# Protection, Productivity and Pleasure in the Smart Home

## Emerging Expectations and Gendered Insights from Australian Early Adopters

**Yolande Strengers**
Faculty of Information Technology
Monash University
Melbourne, Victoria, Australia
yolande.strengers@monash.edu

**Jenny Kennedy**
Digital Ethnography Research Centre
RMIT University
Melbourne, Victoria, Australia
jenny.kennedy@rmit.edu.au

**Paula Arcari**
Centre for Urban Research
RMIT University
Melbourne, Victoria, Australia
paula.arcari@rmit.edu.au

**Larissa Nicholls**
Centre for Urban Research
RMIT University
Melbourne, Victoria, Australia
larissa.nicholls@rmit.edu.au

**Melissa Gregg**
Client Computing Group
Intel Corporation
Portland, Oregon, USA
melissa.gregg@intel.com

## ABSTRACT

Interest and uptake of smart home technologies has been lower than anticipated, particularly among women. Reporting on an academic-industry partnership, we present findings from an ethnographic study with 31 Australian smart home early adopters. The paper analyses these households' experiences in relation to three concepts central to Intel's ambient computing vision for the home: protection, productivity and pleasure, or 'the 3Ps'. We find that protection is a form of caregiving; productivity provides 'small conveniences', energy savings and multi-tasking possibilities; and pleasure is derived from ambient and aesthetic features, and the joy of 'playing around' with tech. Our analysis identifies three design challenges and opportunities for the smart home: internal threats to household protection; feminine desires for the smart home; and increased 'digital housekeeping'. We conclude by suggesting how HCI designers can and should respond to these gendered challenges.

## CCS CONCEPTS

• Human-centered computing → **Empirical studies in HCI**;
• Human-centered computing → **HCI theory, concepts and models**;
• Human-centered computing → **Personal digital assistants**;
• Social and professional topics → **Gender;**
• Networks → **Home networks**

**KEYWORDS:** Gender/Identity; Smart Environments/Connected Home; Ethnography; Home


*CHI 2019, May 4–9, 2019, Glasgow, Scotland UK*

ACM ISBN 978-1-4503-5970-2/19/05…$15.00
https://doi.org/10.1145/3290605.3300875

**ACM Reference format:**
Strengers, Y. Kennedy, J. Arcari, P. Nicholls, L. Gregg, M. 2019. Protection, Productivity and Pleasure in the Smart Home: Emerging Expectations and Gendered Insights from Australian Early Adopters. In *2019 CHI Conference on Human Factors in Computing Systems Proceedings (CHI 2019), May 4–9, 2019, Glagsow, Scotland, UK.* ACM, New York, NY, USA. Paper 645, 13 pages. https://doi.org/10.1145/3290605.3300875

## INTRODUCTION

As Katuk et al. [42] and others have noted, smart home market growth has been slower than expected. This has been attributed to the 'glitchy' nature of devices, interoperability and compatibility issues, affordability challenges, and general concerns over usefulness and desirability [29]. Similarly, industry commentators have suggested that the smart home industry is "a solution in search of a problem" [22; 32], afflicted by the technological 'solutionism' critiqued by Morozov [51]. Another key challenge for the smart home industry is that there has tended to be a technical 'guru', commonly a man, who brings smart technologies into the home, and is responsible for setting up, maintaining and introducing them to other householders [34; 54; 77]. However, interest beyond this guru is limited.

Encouraging a broader range of households to adopt and use smart home technologies remains a key concern for the industry. What makes the connected home business distinctive from other technology industries arising from PC or media consumption, is a convergence of household security solutions and automation. Currently a gap exists between the depth of anthropological research in HCI that relates to computer use in the home and the new imperatives of voice and vision that drive the aspirations of home security and automation companies. Like the PC business, this industry sector is marked by an absence of senior women leaders [15]. But unlike the technology industry, there are few instances of product innovation drawing on social science research from a gender or

feminist studies perspective [41; 63]. This paper continues the work of understanding gendered usability differences in the home by investigating how smart technologies are being incorporated into Australian householders' lives and whether they are viewed as 'useful' and desirable 'solutions'.

The paper analyses smart home households' encounters with new devices in relation to three concepts central to Intel's ambient computing vision for the home: protection, productivity and pleasure, or 'the 3Ps'. These refer to experiences centred on: i) **protection** of the home and householders; ii) **productivity** in the work of running a household; and iii) activities that constitute fun and **pleasure**. Protection devices include smart locks and livestream cameras that aim to secure the home, its contents and occupants. Productivity and multi-tasking devices include digital home voice assistants, such as Google Home and Amazon Echo "Alexa", as well other controllable devices that allow for improved and easy functionality via smart apps or voice control. Pleasure enhancements include smart mood-setting colored lights, automated water features, and connected entertainment devices. While it is not a complete categorization of all smart home devices, the 3Ps encapsulates the bulk of products and functionalities currently available in the smart home market.

Our aim in this paper is twofold. First, we seek to understand how a group of early-adopting smart home households understand and experience the 3Ps in their everyday lives, by drawing out their complementary and contrasting perspectives through case studies (included as Supplementary Material). Second, we draw on these perspectives to identify gender challenges and opportunities for HCI designers to develop smart home devices for a broader range of potential users and their expectations. The remainder of our paper is organized as follows. We continue by identifying how prior work in HCI has foregrounded the tech-oriented masculine guru in smart home research. We identify our concern that a broader range of users, and especially women, are underserved by the industry. This informs our digital ethnography methodology which is described next. In Findings we discuss how Australian households understand and experience the 3Ps, paying particular attention to gender. We identify three gendered HCI design challenges and opportunities: internal threats to household protection; feminine desires for the smart home; and increased 'digital housekeeping'. We conclude by suggesting how HCI designers can and should respond.

## RELATED WORK

### Defining the Smart Home

How a home is understood and portrayed as being 'smart' varies between two perspectives. At one hand, a smart home is "a home that is equipped with technology to remotely control household systems like lighting, temperature, security alarms, surveillance cameras and other connected appliances" [40, p.1]. On the other hand, definitions such as that put forward by Balta-Ozkan et al. [2, p.364], emphasize that the smart home also "provide[s] services that respond to the needs of its inhabitants". Similarly, Darby [20, p.140] notes two broad categories, one being "building- and system-focused" and the other "home- and user-focused". Mennicken et al. [49, p.1] make a related distinction between remote access technologies with no automation, and those that are "responsive to their inhabitants and adapt autonomously in sophisticated ways". Technologies that reflect the former approach have been critiqued by Eggen et al. for their "failure to study the social context in which technology will be used and its implications on daily life" [25, p.44], while the latter better reflects the HCI field [65].

In HCI research, the foregrounding of the home, human, or user in technology design tends to be approached through some sort of categorizing. This can be based on broad user profiles [16; 84] but is more often oriented towards the services people want their smart home to provide. For example, Crowley and Coutaz [19] propose a taxonomy of smart home technologies based on the value they provide to different users as tools, housekeepers, advisors, or media. Other service perspectives shift to the provision of "safety, security, leisure services, health care provision and home energy management" [33, p.1770], energy control, security, entertainment, ambience, health monitoring, and assisted living [28, p.94], and "security, energy savings and comfort" [37, p.1620]. Aldrich's [1, p.17] identification of "comfort, convenience, security and entertainment" as the user-needs of the smart home has gained the most traction in service-focused definitions [29; 35; 50; 74]. However, Gram-Hanssen and Darby [28] and Eggen et al. [26] note that the meaning of these services will vary amongst social groups.

