in the evening when she goes to bed [...] we can find out if there's anything wrong, which is more reassuring than hearing noises"* (H12P). This view is confirmed by the co-inhabitant: *"if we're on vacation, he has programmed it to turn on at a certain time and then switch off again early. We set it to full protection and then we know that the house is secure"* (H12S). Taking care of children and babies is a further use case for SHT aligned with 'Protection'. H12S, for example, initiated to use of sensors: *"especially now with a child and also in summer, that we can see everywhere what the temperature and humidity is in the rooms"* (H12P). *"[In our home], I find it pleasant. Especially when you're out and about and you know the children are coming home, then I know they've arrived, for example"* (H14S1). However, especially secondary users shared doubts about the usage of cameras: *"But basically, I'm not that much of a surveillance freak. [...] So I would assume for myself that if I went outside onto a property and saw it was under video surveillance, then I just wouldn't, I don't know what that feeling is. I just feel like I'm being watched* (H14S1). *"Especially in the middle of the night, I get hungry and I want to go to the kitchen. Even if there's no light, I feel like, okay, someone is, it's the camera, [is following me]"* (H11S).

Our investigation of how participants relate to individual devices and functionalities indicates that it is not always clear which of the '3Ps' a device covers objectively. When reflecting on their attitude, participants sometimes revealed ambiguous feelings about a device, especially when considering in what different roles they could encounter the devices, or confessed to using 'functional' security devices for their own entertainment and curiosity. Especially 'Pleasure' seems to be a purpose that motivates individuals to get engaged with SHT. The latter mirrors prior research that found people using smart home cameras as multi-functional technologies [20]. Tan et al. mentioned that many primary users set up SHT with the argumentation that they would not mind being recorded if the cameras served their protection, and assume the same applies to the secondary users in the home [20]. Accordingly, secondary users typically often lack consent and benefit from smart home cameras [20], which is in line with many statements of our secondary user participants.

4.3 Different Foci and Experiences Depending on Users' Role

One of the key aims of our study was to investigate not just the primary users' experiences, who 'drive' the adoption of SHT, but to also investigate the experiences made by the other household inhabitants. Across the various probe tasks, clear differences emerge. Several primary user participants highlighted compatibility as a pain point for setting up the SHT. *"Communication with devices from another 'cosmos' is mandatory"* (H6P). Further, we have already reported that primary users highlighted implicit interaction via automation as a key feature of 'smartness'.

Such differences became salient especially when asked about the 'ease of use' of devices, where primary users related 'ease' mostly to the setup and installation, whereas secondary users related this question mostly to operational usage. This pattern repeated when participants were asked about their vision for the future.

Given that it is usually the primary users that purchase, install, and configure SH devices, it is to be expected that secondary users have less to say about installation. However, it is noteworthy that primary users do not reflect much on operational usage. In particular, they continue to see themselves as the main operator and device manager for setup and maintenance in the future. This may be partially because they envision the home to be fully automated and reacting implicitly to users' needs (or reading their thoughts), while still anticipating that their role of setting up and configuring the smart home prevails for now.
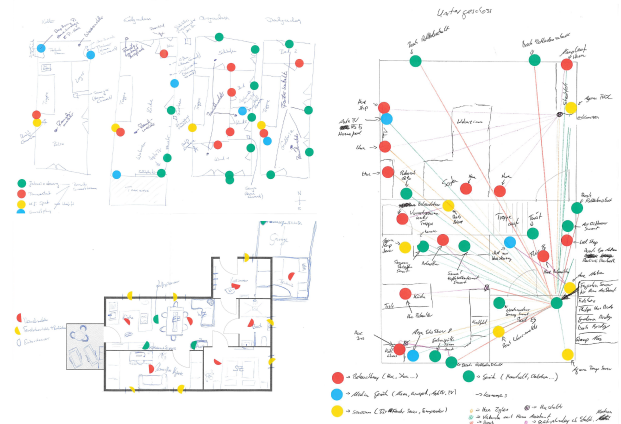

Figure 3: Examples of participants' floor plans visualizing the distribution of their devices and connections.

