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BUILDINGS & CITIES

Technological fascination and reluctance: gendered practices in the smart home

SPECIAL COLLECTION: ENERGY, EMERGING TECHNOLOGIES & GENDER IN HOMES

RESEARCH

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ABSTRACT

Smart home technology (SHT) is becoming more widespread, implemented to enhance convenience as well as energy flexibility and efficiency. Smart heating, lighting, security and entertainment systems are affecting social practices and the use of energy in different ways. This paper explores differences in competences, meanings and forms of knowledge involved in the performance of (gendered) household practices based on two Danish qualitative studies of different user groups: SHT frontrunner households (n = 15) and less tech-interested households (n = 12). The former had incorporated a broad range of smart technologies, *e.g.* vacuum cleaners, lighting and entertainment systems, while the latter were primarily engaged with smart heating systems. In the frontrunner households, internal differences in competences and meanings between men and women were more apparent than in households with less tech interest. A clear division between traditional and digital housekeeping is apparent that reinforces gender inequality. Evidence shows the variation in how SHT is part of gendered everyday practices; how SHT changes meanings and competences in practices and induces new ways of performing practices that can involve gendered digital inequality. Thus, it is necessary to consider competences and meanings in everyday practices as well as gendered ideas behind the technology.

POLICY RELEVANCE

Strategies and policies for a green transition of the energy systems in Denmark and the European Union include a digitalisation of consumption in households. This transition will induce reconfigurations of everyday practices potentially entailing both digital and gendered inequality. The home has often been a contested space, relating to gender roles, inequality and division of household labour. This paper shows that SHT potentially reinforces gender inequality by creating a gendered gap between digital and traditional housekeeping. To avoid potential reinforcement of gender inequality within the home, SHT promotion and development needs to account for gender differences. Actions by industry would include differences of gendered housekeeping, showing an awareness of varying technology competences and meanings in everyday practices as well as the gendered vision of SHT and its users.

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1. INTRODUCTION

Smart technologies are increasingly being adopted in homes and becoming part of mundane everyday practices such as heating, lighting and vacuuming. Smart home technology (SHT) holds the potential of technological and social disruptions in the everyday lives of households, including gender roles, the divisions of household labour and everyday routines (Hargreaves *et al.* 2018; Strengers 2013). There can be differences and inequities in how householders with different genders and socio-economic characteristics consume and benefit from the introduction of new energy services and technologies in the home. With regard to the envisioned and ongoing transformation of energy systems to engender flexible and sustainable consumption of renewable resources, it is essential to understand such differences within and between households, as those related to gender, to ensure a successful and just transition in energy practices (Gram-Hanssen *et al.* 2017).

Smart technologies are already shown to be altering everyday life and the divisions of household tasks. However, this is a rather new area of research that needs to be scrutinised more thoroughly. Traditionally there are gender distinctions in the division of household tasks, although there are cultural and geographical differences and differences between households. Cowan's (1985) seminal work on gender and household technologies showed how the introduction of new technologies in the home increased women's housework burden instead of relieving it envisioned. With the introduction of new smart technologies in households, new ways of performing household practices arise and the technologies might induce new meanings to household practices, just as the competences needed to perform these practices might change.

This paper investigates the different ways that SHT involves and reconfigures gendered everyday practices related to the daily performance of housework. Drawing on two qualitative studies conducted in Denmark by each author, it explores how SHT affects the performance of household practices in different ways among SHT 'frontrunners' and less tech-interested users. This provides new knowledge on everyday life with SHT in comparison with the technology visions of the future. A concept related to everyday life with SHT is digital housekeeping (Tolmie *et al.* 2007). Digital housekeeping comprises a new area of practices that arise with the increase of SHT and the wiring, functionality and maintenance of these, which potentially changes the distribution of everyday activities in households.

Does the division between traditional and digital housekeeping increase with the introduction of smart technologies—and how does it differ between the different households? Applying a gender perspective, the paper illustrates how existing and new household practices are differently performed and distributed among male and female household members. A focus is on how gendered practices of traditional and digital housework are reconfigured by SHT, and how this reconfiguration is mediated by particular meanings and competences (related to technological interest and skill) among more and less tech-engaged users.