### Smart Home Adoption, Desires and Experiences

While much HCI research is explicitly user-focused [23; 37; 62] with a strong interest in daily routines and activity recognition [11; 14; 38; 83], most studies have emphasized "instrumental" or "functional" roles for prospective users. In the instrumental view, householders seek rational control of their home through enhanced information and price-responsiveness, whereas in the functional view

"technophile users are attracted to an ICT-enhanced lifestyle" (p.467). Similarly, Jakobi et al. argue that "[the] smart home so far has targeted the home primarily as a technological space, rather than as a place formed by routines and interaction" [37, p.1629]. These researchers call for a shift in focus from the technologies themselves to their situational and social context where their value to "real people" is foregrounded [34, p.3]. Vianello et al. [80] similarly suggest that targeting specific activities as if they were separate and independent is the reason that dedicated smart home systems "might fall short in capturing the variety and subtlety of domestic arrangements as daily experienced by inhabitants". This ability to complement daily experience is understood as key to the success of smart homes. De Graaf et al.'s study of domestic robots concludes that they need to be "enjoyable and easy to use… and functionally relevant" [23, p.224].

There is now a growing body of research in HCI and beyond focused on understanding how early adopters use and interact with smart home devices. Desjardins et al. [24] acknowledge a concern with social routines, ongoing domestic practices, and the everyday life of the smart home as three distinct "genres" in HCI research. These perspectives foreground users' experiences of home as the fulfillment of specific services, as well as other desirable qualities such as reflection, creativity and "pottering" [86]. A concern with the "usability" [46] of smart technologies, and their user-human-centered design, attuned to "patterns in resident's daily activities" [60, p.1], the "rhythms, patterns and cycles of everyday family life" [26, p.6], or "everyday practices" [56; 70] is therefore already well-established in related work within the field of HCI.

A number of HCI studies on the smart home have identified desires and challenges for adoption. Mennicken et al. discuss a range of motivations, including the smart home's associations with modernity and energy reduction, its role as a hobby for people with technical proficiency, and its incremental introduction into homes through continual upgrades once trust in automated systems has been established [48]. In an earlier study with Jensen et al., we draw on the concept of 'desiderata' to identify ten desires for the smart home relating to three 'smart home personas': the helper (desires omnipresence, control and intelligence), the optimizer (desires efficiency, awareness and automation), and the hedonist (desires uniqueness, nourishment, beauty and play) [39]. Wilson et al.'s review notes the importance of "security, privacy and trust as well as practical and ergonomic concerns with user-friendliness" for adoption of smart home devices [84, p.469]. Jakobi et al.'s [37 p.1624] 18-month living lab study also identifies adoption challenges covering four phases from system set up, installation and configuration, to routinized use and demands for reconfiguration and extension.

There are also significant ongoing advances in smart home technologies, especially improvements in natural user interfaces and system integration. The increasing capacities and connectivity of these technologies are well documented [55], as are the associated challenges [66], and ways to address them [87]. However, as Strengers [71] and other scholars have argued, smart technologies have failed to deliver on promises for effortless and easy living [34; 68]. This persistent gap is commonly attributed to poor understanding of the diversity of users and their multi-facetted desires and needs [18; 33; 34]. A key concern in recent HCI literature is that everyday domestic practices are already highly gendered and, moreover, that technologies designed for the home are emanating from an industry suffering from a lack of gender diversity [63; 64].

### Gender Imbalance in Smart Home Uptake and Use

An early seminal paper by Berg identified the gendered socio-technical construction of the smart home by examining design visions and emerging prototypes [9]. Since then, several HCI researchers, techno-feminist researchers and social scientists have drawn attention to the gendered smart home, from the feminization of devices, to the gendered appeal of smart home technologies to a masculine technophile [77]. Studies have found that current usage of digital technologies within households reflect and reinforce stereotypically gendered divisions of labor, creating more "digital housekeeping" for men [43; 64] or "more work for father" [75]. Rode and Poole's research found that men may be technology "czars", "digitally chivalrous" or "technical in other ways", while women take up roles of "the geek, the good woman, the damsel in distress, [or] the technophobe" [64, p.87].

A key concern for the industry and HCI community is how to design smart home technologies that "support technology use for both men and women with a wide range of gender identities" [64, p.88] and thereby "trouble" the gender stereotypes permeating existing technologies [69, p.878]. Such calls are part of the broader research agenda for feminist HCI [4-6; 63], which has drawn attention to the absence of gender considerations in many HCI studies, and a disturbing tendency to adopt an essentialist gender position, which "assumes a deficit model where male technology use is normative, while females need to 'catch up' to levels of their male counterparts" [63, p.395]. Alternatively, we follow Rode [63] and seminal techno-feminist and gender scholars such as Wajcman [81; 82],

Cockburn [17] and Butler [13] in adopting a performative understanding of gender. This perspective suggests that gender roles and identities are not fixed, but are fluid and continually performed in relation to technologies and their designs. While important in providing theoretical and methodological agendas for HCI research, to date feminist HCI research has not explicitly focused on the smart home or the user experience visions associated with it. In the remainder of this paper, we discuss how householders experience the 3Ps in their everyday routines and perform gender in relation to smart home technologies. We are particularly interested in how men and women perform and transform different expressions of masculinity and femininity in and with the smart home.

## METHODOLOGY

Digital ethnography is a research methodology that provides in-depth insights into how people experience the digital in their everyday lives. It typically involves *in situ* research with participants, through observations, conversations and reflections. It also involves digital methods to explore and gather insights in collaboration with participants [52; 57]. It is not meant to be representative, but provides complexity and richness on a particular issue or research question. Technology companies like Intel have an established history of hiring and engaging ethnographic researchers to deliver insights on people's relationships with emerging devices in different regional settings and technology ecosystems [8]. Intel's 3Ps vision has been informed by extensive ethnographic research, and feedback from multiple industry stakeholders, including the authors' gender studies scholarship and smart home research, conducted independently and together [30; 31; 43; 53; 54; 73-75].

In this study, digital ethnography enabled the research team to explore how Australian householders are incorporating smart home technologies into their everyday lives in relation to Intel's long term ambient computing vision for the home (the 3Ps). It also allowed us to observe and understand gendered dynamics. Given there is continuing fluidity around what a smart home constitutes [20; 28], we also adopted a broad definition of this term, inviting anyone living with automation technologies and smart appliances, or self-identifying as living in a 'smart home', to participate in the study. The only other selection criterion was that the household include at least one adult (over 18 years of age). Participant households were offered an AU$50 supermarket gift voucher for their involvement.

The household ethnography involved three methods undertaken in participants' homes where possible: i) semi-structured, conversational interviews with all available household members, supplemented by observations; ii) participant-directed home technology tours [10]; and iii) digital photographs (taken by researchers) during tours. A demographic questionnaire also captured information about the participants for comparison across the sample. Site visits took 1–2.5 hours, were conducted by authors 1 and 3, audio recorded and professionally transcribed for analysis. Where possible, the site visit involved all adult household members. This 'group interview' approach encouraged reflection amongst participants on their different gendered roles. The total dataset consists of 31 households involving 42 people. Children were present in 11 of these, also contributing to interviews and tours on occasion. The project was conducted with ethics approval from RMIT University.

### Analysis

The research team thematically analyzed [7] the dataset for:

1. Householders' understandings and experiences of the 3Ps in relation to their smart home technologies;
2. Gender differences and dynamics within households in relation to smart home technology;
3. The role of gendered voice-activated digital home assistants (e.g. Google Home and/or Amazon Echo 'Alexa') in delivering the 3Ps; and
4. Other relevant understandings and experiences not captured by the 3Ps.

Coding was conducted as an iterative-inductive process [58], which involved identifying participants' own interpretations of their experiences with smart home technologies. Following this analysis, we categorized themes into the 3Ps framework, allowing participant data and terminology to define these concepts for us. The whole process involved drawing iteratively on the 3Ps and our analysis to develop and refine the framework in relation to our dataset. After completing this process, the research team selected 12 households with illustrative and contrasting aspects of the 3Ps as exemplary case studies (see Table 2 and Supplementary Material: Participant Case Studies). While the findings cannot be generalized, they indicate emerging gendered desires for smart homes in Australia and likely other advanced economies.