4.3.1 Knowledge about Devices versus Knowledge about the Network. The exercise to locate the devices in the shared home and visualize their connections was initially thought to be solved first individually and then discussed among the participating cohabitants. However, several households reported that they quickly moved on to collaborative work or that the secondary users updated their floor plans after the primary user shared their results with them. As shown in figure **??**, secondary users (on the left) primarily sketched the location of individual SH devices on the floor plans, whereas most primary users also sketched network connections (right side).

This illustrates the differences in depth of understanding and indicates that there may be different mental models, with secondary users being aware of individual devices as isolated entities, and not understanding the network character of SHT.

4.3.2 Perceived Ease of Use Depends on Users' Roles. Although two questions about the hardest and the easiest device were phrased in the same style, most secondary users related 'the easiest device' to everyday usage of SHT, and 'the hardest device' to setting up SHT. In the cultural probe, some secondary users emphasized the primary user's effort while answering this question: *"For me, they are all the easiest to use because my husband sets them all up and I just have to operate them"*. H11S explains that *"it requires a lot of patience, time, effort and knowledge or know-how to be able to integrate all devices at the same time for them to properly work together"*. H9S summarized: *"The use of the equipment in our house is set up in such a way that everything is easy to use. If I had to configure something, each device would be too complicated. This shows 2 faces: if well and thoughtfully adjusted, a smart home can help, but there must be someone who sets it up and understands the logic, and thinks up and implements the scenarios. I'm the one who just uses it"*. This argumentation creates the impression of themselves denying their experiences in everyday usage due to the 'inferior' role they assume, just like the primary users do when they argue that their current state is not yet 'smart'. Although we asked for their experiences with 'difficult devices' we hardly received answers about the struggles of controlling a device, even though we know from prior research that it is disruptive for secondary users [16, 42].

Primary users emphasized setup aspects and did not mention everyday usage with devices when asked about the hardest and easiest SH devices. For instance, H11P remarked: *"[The easiest device is the] radiator thermostat, Once set up, you're done"* and H4P: *"Smoke detector: Simply scan the QR code and mount the detector on the ceiling"*. Secondary users, on the other hand, focused rather on the operational side, for instance, H14S2 remarked: *"[Voice assistant]. All you have to do is talk and adjust the volume"* (H14S2) and H6S: *"The light control with voice is easy to use. It works well when you call the right names"*.

The follow-up interviews revealed the need to reflect on the underlying motivations behind participants' replies. Considering a device, such as a voice assistant, as their easiest device to interact with does not necessarily mean that it works smoothly and is pleasant to interact with. H6P reasoned that the answer reflects the limited involvement of his partner: *"A few voice commands. So: lights on, lights off. She swears a bit because she just doesn't like it that much. She accepts it that way. [...] Sitting in the living room and switching the lights by voice command, that's what she does. And that's where it ends"*. H10P shared his frustration from watching only: *"My girlfriend, who originally didn't want it at all, now only uses voice control, so I always get upset, especially when she somehow says something five times and it doesn't work and she's actually sitting halfway next to the switch"*. This raises the question of what motivates the secondary users to choose this interaction modality despite being tedious.

4.3.3 How Participants Imagine Smart Homes in the Future. In interviews and the final task of the cultural probes, participants shared how they envisioned their smart home to evolve in 30 years. Visions for the future included ubiquitous voice control, increased automation and implicit interactions, and even thought control.

These visions mostly extended current technology trends, anticipating voice control to become the dominant mode of interaction, and that features from Alexa or Siri would be seamlessly integrated. They also anticipated increased automation, relying on implicit control *"Many things will work with voice, image and video recognition without explicit input, AI will gain a lot of ground"* (H11P), implants (e.g. implanted RFID) or wearables so that the rooms react to presence (H6P) or even thought-control *"Thinking is doing (think of it + it does it for you)"* (H11S), *"The houses/apartments 'think' with you"* (H6P) through brain-computer interfaces. These answers reveal a split between anticipating more explicit control modes and more implicit interactions, raising questions regarding users' level of control.