2. APPROACHES TO GENDER INEQUITIES IN THE DIGITAL HOME

Gender studies have evolved around issues of power and inequality as well as dualistic gendered characteristics assigned to men and women, their life opportunities and spheres in which to work and live, including the home (*e.g.* Pink 2004). This involves understanding all social relations as gendered and explicating gendered visions of the home and domesticity as well as technology and everyday practices connected to the home. The home has been and remains a contested space with inequality issues, for example, related to housework, income and energy poverty (Tjørring 2016; Petrova & Simcock 2021). At the same time, homes are both material and social entities, and are subject to transformation through homemaking processes that include the use of energy and resources in the production and reproduction of the home (Blunt & Dowling 2006; Petrova & Simcock 2021).

In the literature concerned with housework, it is widely stated that women undertake a major proportion of unpaid work in Western households, although the numbers vary across countries (Clancy & Roehr 2003; Robinson 2019; Sullivan 2018). A divide between the types of unpaid work

that women and men undertake at home is also persistent, which influences the responsibility and performance of everyday practices in households (*e.g.* Allison *et al.* 2019). Women spend more time and resources on activities such as cooking, cleaning and laundering, and tend to be responsible for more of the care activities in the home. On the other hand, men are more often responsible for maintenance, technical decisions and tasks in relation to household energy (Carlsson-Kanyama & Lindén 2007; Clancy & Roehr 2003; Ellegård & Palm 2015; Tjørring 2016). Divisions of housework and childcare are, however, undergoing changes and households' compositions are becoming more diverse (*e.g.* Pink 2004).

Connected to inequities in the division of housework is also gender inequality in relation to access and use of energy resources. A vast amount of literature is concerned with how different genders are affected by a scarcity in resources for the accomplishment of everyday practices and development of household and energy technologies in both the Global North and South (Feenstra & Özerol 2021). Studies have shown that women are more adversely affected by energy poverty. More women than men struggle to afford energy services that meet their needs, and more women than men head low-income families (Robinson 2019; Feenstra & Clancy 2020). Clancy & Roehr (2003) establish that gender issues are influencing how energy is consumed in terms of choices, attitudes and knowledge on energy use and environmental issues. Energy studies have shown that men and women tend to have different capacities to act and also legitimise decisions differently according to their gendered identities, influenced as well by other social characteristics such as age, economy and ethnicity (Clancy *et al.* 2020, Tjørring 2016). Petrova & Simcock (2021: 852) also state that energy poverty exists in 'developed' countries as 'fuel poverty':

> Here, an inability to attain adequate domestic energy services typically results from unaffordable energy services, rather than a lack of material access to electricity. Although emphasis typically is placed on space heating deprivation, recent work has suggested the importance of other energy services such as cooling, lighting, and ICTs [information and communication technologies].

Both energy and digital inequality are gender issues to be aware of in the development of new, smart energy systems based on increased flexibility end digitisation of households' energy use.

Gender studies have underlined that gender is performative and that the dualism of feminine and masculine can be performed and ascribed to identities and practices in multiple ways, for example, in the negotiation and repetition of performing household practices (Butler 2006; Pink 2004). Following Pink (2004), gender is produced and reproduced while performing everyday practices in the home, such as housework that includes resources, material objects, appliances and technologies. Householders can perform household tasks in multiple ways confirming, resisting or altering their gendered identities (Pink 2004: 16). Feminist technology studies have highlighted the relation between gender and technology and their mutual shaping of each other while criticising the traditional conception of technology as masculine (Wajcman 2010). This conception is rooted in the binary oppositions ascribed to male and female gender identities and refer to the technologies of industrialisation. However, symbolic gender binaries are often also at play in the production, design, and use of household and energy technologies (Mechlenborg & Gram-Hanssen 2020). This means that the 'masculine' sides of gender binaries, such as technical, hard, objectivist and abstract, are most often highlighted and connected to technological development, also within the home (Offenberger & Nentwich 2009). In terms of smart technologies, Strengers (2013) coined this masculine connotation of the imagined user of the technologies 'Resource Man'.

The concept of digital housekeeping developed by Tolmie *et al.* (2007) can describe the different tasks and processes required when smart technologies are adopted. Installing, maintaining, updating and adapting the SHT to the organisation and routines of the household are all parts of the digital housekeeping. To perform this successfully, technological skill, competences and knowledge are needed. Without the necessary competences, living in a smart home can be challenging and time-demanding and lead to frustration and feelings of inconvenience (Hargreaves *et al.* 2018; He *et al.* 2019). When people lack interest and refrain from learning how to use the technologies, the properties of the technologies are left unused and people tend to perform workarounds (Wright 2019; Larsen & Gram-Hanssen 2020).