### About the Households

Most participants lived as heterosexual couples (23 households had children living with them). Two sole adult households also participated, as well as three single parent household and two men sharing an apartment. Most households lived in Melbourne (14), and the remainder

were located in the Australian cities of Sydney (7), Adelaide (5), Canberra (3), Darwin (1), and a regional area in the state of Victoria (1). Participants were mostly aged 45–54 years (20) or 35–44 years (15), which likely reflects the demographic most able to afford smart home technologies. The sample was skewed towards men (25) versus women (17) as expected given the gender biased interest in smart home devices. To address this bias we encouraged women to participate in the research and deliberately recruited women who had set up their own smart home system (3). However, this paper only reflects cisgender and heteronormative dynamics, as reflected by our sample.

Where disclosed (24), most households had high incomes of AU$104,100–$156,000 (9) or more than AU$156,000 (12). Nearly all were highly educated (Bachelor's degree or higher), most identified their cultural background as Australian or European, and most owned their own home (27 compared to 4 renting). Participants typically lived in detached dwellings and some were substantially larger than the Australian average. About one half of dwellings were built with smart technologies integrated during construction; the other half had smart technologies retrofitted or introduced at a later stage. The number and type of smart devices in participant households was diverse (see Supplementary Material: Table 1) ranging from one smart device (e.g. robotic vacuum cleaner) to fully integrated and professionally installed smart homes with a range of connected devices providing lighting, entertainment, security, comfort, energy management and garden irrigation. Ten households also had solar panels for hot water or electricity generation. A full audit of smart home products and brands was not undertaken for each household as we were not assessing or evaluating particular products.

Participating households were early adopters of smart home technologies or self-identified technology enthusiasts. Most households had a least one adult (usually a man) who worked in a related technology or engineering field, and were passionate about smart devices and emerging technologies. A few households were directly employed in the smart home technology sector. An additional reason to install smart home systems was to ensure their new home would be considered modern. Several households had installed smart home technologies to assist someone living with a disability. Several others were interested in smart home technologies to improve their house's energy performance. Those who had acquired a standalone smart home appliance or device (e.g. Google Home or robotic vacuum cleaner) talked about being persuaded by their social networks or through marketing and media. They were typically keen to try and make everyday household activities easier and more convenient.

## FINDINGS

In this section we identify how Australian households in this study understood and experienced the 3Ps. For each 'P' we provide a summary of the key themes and gendered dynamics that emerged from the analysis. In addition, we provide four case studies for each P selected from the household dataset as Supplementary Material (see Table 2 and Participant Case Studies). While each case study emphasizes a single households' perspective on *one* P, there is considerable overlap and discussion between the 3Ps amongst these households which we draw out below. Throughout the remainder of this paper, participant quotes are presented verbatim and may contain small grammatical errors. Pseudonyms are used throughout. Case study photographs (included in Supplementary Material: Participant Case Studies) were taken by the research team at the participating households' homes. Identifying features (e.g. faces) are not shown unless permitted by participants.

**Table 2: Case studies of the 3Ps.**

| | | |
|---|---|---|
| **Protection** | | |
| 1 | Tony | "Peace of mind" |
| 2 | Floyd & partner | "Security is a dead-set real problem" |
| 3 | Kirra & partner | "Real OH&S issues" |
| 4 | David & partner | "I've been known to spy on the children" |
| **Productivity** | | |
| 5 | Angela | "A better way to keep organized" |
| 6 | Lindy & Johnno | "Maximizing energy efficiency" |
| 7 | Rachel | "For people with disabilities, smart home stuff is absolutely brilliant" |
| 8 | Gabriel & partner | "It's largely set and forget" |
| **Pleasure** | | |
| 9 | Ken & April | "Show-off factor" |
| 10 | Kristi & Bill | "The resort" |
| 11 | Lauren & Scott | "He's addicted" |
| 12 | Kurt & Graham | "The house welcomes you" |

### Protection

Householders rarely used the word 'protection' (or derivatives) in relation to the smart home or their everyday lives. Protection was commonly expressed as care and concern for the home and its occupants (particularly children). Following Richardson et al. [61] we view this protection as a form of "careful [or care-full] surveillance" of children and increasingly pets. In our 3Ps analysis,

careful surveillance was evident through internal and external cameras monitored by adults who were working away from home. In particular, it allowed men in our study to express a form of care-full masculinity, in which technology (a traditionally masculinized domain) was applied to practices of care (traditionally feminized).

David, for example, described monitoring his children without their knowledge when he and his wife were out (case study 4). David also monitored his pets during the day via a livestream camera in the laundry (where he had installed a television for their entertainment). He described coming home one day because "one of the dogs…got a toy stuck in the doggy door and they couldn't get in or out". David's intentions were caring rather than sinister – he wanted to check up on whether his children were doing their homework and his pets were safe and happy. However, several other householders, like Floyd (case study 2), acknowledged that monitoring could be used to invade the privacy of others without their knowledge or consent, and potentially exacerbate domestic violence situations by, for example, using a smart lock to restrict access to the house.

Protection as a form of care was also evident in households with disabled occupants, where smart technology was used to safeguard against potential health and other vulnerabilities. For Rachel, this included being able to remotely unlock doors for visitors (case study 7), and for Kirra, it involved things like monitoring the room temperature and health of children with special needs (case study 3). As Kirra explained, automated safety features, like a wave-operated shower system which prevented the children from turning on the water themselves, and an Aquatrip system that prevented flooding, helped her care for her children and home. In this way, smart home monitoring also constituted new forms of care-full femininity in some households, allowing parents like Kirra to express concern for her children with the aid of connected devices.

Desire to improve home security, particularly securing the home from potential intruders was also common (case study 1) and can be understood as a form of technical care that allowed men in particular to perform traditionally masculine gender roles of being the protector. Following Rode and Poole [64], this can also be understood as a form of "digital chivalry" in which securing the door for one's partner and loved ones is akin to opening it. Increased accessibility of the home via webcams and smart phone control, enabled from anywhere in the world, was also frequently identified as providing "peace of mind" (case study 1). Livestream webcams and remotely controlled or automated lights were used to secure the house when householders were away from home. However, system 'bugs' and false alerts were also common and took time to fix.

While smart technologies protected the home and its occupants, there were also significant concerns about how smart technologies might compromise security or privacy through hacking attacks (case study 2), or how smart home technology companies might access and use personal data (case study 3). Floyd, for example, highlighted how "someone could find a loophole in your kettle and use it to … turn your kettle on when it's dry" to cause a fire in the home. To allay his concerns, he opted for open source software, used his advanced information technology skills and reprogrammable devices, and avoided devices that would lock him into one system. These concerns may be less prevalent in more 'typical' households that are considering installing smart home technologies but would not usually possess Floyd's technological expertise, programming skills and confidence to overcome these concerns and proceed with the project. They also highlight a potentially significant barrier to wider uptake of these technologies for householders who are likely to hold basic or poor knowledge and technical skills [3; 44; 78].

### Productivity

A commonly identified benefit of smart home technologies amongst early adopting households were the 'small conveniences' generated when saving time in relation to work, cleaning, lighting and other activities. These reduced the physical or mental effort involved in daily tasks and created efficiencies that allowed householders to do 'more with less'. Although small, conveniences such as using smart control or voice activation for lights, doors or blinds became significant and expected. Householders doubted whether they could live well without these conveniences after becoming accustomed to them [see also, 74].

Smart home technologies also improved productivity through coordination and multi-tasking functionalities, particularly via digital voice assistants such as Amazon Echo (Alexa) and Google Home. Voice-enabled devices freed up people's hands to do other tasks while communicating with Alexa or Google Home, and helped to support "the organic evolution of routines and plans" as recommended by Davidoff et al. [21] in an earlier study of smart home control. This was a key benefit for busy CEO and single Mum Angela (case study 5), who used her Google Home's scheduling, voice calendar entries, shopping lists and timers to assist with coordinating her parenting, housekeeping and business roles. She was particularly

interested in devices that saved her time, like her smart door lock that sent access codes to people who rented her house over the summer.