Most primary user participants concurred that in the future every home will be smart. Primary users see themselves as pioneers who equip themselves to be prepared: *"The Future is Now! I think my self-built sensors will be standard in every apartment of the future."* (H16P). Some believe that *"at one point, it will be kind of forced because all the new devices have it. If you want to use it or not, they will have it. And somehow even if you don't connect it, they will be connected automatically. Without you knowing it at the end"* (H1P). This perspective is in line with a recurring theme Wilson et al. recognized in a systemic literature review of smart home publications: equipping all kinds of devices with computational capabilities is understood as another wave of electrification, and will thus spread throughout society [54].

This reveals a pessimistic perspective regarding users' ability to remain in control. Respectively, some respondents expressed a desire for a balance between automated convenience and personal engagement *"The current facilitation in everyday life is certainly useful and pleasant, but not everything has to be controlled by technology"* (H14S1). In particular, secondary users appreciate the idea of automating tasks such as laundry and cleaning but underlined that some activities should remain with humans (e.g., cooking and social interactions). *"But actually, I think it's good if you still do a lot of things yourself. For example, cooking, showering, going to the hairdresser with whom you can talk"* (H10S1).

Mirroring answers on the 'easiest' and 'most difficult' devices, users expressed different expectations and hopes for the future aligned with their user role. While primary users shared hopes for standardization via *"centralization in one app"* (H3P) and industry collaboration *"manufacturers will have to give up their blockades and cooperate more"* (H9P), secondary users hoped for *"making household chores easier"* (H12P), such as *"the floor automatically detects dirt and prompts the mopping robot"* (H10P).

This reflection on wishes and fears for the future highlighted the different relations smart home users develop with their homes depending on which role they assume. Users who see the technology as a tool to control devices and facilitate household chores seem to be rather hesitant, aiming for a balance in automation. Others, especially those who relate to the devices from a setup and maintenance perspective, show a far more technology-deterministic point of view, either adopting IoT technology for the home, so as to be

prepared for the future or seeing themselves as shaping the future actively.

4.4 Sociomorphing the Smart Home - the Connected Devices as a Living Entity

Prior research in Human-Robot Interaction has observed that people develop proto-social relationships with autonomous technology and ascribe social agency to it [6, 45, 57]. To a certain degree, this is also visible in our data, albeit not as strongly as in observational studies, especially in interaction with robots. In the cultural probes, we asked participants what living entity their smart home would be if it were a living being. With this prompt, we attempted to steer people away from the tendency to anthropomorphize 'intelligent' technologies and to rather invite 'sociomorphing' [7, 43] metaphors. The answers reveal insights into the kinds of relationships and emotional connections to the technology, as well as highlighting characteristics of the technology perceived as prominent.

In one household, the participants reported struggling with this task and characterized specific devices with a living being, mostly based on their functionalities (e.g., *"robot vacuum cleaner = elephant, vacuums everything"*, *"heating = alternately warm animals"*). The other participants selected one species to describe their smart home network as one entity, which are the findings that we focus on in this section.

Responses ranged from beloved pets with whom people share a familial bond, perceiving the SH as a larger community of animals, to rather alien creatures. One frequent cluster of metaphorical associations concerned pets (16 mentions) emphasizing that the SHT has become a part of the family home: *"Dogs are man's best friend"* (H11S), or a cat that is *"somehow part of the family"* (H16S). These animals have the characteristic of sharing home life with human inhabitants and being domesticated. More unusual pet metaphors included a parrot that (*"answers"* (with voice)(H14S2) and the mention of a spider could also be interpreted as a pet (an *"inconspicuous, constant companion"*) (H13S).