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As recent research shows, the design of SHT is also gendered (Strengers & Kennedy 2020). Smart technologies and artificial intelligence (AI) are developed in male-dominated industries that reproduce heteronormative stereotypes, having negative impacts on gender equity (Perez 2020). While Perez (2020) presents statistical material on gendered inequalities, these issues are also reflected in qualitive empirical research. As Kennedy *et al.* (2015) found in their field and interview studies of Australian households, different genders engage with smart technologies in different ways, and often men rather than women are found to be the ones in charge of the smart home. In Denmark, which has recently been ranked as number one in terms of SHT usage among European countries, approximately two-thirds of the users are male (Statistics Denmark 2020). The gendered distribution of SHT use has important implications for households' tasks and responsibilities as it might lead to a clearer division between traditional manual housework, on the one hand, and digital housekeeping, on the other, reinforcing traditional gender roles and spheres, as found by Strengers & Nicholls (2018) in their empirical studies of Australian households. Building on this existing research, the present paper explores gender and (digital) housekeeping in a Danish context.

3. RESEARCH APPROACH AND METHODS

In exploring household practices and everyday life with smart technologies, this paper takes inspiration from theories of social practice. Within this framework, practices can be defined as the nexus of sayings and doings situated in specific times and places (Schatzki 1996, 2002). Furthermore, practices are understood as constituted by interlinked elements. Following Shove *et al.* (2012), a focus is not only on the materials in practices, such as the physical house and technologies, but also on the particular *competences* forming (household) practices, defined by forms of understandings and practical know-how, and on *meanings*, referring to the social and symbolic significance of a practice, emotions and motivations, exploring the interdependent relations between them (Shove *et al.* 2012: 23). In particular, the paper investigates how competences and meanings differ among the different research participants in their performance of practices that include SHT and how this relates to gender dynamics.

The paper builds on two qualitative studies conducted by each author, in total comprising 23 in-depth interviews combined with show-and-tell home tours in Danish homes with various smart technologies installed. Study 1 (15 households, 26 participants)[1] was conducted in autumn 2020 and included households with a combination of various forms of SHT (*e.g.* smart lighting, smart heating, digital voice assistants and robotic vacuum cleaners). The first nine households in the study were recruited via SHT Facebook groups where people share experiences and advice, and six additional households were recruited via snowball sampling referred from the initial participants and from one contact of the authors. Only men responded to the posted research call and common to all of them was an outspoken interest in technology. They all lived in opposite-sex relationships, except one single man, and were asked to bring their female partners for the interviews, which 12 out of 14 did.

Study 2 was conducted in the winter of 2019–20 and included households with smart heating installed by outside professionals as part of smart energy demonstration projects. The sample thus represents more mixed users in terms of technology interest and engagement compared with those in study 1. These participants were recruited via publicly accessible contact information on internet sites and the sample (eight households, 12 participants) included four opposite-sex couples and four singles (seven male, five female). Households in both studies were located in different parts of Denmark, including both rural and urban areas (see Appendix A for a summary of participants).

The combination of interviews with show-and-tell home tours in which participants showed and talked about their different technologies was able to spark participants' memories and gave a practical insight into their everyday engagements and concrete scenarios. Interviews took an open and semi-structured form, following an interview guide with a list of themes relating to everyday life and different components of social practices (*e.g.* materials, competences, meanings, roles,

interests, comfort, energy consumption and technology use). The interviews lasted about 1.5–2 hours and were audio-recorded, transcribed and analysed in the software tool NVivo through an open-coding process in which prevalent themes were identified.

In study 1, there was a general tendency of male participants being primarily or solely in charge of setting up and maintaining the smart technologies, while the women were less engaged. In study 2, both men and women were in general less interested in SHT and to a larger degree shared the responsibility of running the technology. The following section presents four cases, two from each study, that exemplify these prevalent gender dynamics and distributions of housework. The discussion of cases is not meant as a one-to-one comparison, nor generalisable. Rather, it illustrates several different gender dynamics and possible outcomes of SHT implementation that links with competences and meanings at play in everyday practices. The cases were selected for being generally illustrative of recurring gender dynamics in the two studies respectively and as such synthesise central tendencies in findings.