However, as a feminist, Angela was also disturbed by the feminized voices of her digital home and work assistants, and had deliberately switched to male voices to challenge gendered stereotypes of feminized cleaning and administrative roles, and avoid reinforcing these normative assumptions with her two young sons. While enjoying the efficiencies she had put in place, Angela reflected on how technology tends to "give us [e.g. women] more time to go to work". Comparing it to household appliances which "just crammed more into our lives" she was concerned that home automation "is just going to give us more time to do more". Thus, she fundamentally questioned the productivity advantages of smart home devices, noting how they could also exacerbate what Hochschild has termed the "time bind" for women – the expectation of running households *and* fully participating in paid work [36].

In other households, productivity was understood as a way of conserving one's energy for other tasks, as Rachel described (case study 7). She was living with a debilitating disability that made small everyday tasks extremely difficult and draining. Rachel described smart home technologies as "absolutely brilliant and invaluable", allowing her and others to "live independently in their own homes for so many more years". Rachel noted how simple conveniences like remotely checking who's at her front door and letting them in through her smart phone had increased her security and helped manage physical exhaustion. She also desired smart home technology that decreased her dependence on home carers – an outcome which "could mean that we felt less invaded" and allow people with disabilities to have "peace and quiet".

Productivity was understood by some households as maximizing the energy performance of their home, through automation, monitoring, sensors and other energy efficiency measures (case study 6). 'Setting and forgetting' was a common method of improving energy performance, as well as providing small conveniences (case study 8). Reflecting Strengers' gendered "Resource Man" [72], most of the interest and work involved in monitoring and automating the home to improve energy outcomes was carried out by men. However, this was often undermined by other householders' everyday practices, or the other (energy-consuming) pleasures associated with the smart home (see Pleasure, below). Energy monitoring activities also constituted another form of household surveillance that enabled expressions of masculine care. Gabriel pointed out that he wasn't "spying on people's comings and goings. … Just [checking the cameras and data] for interest… and [then] forget[ting] about it." However, as noted previously, more sinister uses have been reported elsewhere [78].

These productivity benefits could be undermined by the additional "digital housekeeping" required to keep the technologies running, updated and integrated [64; 79]. Digital housekeeping or 'tech-work' was predominantly done by men and was often a source of pleasure or 'play' – Angela and Rachel were notable exceptions (case studies 5 & 7). Gabriel, for example, said his smart home "hobby" took up to 12 hours every week. Likewise, Johnno spent considerable time installing, monitoring and operating his household's smart home technologies, taking time away from other household chores. This reflects other studies noting the commonly masculinized role of the technical smart home 'guru' [43; 77].

**Pleasure**

Households derived considerable pleasure from using smart devices and living in a smart home, although these were often partially offset by the frustrations and complexities involved in learning to use and maintain smart home technologies, as already outlined. Smart lighting was the main source of this pleasure, generating new sensory experiences and opportunities for ambience and mood creation in line with current smart home marketing [76]. These pleasures were often connected with the natural environment. Kristi, for example, described how her and husband Bill had "the yin and the yang because we're really getting into the automation … but we still really love the nature that's around us as well" (case study 10). For roommates Kurt and Graham, smart lighting provided an opportunity to create "chilled" ambiance, where "the house welcomes you" (case study 12). These desires resonate with those reported by Woodruff et al. [85] in their study of automation in Jewish households, where devices were used to enhance sensory experiences associated with the Sabbath.

Aesthetic pleasures were often part of creating a relaxing home environment that replicated the experience of going on a "staycation" (case study 10) or "holiday[ing] at our own home" (case study 9). Home cinemas, audio-visual systems, pools, and outdoor/indoor entertainment areas were part of this expectation. Fun was also derived by 'playing' with smart home technologies, particularly digital voice assistants like Google Home and Alexa. Ken and April described how they like to use Alexa to "show off to people" and play music in the kitchen "so we're all dancing while we make breaky [breakfast]" (case study 9). They described their Alexa voice assistant as their "best friend"

who they take to their house parties to stream music. Similarly, Kristy and Bill (case study 10) discussed how their friends like to stay at their "resort", noting that their smart technology is "definitely a talking point". These findings also connect with Raptis et al. and other HCI research on the importance of 'coolness' in user experiences of digital products [59]. Generating fun, cool and sensory experiences, and relaxing home environments, were areas where women expressed more enthusiasm for smart home technologies, reflecting the opportunities these devices afforded them to express their femininity as homemakers, partners, and hosts.

Setting up, tinkering or playing with the devices was another significant source of pleasure – predominantly for men. These findings are supported by Mennicken et al.'s study, which found that (more commonly masculine) technologically-competent users experienced a "joy of hacking" [48]. The masculine technology enthusiasts in our study described themselves (or were described by their partners) as being "pretty gadgeted up" (Graham), "addicted" (Lauren speaking about partner Scott), or someone who "loves gadgets" and "always has to have everything first" (Ken). However, these same enthusiasts acknowledged that the pleasure derived from playing with technology could also become a time-consuming burden. For example, Gabriel noted that smart home software was "ridiculously difficult" for non-IT savvy people to operate (case study 8), and Tony said that the technology can "drive you mad" (case study 1). Presumably these frustrations would be exacerbated and even impossible to overcome for other householders who do not have the technical expertise of these early adopters. As Ken put it, if you don't have an IT background, "you'd probably be screwed" (case study 9). Given that men are most likely to possess these smart home skills, these findings provide further indications of the gendered challenges involved in greater uptake.

## CHALLENGES AND OPPORTUNITIES

We now identify three gendered usability design challenges and opportunities that are extensions from our analysis of the 3Ps. Table 3 provides a summary.

### Internal threats to household protection

As discussed above, our findings suggest that the concept of protection is commonly understood as enabling careful surveillance and security via smart technology. In our study, this was most commonly expressed by men as a form care-full masculinity.

**Table 3: Summary of design challenges and opportunities.**

| **Challenge: Internal threats to household protection** |
|---|
| • Limit opportunities for 'toxic' masculinity<br>• Allow for diverse performances of gender and enhanced independence for marginalized users<br>• Ensure that women (and all users) are supportive of how smart devices are being used within their home, and are able to operate them safely and securely |
| **Challenge: Expressing femininity with the smart home** |
| • Incorporate diverse expressions of femininity into smart home design and marketing strategies<br>• Design to encourage Technical Femininity [63]<br>• Conduct further research with women and other marginalized smart home users to better understand gender diversity to inform product design |
| **Challenge: Increased 'digital housekeeping'** |
| • Design products intended to reduce digital housekeeping<br>• Revise community guidelines for technical and trouble-shooting forums and provide moderation to encourage more women to participate<br>• Conduct further research to better understand the ways in which digital housekeeping changes the gendered division of household labor |

However, while these householders had confidence in their own knowledge, skills and ethics, they also expressed concerns for the security and privacy of other less aware or capable households. For example, some participants were concerned that smart home technologies could be used to invade other household members' privacy or lock them out of critical services and access points to the property (case studies 2&4). This potential is particularly concerning given the current gendered dimensions of smart home uptake and usage discussed earlier, which prioritizes a masculine technical user who has more access to and control over the technology.