One participant envisioned a beehive (here it is unclear whether this could be interpreted as a pet with the primary user as a hobby beekeeper), arguing that *"bees do not live alone, they are a community and work together. Together they build their home and take care of it. They also take care of the queen, which is the control center"* (H11P). The smart home systems in H11 and H16 were the most advanced and enthusiastically described by the primary users in the follow-up interviews. H11P added to his beehive description that *"honey is delicious"*, potentially pointing out the benefit the smart home holds for him in the form of 'Pleasure'. Also, H16S described her relationship to the smart home that her partner created and she characterized it as a cat: *"most of the time it's really cool, you're proud of it"*.

On the other hand, another cluster (14 mentions) includes animals that do not live with humans, (octopus, elephant, chameleon, a flock of orcas, or an ant colony), as well as aliens, thus including an element of estrangement and otherness. The expressed reasons for choosing pet-like and non-pet metaphors are often related to other characteristics. Ants, bees, and orcas are well organized by communicating with their peers, dogs and monkeys can be taught things, and elephants and monkeys both have a good memory.

The most prevalent metaphorical association (listed 14 times) was a dog. However, only one person explicitly described an affectionate relationship: *"Dogs are man's best friend. It protects me. It understands what I need and feel. It provides me comfort. It entertains me. It values my well-being. It is always there when I need it"* (H11S). The other participants referred to more functional roles of a dog, such as: *"A shepherd dog. It protects the house, is vigilant and loyal. Its main task is protection, just as a shepherd dog protects its flock. In a way, the smart home also protects us via intelligent security technology"* (H4S), being *"vigilant"* (H7P) or *"a guide dog. It supports people, you can rely on it, it helps you to cope with the day/trip. It's trained once and from then on it can support you independently. It's also capable of learning"* (H13P). In particular, dogs being teachable and *"obedient"* (H16P, H10S2, H6P, H5S2, H5S1, H2S, H2P) by executing commands (H14P, H13P, H12S, H10S2) were the most mentioned characteristics with regard to dogs, thus relating to the ability to program (and thus train) SHT. The same traits, learning, and intelligence were central properties ascribed to a monkey (listed 4 times). *"You can train it and it can then do things that you would otherwise have to do manually"* (H8P). *"A clever monkey. It can do as much as it is taught, performs with natural instinct, and thinks slightly beyond the horizon"* (H12P).

Further, an octopus (4 mentions) was chosen for its skillfulness and its ability to reach out to different things simultaneously with its (networked) tentacles: *"My smart home would be an octopus. One brain and many arms that are controlled by it. Each arm knows what the others are doing and can act together as one"* (H10P). Similarly, a participant mentioned extraterrestrial creatures: *"Alien - with many arms, it can adjust everything on a large tablet"* (H6S). Notably, both metaphors do not associate with a pet or anything cute and homely. Furthermore, a chameleon (H3P) was chosen for its ability to adapt to any situation or challenge. Another metaphor that - even if living in the home - might be perceived as strange or even scary was that of a spider *"Small, easily removable - quiet, stylish - fast, flexible - repairable - inconspicuous - compatible - extensible - constant companion"* (H1S).

Across all these animals, participants also mentioned the limits of their abilities and failures. Some participants blamed the lack of intelligence on the SHT: *"An octopus that does exactly what you call it to do with its tentacles. Sometimes it gets its tentacles mixed up, resulting in mistakes"* (H9P). Others blamed the 'personality' of the smart home, expressed in stubbornness: *"[The dog] may also be stubborn and not do some tasks the way you want or simply not understand some things"*. Having their own will was a dominant characteristic for cats: *"they want to be pampered and fed, but are not always there, often unexpectedly gone. But most of the time it's also very cool, you're proud of it, somehow part of the family"* (H16S) and *"It's a tiger. Depending on its mood, you can use it or not"* (H9S). Others held the primary user responsible: *"The smart home is only as smart as the owner (that) operates and adjusts it"* (H12S).