4. CASE STUDIES

4.1 CASE 1: ENJOYING DIGITAL HOUSEKEEPING

Adam and Cecilie are both in their mid-30s and live with their two small children in a detached house in a suburb to a larger city. Adam works as an accountant and Cecilie as a nurse. Their home contains a vast number of different technologies: digital voice assistants, smart lights, smart music control, a robotic vacuum cleaner, a robotic lawn mower, smart blinds, a smart security system with cameras, *etc.* Adam is the driver of the smart home and in charge of it. He has a do-it-yourself (DIY) approach and enjoys programming, integrating the different technologies, creating flows and exploring new possibilities for smart solutions in the home. Cecilie, on the other hand, is not very interested in SHT. She learns the necessary things from Adam, *e.g.* how to operate their robotic vacuum cleaner through an app, but she does not spend time tinkering with the technology as does Adam.

Adam has set up smart switches in the living room so they can control not only the lights but also the music, the robot vacuum cleaner and the window blinds. The switches make the connection run through wires (*e.g.* not Bluetooth), which allows for an instant signal with no delay, which is what Adam prefers. Adam has no technical background and does not work with information technology (IT). However, his father has always been interested in technology and Adam believes he has inherited this.

Adam describes himself as a hi-fi nerd: he is interested in technological quality (sound, vision, fast signals and gadgets). He prefers an open-source control system because it allows more technologies to be integrated. He aims to create the cheapest solutions possible while not compromising in terms of stylishness. In his own words, it has almost become a sport to him to create cheap homemade solutions and avoid buying the expensive technology. Rather than having the readymade software from SHT companies, he prefers buying the hardware and then build the automations himself, trying to create SHT solutions that use the least power. However, he estimates their total energy consumption as being higher now compared with if they did not have any smart technologies. During the interview he states that although the time he saves from the technological solutions does not make up for the time he spends on tinkering with SHT, he finds it valuable, nevertheless.

Cecilie often has trouble with operating the technology, especially when Adam has changed the settings, made updates or added new features. In the beginning when they obtained their robotic vacuum cleaner, it was only Adam who was able to operate it since Cecilie did not have the app on her phone. Sometimes she would call or text Adam at work and ask him to turn it on, which he was able to do remotely, via the app. Eventually, Cecilie also got the app and now they both estimate that she has been more in charge of vacuuming lately, in contrast to the beginning when it was always Adam (however often prompted by Cecilie). They vacuum on an ad-hoc basis, approximately once a week. Adam also installed sensors for their plants that can send notifications

to his phone when they need watering. Before, Cecilie would usually water the plants, but now Adam does it when he receives notifications. Cecilie finds this set-up 'totally unnecessary'. When she waters the plants, she checks whether the leaves are drooping or if the soil is dry, but now it has become Adam's domain. As Adam says during the interview:

> You're [Cecilie] actually lucky, now I water the plants way more. I never watered the plants before, it's only within the last year I began doing it. When I get a notification then sure I'll do it.

4.2 CASE 2: SIMPLIFYING DAILY CHORES

Nadia and Erik are both in their late 20s. They live with their two small children in a rented three-room apartment in a big city. Nadia works as a nursery schoolteacher and Erik as a facility operations manager. Apart from working fulltime, the couple primarily spend their time on running the household and taking care of practical matters related to having small children. It is Erik who has purchased the different SHT, and he is in charge of installing and updating it. As he says, he kickstarted their smart home while Nadia just 'tagged along'.

Nadia and Erik's SHT set-up consists of two Google Home speakers integrated with digital voice assistants which they use for controlling the television, music, adding things to their shared digital shopping list, setting timers during cooking, browsing the internet and controlling their smart lights. One example of the digital housekeeping that Erik performs is creating chains of actions in Google. He has, for instance, recently created one called 'Good night'. Thus, when saying 'good night' to their voice assistant during night-time, the television and the lights turn off and a dimmed night light in the hall is switched on. However, they rarely use this function: Erik estimates he uses it once a month. As he says, he just set it up to see if the function worked. Erik uses the digital voice assistant mostly in the mornings and evenings to turn the music or television on while looking after the children, *e.g.* when preparing their meals. During this, the children tell him what they want to watch and he then puts it on via voice command. As he says:

> I think it makes life much easier, especially having small children who wants one thing, then the other, and you're constantly occupied. [...] So, it can simplify things and make them easier.