For example, emerging research suggests that these technologies may also be used to perform forms of harmful or 'toxic' masculinity, in which the smart home facilitates technology-assisted abuse and domestic violence [12]. Preliminary findings from a study by Leitao [45] into technology-enabled abuse with a cohort of domestic abuse survivors shows that location tracking, and the use of smart home speakers and hidden cameras, are emerging key concerns. Freed et al. [27] examined the exploitation of technologies by abusers in intimate partner violence, particularly devices that allow tracking and spyware installation—creating "a stalkers paradise", as one of their participants describes it. Noting the capacity of these technologies to be used "to intimidate, threaten, monitor, impersonate, harass or otherwise harm their victims" [27,

p.2], the authors lay the groundwork for future research on intimate partner violence. Growing awareness of such issues may be an under-acknowledged factor in slow technology uptake. Relatedly, in their exploration of ethical issues for older adults using smart home technologies, Chung et al. [16] found that privacy and obtrusiveness were the most important issues affecting adoption. However, to date this concern has received little attention by the HCI community in relation to the smart home [47].

Our research specifically flags security risks for women, not directly through examples from our households, but as a logical extension of a home in which one (primarily masculine) user has increasing control and ability to monitor the movements of all household members. When situated within the domestic violence literature noted above, our findings demonstrate the need to ensure that smart home technologies are accessible and flexible in allowing for different performances of gender and enhanced forms of independence (for women, children and those with disabilities as demonstrated by Angela and Rachel's case studies (5&7). Additionally, our findings highlight the importance of ensuring that women (and all smart home users) are aware and supportive of how smart devices can and are being used within their home, and are able to operate them safely and securely without exposing themselves or others to additional internal or external threats.

Importantly, we don't expect all women (or users) to become technology enthusiasts or to 'catch up' to men, an idea that we noted earlier as counterproductive to feminist HCI's objectives. Instead, we suggest placing this responsibility back onto smart home designers (through industry regulations or ethical guidelines) to ensure that smart products address these gendered concerns.

### Expressing femininity with the smart home

As Bell notes, speaking for 'all women' is not a desirable nor possible ambition [8]. Nonetheless, most women who participated in our study were less tolerant of technology that was glitchy or time-consuming, wanting it to 'just work'. Men also wanted the technology to work, but were more likely to persist with technical difficulties, in some cases identifying this as a pleasurable 'hobby'. One explanation for this gender difference is that smart home technology has traditionally been associated with expressions of hegemonic masculinity, and afforded limited opportunities for expressions of femininity. As Berg [9] and others have argued, the smart home (and domestic technology more generally) has prioritized technically-enhanced security and entertainment, underpinned by engineering concepts of control, efficiency and optimization. While masculinity remains closely tied to demonstrating prowess with technology, men are more likely to continue playing this role, meanwhile women (whose performance of femininity is *not* commonly tied to technology proficiency) are likely to have less tolerance and time for 'playing around' with tech [43]. This means that for smart technology to appeal to more women, in a general sense, it has to provide for different and multiple expressions of femininity.

This points towards an opportunity raised by Rode [63] to design technologies that afford "Technical Femininity" as well as other flexible and diverse definitions of gender and technological identity. In the smart home, this might include technologies that support feminized roles and responsibilities, as discussed in Productivity and Pleasure above. For example, in their multiple roles as mothers, wives, carers, employees, hosts, housekeepers and emotional labourers, some women in our study valued the multi-tasking, coordinating functionalities of devices (like voice scheduling features on Google Home) that allowed them to undertake multiple tasks simultaneously, or use technology to unburden their minds from multiple duties. They also valued these assistants as helping hosts while they were entertaining guests in their homes. This observation reflects Davidoff et al.'s study of the smart home [21], which found that families pursue smart control to juggle the multiple priorities and roles they play at home and work. As they note, "many tasks are time-intensive but are vital to our identities as Moms, Dads and Families" [21: 31]. The aim is not necessarily to completely hand over everyday tasks to smart technology, but to use them to support these multiple activities and (gender) roles.

Designing devices that specifically respond to women's multiple and varied interests and concerns will involve a concerted effort from the HCI community, given that most studies have tended to foreground technically proficient and enthusiastic men as the early adopters of smart homes. As illustrated by this and other studies, it is much harder to recruit women for smart home research, and therefore innovative and deliberative methods are needed, as discussed by Bardzell and Bardzell in their development of a feminist HCI methodology [5]. While we have focused on heteronormative gender roles in this paper, a logical extension is to conduct research with other marginalised or minority smart home users, such as older people, same sex couples, transgender people, children and pets.

### Increased 'digital housekeeping'

Our findings support past research [43; 48; 64; 75], which shows that masculine-identifying tech-enthusiasts more commonly enjoy researching, setting up, maintaining, and tinkering with smart devices, often considering these activities a leisure activity, even though they can become burdensome and annoying over time. This housekeeping is required as a 'backdrop' for the achievement of the 3Ps.

As we have discussed, a variety of issues with smart home technologies in the households we visited required considerable time, technical expertise and trouble-shooting skills. This digital housekeeping was mostly performed by men, potentially taking them away from other chores or domestic activities, and therefore changing the gendered division of labor in the home. While digital housekeeping may initially be perceived as fun, this pleasure may wear off over time and become another mundane household chore. Furthermore, all genders may be less likely to take smart home technologies 'seriously' if they are considered a 'toy' or play-thing for men. Some women also felt excluded from becoming more competent at digital housekeeping. They found smart home technology support networks and forums unappealing and unhelpful, because they tended to be predominantly used by men, or focused on stereotypical 'men's interests' (e.g. 'geeky' technical details).

Developing products and devices that require less digital housekeeping is one way to respond, as is ensuring that the spaces and forums where technical expertise and troubleshooting are discussed are welcoming spaces for women and provide opportunities to perform diverse expressions of gender [6; 64]. Importantly, a reduction in digital housekeeping would benefit all householders, for different but complementary reasons. For tech-enthusiast men, it would ensure that the pleasure they derive from their smart home hobby is not undermined by frustrations and time-consuming problem solving. For some women, it may make these devices more accessible without having to develop technical expertise. In addition, it could help ensure that the 'harmless' hobbies and technical pursuits of partnered men don't take away from other essential household tasks, such as performing traditionally feminized activities like preparing meals and parenting children.

Having said that, the nature and need for digital housekeeping in smart and networked homes is still an under-researched and fast changing area. More research is required to understand the new forms of digital housework smart home technologies can engender, as well how it changes the roles and responsibilities of more traditional housekeeping tasks (such as automating vacuuming with a robotic vacuum cleaner). Applying the HCI concepts of 'pottering' [86] (akin to smart home 'tinkering') or 'non-use' [67] (in relation to devices that don't work) may prove fruitful here in uncovering the pleasurable (and also frustrating) tech-work that smart home enthusiasts currently undertake in their homes, and how this affects the redistribution of domestic labor and leisure.

## CONCLUSION

In this paper we have analyzed the smart home through Intel's ambient computing vision of the '3Ps' (protection, productivity and pleasure) in relation to our ethnographic research with early-adopting smart home households. We have framed our analysis in the context of emerging gendered usability challenges identified in HCI and social science literature, particularly the need for studies that better understand how householders are incorporating these technologies into their everyday lives and diverse performances of gender. Our findings and household case studies make an important contribution regarding how householders understand and experience the smart home. We have shown how protection can be understood as a form of gendered caregiving; productivity as the generation of 'small conveniences' and multi-tasking possibilities; and pleasure as being derived from ambient and aesthetic features and the joy of playing around with technology. Additionally, we have demonstrated how men and women can take up different roles and responsibilities in the smart home, and in some cases desire different variations of productivity, protection and pleasure. In this regard, our participants' interactions with the smart home afford them opportunities to express, and experiment with, multiple and emerging versions of masculinity and femininity.

A further contribution of this paper is the identification of three smart home design challenges and opportunities for the HCI design community that build on feminist HCI scholarship [6]. These are: overcoming potential threats to women posed by increased security, surveillance and control in the home; allowing for different expressions of femininity (and masculinity) in relation to smart home devices; and reducing the gendered impacts of digital housekeeping in smart homes. Through this discussion, we have shown how the achievement of the 3Ps poses differently experienced gendered opportunities and risks.