Some participants envisioned their smart homes as a broader ecological system, mirroring the cooperative behavior of various living creatures (5 mentions overall). This metaphor highlights the interconnectedness of devices required for the smooth operation of the smart home. Three metaphors concern animals that live in groups and collaborate for the survival of this group, namely ants (2 times), bees (2 times), and orcas (1 time): *"It would probably be*

an orca. It's big and learns within the group. It's also very smart and always finds a solution. And if it doesn't, it is taught by the others via the community" (H4P). The rationale for choosing 'ant colony' was very similar to this *"every living being has its task and contributes with it to the 'big whole'"* (H1S). Further, participants referred to the ubiquity and invisibility of SHT: *"An ant is small, functional, strong, inconspicuous, versatile, works a lot, knows exactly what it has to do within its group without losing track of things"* (H14S1). This aspect was also present in the spider metaphor (small, quiet, inconspicuous) and bees.

Character traits that were mentioned frequently thus include: teachable (dogs, monkeys), learning and intelligent (dogs, orca, monkey), vigilant and protective (dogs, orca flocks, bees), supporting and comforting (guide dog and family dog), part of the family (cat, dog), moody and stubborn (cat, tiger, dog), invisible and inconspicuous (ants, spider), adaptive (chameleon), acting as a unit (ants, orcas, bees) or multi-armed and/or able to act at a distance in coordinated ways (octopus, bees, ants, alien). The references to cats and most of the dogs were given by secondary users, emphasizing a social connection to humans by being held as a pet. Primary users more frequently relied on metaphors that underline the efficiency achieved by connectedness and the capabilities of individual entities, such as units of animals and octopuses.

5 DISCUSSION

Prior research has revealed that it is the primary users (who set up and install the SHT) that actively control and configure their smart home, with other household members taking a more passive role [16, 18, 25]. As a consequence, secondary users lack access, control, feedback, consent, awareness and benefit [20, 25, 42] from the cohabited smart home. Furthermore, secondary users are exposed to increased risk or harm in case of malfunction or privacy breaches, non-primary users [16, 20]. Accordingly, also in routine life, primary users, who set up the devices and maintain the network [56], might encounter the SHT from a perspective that differs substantially from the experience of secondary user's everyday usage in many ways.

In our study, this difference in perspective of primary users and other inhabitants (secondary users) who assume a more passive role of 'mere users' ran across all themes and findings reported. Depending on their role, participants described SHT in different ways. This was most visible when participants reported on the device they found easiest and most difficult: While secondary users tend to focus on operational usage in their answers, primary users focus on setup and installation. Primary users further emphasize implicit interaction and automation as features of 'true' smartness in SHT, a phenomenon that continues into their visions of the future.

Regarding the purposes of smart homes, our findings confirm observations from prior research [48, 56, 58]. Firstly, they confirm the relevance of the 3Ps: 'Protection', 'Productivity', and 'Pleasure' [48] as goals. Secondly, we found that primary users gain pleasure from the very aim of setting up a smart home, as part of a mission to achieve real 'smartness'. In an analysis of industry visions for smart homes, Strengers and Nicholls found that the technology is advertised as simplifying domestic life by improving energy efficiency

and creating pleasure through customization [49]. According to the authors, vendors acknowledge the complexity of setting up a smart home and especially promote the convenience SHT can achieve, once customers understand the opportunities [49]. Our primary users might have internalized the vendor's promises and see themselves as enablers for the future when they argue that they are ahead of commercial solutions with their DiY smart home set-up. According to primary users in our study that aim to achieve a fully automated home, explicit interactions will not be necessary anymore in the future, because the desires and needs of inhabitants will be anticipated. Secondary users, in contrast, consider SHT rather as a tool to achieve new operational modalities (mostly voice and remote control). In the follow-up interviews, we gained the impression that based on these conflicting views, primary users considered secondary users' interaction with SHT as 'not yet smart', because (in their opinion) true smart interactions should be implicit. In a way, this denies secondary users' experience of interacting with SHT the status of a valid experience, worthy to take account of. In doing so, primary users might see it as their mission to educate secondary users, by demonstrating the opportunities of SHT to achieve 'lifestyle convenience' as advertised by the industry [49].

In some ways, the vision of primary users to achieve a fully automated home resembles the vision of Ubiquitous Computing [53]. A central characteristic of UbiComp is the 'invisibility' of technology [15, 53] – which is also a goal that our primary users work towards, especially when they hope that maintenance work should disappear completely in the future. Dourish and Bell [5] pointed out that despite the constant progress of research, the research community constantly posits the 'UbiComp era' as something still to be achieved, an ever 'proximate future' that is always placed just out of reach. UbiComp is a moving goalpost - very similar to how current primary smart home users see 'smartness' as not quite there yet. Bell and Dourish further emphasized that, even if some systems might appear to be invisible to their users and function seamlessly, the individuals maintaining them always see their messiness [5].

Currently, the messiness of SHT is probably very visible to primary users doing digital housekeeping that requires technical expertise (which is labeled masculine) [42, 46, 47]. Rode et al. forecast that over time, when technology becomes commonplace in domestic places, women will take over the technical work and these tasks will get labeled as feminine [40]. Primary users that work towards the vision of invisible technology, simplifying digital housekeeping, thus might contribute to increasing the amount of future 'invisible labor' performed by women to keep domestic life running [13, 40, 49].

Regarding the relation of individiuals to SHT, asking participants to describe what their smart home would be if it were a living being, yielded a (for us) surprisingly rich menagerie (or zoo) of (mostly) animal metaphors. Seibt et al. use the term 'sociomorphing' for the direct perception of non-human social behavior - humans intuitively interpret autonomous entities in social ways [43]. How humans interact with animals is a prime example of sociomorphing [43]. Almost all participants in the cultural probe study provided an animal reference (and not a plant, which although being living beings, usually do not react directly to intervention or communicate, and do not move in observable ways). Notably, even if the question design had not ruled out human metaphors, none of the participants

named a butler or other type of servant, or any human-type role. This is different from earlier studies that asked participants to provide a metaphor for voice interfaces [14].

It could be argued that in describing cats as stubborn or tigers as moody, participants still tended to anthropomorphize these animals, but our prompt elicited a variety of animals, including entire flocks or hives, and around half of the participants alluded to animals that we humans have little everyday understanding of and relation to. The frequent referrals to non-pet animals point to the potential of the 'otherware' approach for the design of artificial counterparts, which calls to "cultivate the otherness of computational counterparts rather than to mimic existing lifeforms" [22, 26]. The call for 'otherware' asks to create alternatives to anthropomorphism and zoomorphism to avoid reinforcing stereotypes, that nevertheless rely on animism and imply a relationship between humans and technological artifacts, and to investigate what would be appropriate interaction paradigms for communicating with such 'third species' [22].

Most of our participants relied on zoomorphic metaphors since they did have to draw on existing experience - we cannot expect users to come up with ideas for 'third species' easily. However, although many mentioned animals such as octopuses, whales, ants, or bees which are existing lifeforms, they are still foreign to us and have an element of 'otherness'. Some participants even labeled the SHT as being an alien. The 'otherware' analogies were more often described by primary users. A reason might be that relating to these species might require more expert knowledge than for example with a cat or a dog - the initial handling might not be intuitive to humans in everyday life but if you examine them more closely, they hold a huge potential for fascination and inspiration.