Finally, our analysis constitutes a unique academic-industry partnership that has allowed us to iteratively inform and revise a technology company's ambient computing vision for the smart home in the context of the Australian market. Further, by situating this framework within a broader discussion about gendered household dynamics, we have

added previously under-acknowledged insights to the smart home vision. Importantly though, we acknowledge that in some instances, smart home technologies may not be beneficial or desirable. In order to avoid the 'solutionism' raised at the beginning of this paper, the findings discussed should be viewed as important considerations for smart home designers; however, they are not an open endorsement of these technologies for any of the issues discussed. In some cases, other non-smart 'solutions' may be far more appropriate. We conclude that ensuring greater uptake of automated and connected devices involves allowing for more diverse expressions and performances of gender, and considering a wider range of potential users. We therefore call on the HCI community to pay more attention to gendered dynamics in future work on the home and beyond.

## ACKNOWLEDGMENTS

We thank all the households who participated in this project. This research was supported under the Australian Research Council's Discovery Early Career Researchers Award funding scheme (project number DE150100278), and through a generous gift from Intel Corporation.

## REFERENCES

[1] ALDRICH, F.K., 2003. Smart Homes: Past, Present and Future. In *Inside the Smart Home*, R. HARPER Ed. Springer, London, 17-39.

[2] BALTA-OZKAN, N., DAVIDSON, R., BICKET, M., and WHITMARSH, L., 2013. Social barriers to the adoption of smart homes. *Energy Policy 63*, 363-374. DOI = http://dx.doi.org/10.1016/j.enpol.2013.08.043.

[3] BARASSI, V., 2018. Home Life Data and Children's Privacy. In *Child Data Citizen*.

[4] BARDZELL, S., 2010. Feminist HCI: Taking Stock and Outlining an Agenda for Design. In *CHI 2010: HCI For All* ACM, Atlanta, Georgia, April 10-15, 1301-1310.

[5] BARDZELL, S. and BARDZELL, J., 2011. Towards a feminist HCI methodology: social science, feminism, and HCI. In *Proceedings of the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada2011), ACM, 1979041, 675-684. DOI = http://dx.doi.org/10.1145/1978942.1979041.

[6] BARDZELL, S. and CHURCHILL, E.F., 2011. IwC Special Issue "Feminism and HCI: New Perspectives" Special Issue Editors' Introduction. *Interacting with Computers 23*, 5, iii-xi. DOI = http://dx.doi.org/10.1016/S0953-5438(11)00089-0.

[7] BAZELEY, P., 2013. *Qualitative data analysis: practical strategies*. SAGE, London.

[8] BELL, G., 2018. Making life: a brief history of human-robot interaction. *Consumption Markets & Culture 21*, 1, 22-41. DOI = http://dx.doi.org/10.1080/10253866.2017.1298555.

[9] BERG, A.J., 1994. A gendered socio-technical construction: the smart house. In *Bringing technology home: gender and technology in changing Europe*, C. COCKBURN and R. FURST DILIC Eds. Open University Press, Buckingham, 165-180.

[10] BLYTHE, M. and MONK, A., 2002. Notes towards an ethnography of domestic technology. In *Proceedings of the 4th conference on designing interactive systems: processes, practices, methods, and techniques* ACM, New York, 276-281.

[11] BOUCHARD, B., GABOURY, S., BOUCHARD, K., and FRANCILLETTE, Y., 2018. Modeling Human Activities Using Behaviour Trees in Smart Homes. In Proceedings of the Proceedings of the 11th PErvasive Technologies Related to Assistive Environments Conference on - PETRA '18 (Corfu, Greece2018), ACM, 67-74. DOI = http://dx.doi.org/10.1145/3197768.3201522.

[12] BOWLES, N., 2018. Thermostats, Locks and Lights: Digital Tools of Domestic Abuse. In New York Times.

[13] BUTLER, J., 1990. Gender Trouble: Feminism and its subervsion of identify. Routledge, New York.

[14] CAROLIS, B.D., FERILLI, S., and REDAVID, D., 2015. Incremental Learning of Daily Routines as Workflows in a Smart Home Environment. ACM Transactions on Interactive Intelligent Systems 4, 4, 1-23. DOI = http://dx.doi.org/10.1145/2675063.

[15] CHANG, E., 2018. Brotopia: Breaking Up the Boys' Club of Silicon Valley. Portfolio, New York.

[16] CHUNG, J., DEMIRIS, G., and THOMPSON, H.J., 2016. Ethical Considerations Regarding the Use of Smart Home Technologies for Older Adults: An Integrative Review. Annu Rev Nurs Res 34, 155-181. DOI = http://dx.doi.org/10.1891/0739-6686.34.155.

[17] COCKBURN, C. and FURST-DILIC, R., 1994. Bringing Technology Home: Gender and Technology in a Changing Europe. Open University Press, London.

[18] CRONIN, M.J., 2010. Smart Products, Smarter Services: Strategies for Embedded Control. Cambridge University Press, Cambridge, UK.

[19] CROWLEY, J.L. and COUTAZ, J., 2015. An Ecological View of Smart Home Technologies. In AMI 2015: European Conference on Ambient Intelligence, Athens, Greece.

[20] DARBY, S.J., 2018. Smart technology in the home: time for more clarity. Building Research & Information 46, 1, 140-147. DOI = http://dx.doi.org/10.1080/09613218.2017.1301707.

[21] DAVIDOFF, S., LEE, M., YIU, C., ZIMMERMAN, J., and DEY, A., 2006. Principles of Smart Home Control. In UbiComp 2006: Ubiquitous Computing, P. DOURISH and A. FRIDAY Eds. Springer, Berlin, 19-34. DOI = http://dx.doi.org/10.1007/11853565_2.

[22] DAWSON, J., 2016. The smart home is stuck. In recode.

[23] DE GRAAF, M., BEN ALLOUCH, S., and VAN DIJK, J., 2017. Why Do They Refuse to Use My Robot? In Proceedings of the Proceedings of the 2017 ACM/IEEE International Conference on Human-Robot Interaction - HRI '17 (Vienna, Austria2017), ACM, 224-233. DOI = http://dx.doi.org/10.1145/2909824.3020236.

[24] DESJARDINS, A., WAKKARY, R., and ODOM, W., 2015. Investigating Genres and Perspectives in HCI Research on the Home, 3073-3082. DOI = http://dx.doi.org/10.1145/2702123.2702540.

[25] EGGEN, B., HOLLEMANS, G., and VAN DE SLUIS, R., 2003. Exploring and ehancing the home experience. Cogn. Tech Work 5, 1, 44-54. DOI = http://dx.doi.org/10.1007/s10111-002-0114-7.

[26] EGGEN, B., VAN DEN HOVEN, E., and TERKEN, J., 2014. Human-Centered Design and Smart Homes: How to Study and Design for the Home Experience? In Handbook of Smart Homes, Health Care and Well-Being, 1-9. DOI = http://dx.doi.org/10.1007/978-3-319-01904-8_6-1.

[27] FREED, D., PALMER, J., MINCHALA, D., LEVY, K., RISTENPART, T., and DELL, N., 2018. A Stalker's Paradise. In Proceedings of the Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18 (Montreal, QC, Canada2018), ACM, 1-13. DOI = http://dx.doi.org/10.1145/3173574.3174241.

[28] GRAM-HANSSEN, K. and DARBY, S.J., 2018. "Home is where the smart is"? Evaluating smart home research and approaches against the concept of home. Energy Research & Social Science 37, 94-101. DOI = http://dx.doi.org/10.1016/j.erss.2017.09.037.

[29] GREEN, W., GYI, D., KALAWSKY, R., and ATKINS, D., 2004. Capturing user requirements for an integrated home environment. In NordiCHI '04, 23-27 October, Tampere, Finland.
[30] GREGG, M., 2011. Work's Intimacy. Polity Press, Malden, MA.
[31] GREGG, M., 2018. Counterproductive: Time management in the knowledge economy. Duke University Press, Croydon, UK.
[32] GRUMAN, G., 2014. Home automation is a solution in search of a problem. In InfoWorld.
[33] HARGREAVES, T. and WILSON, C., 2013. Who uses smart home technologies? Representations of users by the smart home industry. In ECEEE Summer Study Proceedings: Rethink, Renew, Restart, 1769-1780.
[34] HARGREAVES, T. and WILSON, C., 2017. Smart Homes and Their Users. Springer, Cham, Swtizerland.
[35] HARGREAVES, T., WILSON, C., and HAUXWELL-BALDWIN, R., 2018. Learning to live in a smart home. Building Research & Information 46, 1, 127-139. DOI = http://dx.doi.org/10.1080/09613218.2017.1286882.
[36] HOCHSCHILD, A.R., 2001. The Time Bind: When Work Becomes Home and Home Becomes Work. Henry Holt & Co., New York.
[37] JAKOBI, T., OGONOWSKI, C., CASTELLI, N., STEVENS, G., and WULF, V., 2017. The Catch(es) with Smart Home: Experiences of a Living Lab Field Study. In Proceedings of the Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI '17 (Denver, CO, USA2017), ACM, 1620-1633. DOI = http://dx.doi.org/10.1145/3025453.3025799.
[38] JARRAYA, A., BOUZEGHOUB, A., BORGI, A., and AROUR, K., 2018. Distributed Collaborative Reasoning for HAR in Smart Homes. In 17th International Conference on Autonomous Agents and Multiagent Systems (AAMAS), 10-15 July, M. DASTANI, G. SUKTHANKAR, E. ANDRE and S. KOENIG Eds. IFAAMAS, Stockholm, Sweden, 1971-1973.
[39] JENSEN, R.H., STRENGERS, Y., KJELDSKOV, J., NICHOLLS, L., and SKOV, M., 2018. Designing the desirable smart home: A study of household experiences and energy consumption impacts. In Conference on Human Factors in Computing Systems (CHI) Association of Computing Machinery, Montreal, Canada. DOI = http://dx.doi.org/https://dl.acm.org/citation.cfm?doid=3173574.3173578.
[40] KARIMI, K. and KRIT, S.-D., 2018. Systems and technologies for Smart Homes/Smart Phones. In Proceedings of the Proceedings of the Fourth International Conference on Engineering & MIS 2018 - ICEMIS '18 (Istanbul, Turkey2018), ACM, 1-7. DOI = http://dx.doi.org/10.1145/3234698.3234706.
[41] KATTERFELDT, E.-S. and DITTERT, N., 2018. Co-designing Smart Home Maker Workshops with Girls. In Proceedings of the Proceedings of the Conference on Creativity and Making in Education (Trondheim, Norway2018), ACM, 3213833, 100-101. DOI = http://dx.doi.org/10.1145/3213818.3213833.
[42] KATUK, N., KU-MAHAMUD, K.R., ZAKARIA, N.H., and MAAROF, M.A., 2018. Implementation and recent progress in cloud-based smart home automation systems. In 2018 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), 28-29 April, Penang, Malaysia.
[43] KENNEDY, J., NANSEN, B., ARNOLD, M., WILKEN, R., and GIBBS, M., 2015. Digital housekeepers and domestic expertise in the networked home. Convergence 21, 4, 408-422. DOI = http://dx.doi.org/10.1177/1354856515579848.
[44] LEAVER, T., 2017. Intimate Surveillance: Normalizing Parental Monitoring and Mediation of Infants Online. Social Media + Society 3, 2, 2056305117707192. DOI = http://dx.doi.org/10.1177/2056305117707192.
[45] LEITÃO, R., 2018. Digital Technologies and their Role in Intimate Partner Violence. In Proceedings of the Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18 (Montreal, QC, Canada2018), ACM, 1-6. DOI = http://dx.doi.org/10.1145/3170427.3180305.
[46] LEITNER, G., AHLSTROM, D., and M., H., 2007. Usability - Key Factor of Future Smart Home Systems. Home Informatics and Telematics: ICT for The Next Billion 241.
[47] MATTHEWS, T., O'LEARY, K., TURNER, A., SLEEPER, M., WOELFER, J.P., SHELTON, M., MANTHORNE, C., CHURCHILL, E.F., and CONSOLVO, S., 2017. Stories from Survivors, 2189-2201. DOI = http://dx.doi.org/10.1145/3025453.3025875.
[48] MENNICKEN, S. and HUANG, E.M., 2012. Hacking the Natural Habitat: An In-the-Wild Study of Smart Homes, Their Development, and the People Who Live in Them. In Pervasive Computing. Pervasive 2012. Lecture Notes in Computer Science, J. KAY, P. LUKOWICZ, H. TOKUDA, P. OLIVIER and A. KRÜGER Eds. Springer Berlin Heidelberg, Berlin, Heidelberg, 143-160. DOI = http://dx.doi.org/https://doi-org.ezproxy.lib.rmit.edu.au/10.1007/978-3-642-31205-2_10.
[49] MENNICKEN, S., VERMEULEN, J., and HUANG, E.M., 2014. From Today's Augmented Houses to Tomorrow's Smart Homes: New Directions for Home Automation Research. In Proceedings of the UbiComp '14 (Seattle, WA, USA, 13-17 September 2014 2014). DOI = http://dx.doi.org/10.5167/uzh-98109.
[50] MISSAOUI, R., JOUMAA, H., PLOIX, S., and BACHA, S., 2014. Managing energy Smart Homes according to energy prices: Analysis of a Building Energy Management System. Energy and Buildings 71, 155-167. DOI = http://dx.doi.org/10.1016/j.enbuild.2013.12.018.
[51] MOROZOV, E., 2013. To save everything click here: Technology, solutionism and the urge to fix problems that don't exist. Penguin Books, London.
[52] NANSEN, B., WILKEN, R., KENNEDY, J., ARNOLD, M., and GIBBS, M., 2016. Ethical concerns associated with digital ethnography in the domestic environment: informant burden and burdensome technologies. In Visual Research Ethics: Learning from practices, D. WARR, M. GUILLEMIN, S. COX and J. WAYCOTT Eds. Palgrave Macmillan, London, 45-59.
[53] NICHOLLS, L. and STRENGERS, Y., 2019. Robotic vacuum cleaners save energy? Raising cleanliness conventions and energy demand in Australian households with smart home technologies. Energy Research & Social Science 50(2019/04/01/), 73-81. DOI = http://dx.doi.org/https://doi.org/10.1016/j.erss.2018.11.019.
[54] NICHOLLS, L., STRENGERS, Y., and TIRADO, S., 2017. Smart home control: exploring the potential for enabling technologies in households. Centre for Urban Research.
[55] PARAVATI, G. and GATTESCHI, V., 2015. Human-Computer Interaction in Smart Environments. Sensors 15, 8, 19487-19494. DOI = http://dx.doi.org/10.3390/s150819487.
[56] PIERCE, J., STRENGERS, Y., SENGERS, P., and BODKER, S., 2013. Introduction to the special issue on practice-oriented approaches to sustainable HCI. ACM Trans. Comput.-Hum. Interact. 20, 4, 1-8. DOI = http://dx.doi.org/10.1145/2494260.
[57] PINK, S., HORST, H., POSTILL, J., HJORTH, L., LEWIS, T., and TACCHI, J., 2016. Digital Ethnography: Principles and Practice. SAGE, London.
[58] PINK, S., LEDER MACKLEY, K., MOROSANU, R., MITCHELL, V., and BHAMRA, T., 2017. Making Homes: Ethnography and Design. Bloomsbury, London.
[59] RAPTIS, D., BRUUN, A., KJELDSKOV, J., and SKOV, M.B., 2017. Converging coolness and investigating its relation to user experience. Behaviour & Information Technology 36, 4 (2017/04/03), 333-350. DOI = http://dx.doi.org/10.1080/0144929X.2016.1232753.
[60] RASHIDI, P. and COOK, D.J., 2009. Keeping the Resident in the Loop: Adapting the Smart Home to the User. IEEE Transactions

on Systems, Man, and Cybernetics - Part A: Systems and Humans 39, 5, 949-959. DOI = http://dx.doi.org/10.1109/tsmca.2009.2025137.