Although we purposely asked participants to describe the smart home as a living being, many chose a pet. A reason might be the effort in digital housekeeping that could provide an analogy to having a pet: even after establishing it as part of domestic routines, it requires continuous attention that is acknowledged by all cohabitants. The pet metaphor was mostly selected by secondary users, who more often face difficulties in handling SHT in everyday life than primary users [16, 25, 42]. For them, the metaphor might underline the hobby component: just like a person will usually accept their partner's pet when in a relationship, in a previous study secondary users shared that they accept living in a smart home if they have a relationship with a smart home enthusiast [42].

Ehrenberg et al. [16] suggested that secondary users might feel frustrated about certain aspects of a smart home created by a primary user and that when they perceive the SHT as an active agent, they see the home as exercising power and control. Thus, the smart home becomes the recipient of users' emotional responses, who lack a counterpart to discuss or fight with. Besides, some secondary users argued that the relationship between themselves and their smart home is determined by SHT being their partner's hobby. In earlier research, secondary users shared that they consciously hold back from engaging with the smart home because they do not want to interfere with their partner's hobby [42].

5.1 Limitations and Future Work

The difference in perspective and understanding of smart home technology is a natural result of the fact that primary users dominate 'digital housekeeping work', but also has consequences for any research that aims to create a more equitable situation. The design of user studies in this context thus may need to adapt to participants' roles. Although we tried to accommodate these effects, we faced challenges in our recruitment process and while reaching out for follow-up interviews: as primary users were typically the main communicators with us, we relied on them to initiate conversation with secondary users. Moreover, while it is always difficult to keep participants engaged with research material for a longer period (our probe study was to take 2 weeks at minimum), we noticed that secondary users tended to provide less information (e.g., not answering questions or referring to their partner's description). To avoid the follow-up interviews being dominated by primary users, we attempted to engage more with the secondary users by talking to them alone towards the end. Still, secondary users were more likely to be less interested in participating in research activities or often referred in their answers to the primary user.

Furthermore, our study took place in Germany with most participants living in Germany for most of their lives. Thus, our research only covered Western European perspectives. Moreover, participants were mostly couples living in heterosexual relationships. A few participants lived in a nuclear family, but the perspectives of children and parents were not specifically covered. Future work should cover a more diverse range of participants across various aspects (e.g., gender, relationship type, form of cohabitation, (dis)abilities). In doing so, special attention needs to be paid to the complex dynamics due to different roles in shared households, their relation to each other, and the SHT, since they impact research activities as well as individual experiences with the smart home themselves.

6 CONCLUSION

Our study provides insights into how individuals relate to smart home technology installed in their shared homes, and into differences in perspective between primary and secondary users. Through cultural probes and interviews, participants (both primary and secondary users) reflected on their attitudes and beliefs. When investigating how primary and secondary users experience, perceive and understand their smart home, we realized that trying to capture the experience and opinions of both user groups equally is a challenge: Even if the research design aims to have secondary users heard, they seem to hesitate, reject to engage in the activity or refer in their answers to the primary user who thus, still dominate responses. Nevertheless, it is crucial to capture secondary users' concerns, wishes, and preferences with regard to SHT, as primary users otherwise overrule their cohabitants through their enhanced power of the system. Researchers thus need to invest increased effort and creativity to find appropriate methods to consider the complex dynamics of individuals and user roles in shared households.

Next to gaining descriptive information, such as how people define smart home technology, our research design included tasks that aimed to elicit inspirational data. The different future visions

of primary and secondary users highlight tensions that might come up in shared households while expanding the smart home. How participants describe their smart home network as a living being gave insights into what characteristics they perceive as dominant and how they relate to their smart home. Participants mostly described either pet-owner relationships between users and their smart home or chose animals that are known to live as a community (e.g., bees, whales, and ants). These metaphors can be used by the HCI community as a foundation for future research and inspiration for design analogies. Especially for depicting connected and interactive systems as 'otherware' [22] instead of relying on traditional zoomorphic and anthropomorphic approaches, the metaphors chosen by our participants might be useful. At the same time, incorporating users' impressions of the relationship to their smart home might help to start conversations among user groups or their mental models, in research or system design.

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