[61] RICHARDSON, I., HJORTH, L., STRENGERS, Y., and BALMFORD, W., 2017. Careful surveillance at play: human-animal relations and mobile media in the home. In Refiguring Techniques in Digital Visual Research, E. GÓMEZ CRUZ, S. SHUMARTOJO and S. PINK Eds. Palgrave MacMillan, London, 105-116.

[62] ROBILLARD, J.M., LI, A.W., JACOB, S., WANG, D., ZOU, X., and HOEY, J., 2017. Co-Creating Emotionally Aligned Smart Homes Using Social Psychological Modeling. In Proceedings of the Proceedings of the 4th international Workshop on Sensor-based Activity Recognition and Interaction - iWOAR '17 (Rostock, Germany2017), ACM, 1-6. DOI = http://dx.doi.org/10.1145/3134230.3134242.

[63] RODE, J.A., 2011. A theoretical agenda for feminist HCI. Interacting with Computers 23, 393-400.

[64] RODE, J.A. and POOLE, E.S., 2018. Putting the gender back in digital housekeeping. In GenderIT ACM, Heilbronn, Germany, 14-15 May, 79-90. DOI = http://dx.doi.org/10.1145/3196839.3196845.

[65] SAIZMAA, T. and KIM, H.-C., 2008. A Holistic Understanding of HCI Perspectives on Smart Home. In Proceedings of the 2008 Fourth International Conference on Networked Computing and Advanced Information Management (2008), 59-65. DOI = http://dx.doi.org/10.1109/ncm.2008.141.

[66] SAKAMOTO, S.G., DE MIRANDA, L.C., and HORNUNG, H., 2014. Home Control via Mobile Devices: State of the Art and HCI Challenges under the Perspective of Diversity. In Universal Access in Human-Computer Interaction. Aging and Assistive Environments. UAHCI 2014, S. C. and A. M. Eds. Springer.

[67] SATCHELL, C. and DOURISH, P., 2009. Beyond the user: use and non-use in HCI. In Proceedings of the Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7 (Melbourne, Australia2009), ACM, 1738829, 9-16. DOI = http://dx.doi.org/10.1145/1738826.1738829.

[68] SMIREK, L., ZIMMERMANN, G., and BEIGL, M., 2016. Just a Smart Home or Your Smart Home – A Framework for Personalized User Interfaces Based on Eclipse Smart Home and Universal Remote Console. Procedia Computer Science 98, 107-116. DOI = http://dx.doi.org/10.1016/j.procs.2016.09.018.

[69] SØNDERGAARD, M.L.J. and HANSEN, L.K., 2018. Intimate Futures: Staying with the Trouble of Digital Personal Assistants through Design Fiction. In Proceedings of the Proceedings of the 2018 on Designing Interactive Systems Conference 2018 - DIS '18 (Hong Kong2018), ACM, 869-880. DOI = http://dx.doi.org/10.1145/3196709.3196766.

[70] STRENGERS, Y., 2011. Designing eco-feedback systems for everyday life. In Proceedings of the 2011 annual conference on Human factors in computing systems ACM, Vancouver, 2135-2144. DOI = http://dx.doi.org/10.1145/1978942.1979252.

[71] STRENGERS, Y., 2013. Smart Energy Technologies in Everyday Life: Smart Utopia? Palgrave Macmillan, Basingstoke, Hampshire, UK.

[72] STRENGERS, Y., 2014. Smart energy in everyday life: are you designing for resource man? interactions 21, 4, 24-31. DOI = http://dx.doi.org/10.1145/2621931.

[73] STRENGERS, Y., KENNEDY, J., NICHOLLS, L., and ARCARI, P., 2018. The 3Ps: Protection, Productivity and Pleasure for Australian smart home early adopters. Centre for Urban Research and Digital Ethnography Research Centre.

[74] STRENGERS, Y. and NICHOLLS, L., 2017. Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond. Energy Research & Social Science 32, 86-93.

[75] STRENGERS, Y. and NICHOLLS, L., 2018. Aesthetic pleasures and gendered tech-work in the 21st-century smart home. Media International Australia 166, 1, 70-80. DOI = http://dx.doi.org/10.1177/1329878x17737661.

[76] STRENGERS, Y., NICHOLLS, L., OWEN, T., and TIRADO, S., 2016. Smart home control devices: Summary and assessment of energy and lifestyle marketing claims. Centre for Urban Research, RMIT University.

[77] TAKAYAMA, L., PANTOFARU, C., ROBSON, D., SOTO, B., and BARRY, M., 2012. Making technology homey: finding sources of satisfaction and meaning in home automation. In Proceedings of the Proceedings of the 2012 ACM Conference on Ubiquitous Computing (Pittsburgh, Pennsylvania2012), ACM, 2370292, 511-520. DOI = http://dx.doi.org/10.1145/2370216.2370292.

[78] TANCZER, L., BLYTHE, J., YAHYA, F., BRASS, I., ELSDEN, M., BLACKSTOCK, J., and CARR, M., 2018. Summary literature review of industry recommendations and international developments on IoT security. PETRAS IoT Hub, Department for Digital, Culture, Media & Sport (DCMS).

[79] TOLMIE, P., CRABTREE, A., RODDEN, T., GREENHALGH, C., and BENFORD, S., 2007. Making the home network at home: digital housekeeping. In ECSCW'07: Proceedings of the Tenth European Conference on Computer Supported Cooperative Work, L. BANNON, C. WAGNER, R. GURWIN, R. HARPER and K. SCHMIDT Eds. Springer, Limerick, Ireland, 331-350.

[80] VIANELLO, A., FLORACK, Y., BELLUCCI, A., and JACUCCI, G., 2016. T4Tags 2.0: A Tangible System for Supporting Users' Needs in the Domestic Environment. In Proceedings of the Proceedings of the TEI '16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction - TEI '16 (Eindhoven, Netherlands2016), ACM, 38-43. DOI = http://dx.doi.org/10.1145/2839462.2839479.

[81] WAJCMAN, J., 1991. Feminism Confronts Technology. Polity Press, Cambridge, UK.

[82] WAJCMAN, J., 2004. Techno Feminism. Polity Press, Cambridge, UK.

[83] WAN, J., O'GRADY, M.J., and O'HARE, G.M.P., 2015. Dynamic sensor event segmentation for real-time activity recognition in a smart home context. Personal and Ubiquitous Computing 19, 2, 287-301. DOI = http://dx.doi.org/10.1007/s00779-014-0824-x.

[84] WILSON, C., HARGREAVES, T., and HAUXWELL-BALDWIN, R., 2015. Smart homes and their users: a systematic analysis and key challenges. Pers. Ubiquit. Comput. 19, 463-476.

[85] WOODRUFF, A., AUGUSTIN, S., and FOUCAULT, B., 2007. Sabbath day home automation: "it's like mixing technology and religion". In Proceedings of the Proceedings of the SIGCHI conference on Human factors in computing systems (San Jose2007), ACM, 1240710, 527-536. DOI = http://dx.doi.org/10.1145/1240624.1240710.

[86] WYCHE, S.P., TAYLOR, A., and KAYE, J., 2007. Pottering: a design-oriented investigation. In Proceedings of the CHI '07 extended abstracts on Human factors in computing systems (San Jose, CA, USA2007), ACM, 1240917, 1893-1898. DOI = http://dx.doi.org/10.1145/1240866.1240917.

[87] ZHAO, Y., ZHANG, X., and CRABTREE, J., 2016. Human-computer interaction and user experience in smart home research: A critical analysis. Issues in Information Systems 17, III, 11-19.