Nadia, on the other hand, does not use the voice assistant very often because she still finds it difficult to talk to. However, she has slowly begun to use some of its functions, for instance, setting timers while cooking or asking about the weather. She describes herself as not being very interested in technology and prefers when it just works without requiring too much effort or skill from her side. As she says, she does not care 'to learn the ropes'. Furthermore, she has had troubles with getting used to the technology and often uses it through Erik. For example, she asks him to perform the voice commands for her. As she formulates it, she feels like it belongs more to him: 'I have something about it being yours [Erik's].' When she eventually does give the voice commands, it feels unnatural. She reflects that if she and Erik did not live together, she would not have the smart technologies installed. One of the things that makes her uncomfortable about the technology is, for instance, their voice assistant's listening function which she sometimes finds 'creepy' when it suddenly interacts at random points in their conversations.

4.3 CASE 3: MINIMISING HOUSEWORK

Nanna and Allan are in their 40s and live with their teenage daughter in a newly built owner-occupied apartment in an expensive part of a big Danish city. Allan has a leading position as a business services manager and Nanna works as a senior consultant. Their new-built apartment has underfloor heating, mechanical ventilation and is highly insulated. The apartment has a smart heating system installed with digital thermostats in each room and one in-home display (IHD) screen in the hallway. They also recently obtained a robotic vacuum cleaner which they were trying out at the time of the interview.

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Both Nanna and Allan work quite long hours and sometimes also in the evenings. Allan has for many years done much work-related travelling, and around the time when they moved into the new apartment he was living abroad for a period. Therefore, Nanna was the one taking care of most things in relation to decorating and getting settled in the new apartment. She also took on the responsibility of learning how to use the heating system and was in charge of the heating. After Allan moved back home and into their new apartment, he also learned how to use the system. Now, a few years after moving in, Allan is the primary user of the IHD screen, which they use to control temperatures in all rooms rather than the digital thermostats in each room. They have played with programming a schedule for the heating according to when they are at home so that the heat is turned down during night- and daytime on weekdays when they are at work. They have also used the vacation mode when going away on a holiday. In relation to this, money saving is not very relevant to them, although Nanna mentioned that it is nice to save money at the same time as contributing to the green transition and maintaining high comfort levels. They are usually happy with the system and find it quite easy to use, although at the time of the visit they were have some problems with controlling it. The system does not confer to their set temperatures, and they felt out of control at that moment. This could be related to the demonstration project, as their temperature settings could also be controlled remotely by the project partners experimenting with avoiding heating peaks.

Their new apartment is smaller than their old traditional apartment and therefore they feel that they live more compactly now, but with all the functions they need in their everyday life. Also, they think their current apartment is more energy efficient. They enjoy living in a new and smaller apartment because they have less housework and maintenance and more time to relax when at home, which is important to them. Nanna explains that her home should be simply decorated to induce calmness as she needs to relax her mind when she comes home after a long working day. During the week they do not cook themselves as they return quite late. Instead, Nanna buys and brings home an evening meal from the cantina at her workplace. On Fridays they often buy takeaways or eat out, but during the weekend they cook themselves. When living in the old apartment they had a cleaning service as they felt it was a hassle to clean. Living in the new apartment they feel it is much easier to clean (as it has a smaller area) and therefore they have agreed to do it themselves. They do this together spending a few hours at the weekend along with doing the laundry. Nanna does not really expect that the robotic vacuum cleaner will take over their cleaning routine.

4.4 CASE 4: TESTING GROUND

Karen and Poul live in a newly built apartment similar to the one in which Nanna and Allan live. It has the same smart heating system with digital thermostats in each room and one IHD screen in the hallway. This system was installed in all apartments in the building complex before the new owners moved in. Poul and Karen have an electric car, but they do not own any other smart technologies. Karen is 62 and works fulltime as an associate professor, and Poul is 70, a pensioner and, in his own words, a ‘stay-at-home dad’. They have grown-up children and grandchildren.

Because he is a pensioner, Poul does most of the housework during weekdays. He shops for groceries and most often also cooks so that meals are ready when Karen arrives home from work. Karen cooks more often at the weekends. Before, when they were both working, they would share housework responsibilities. Poul also does much of the cleaning during weekdays and is in charge of charging the electric car. This cannot be done from their apartment or a private parking lot in connection to the apartment, so he takes it to a neighbouring public parking space or somewhere else in the city and goes for a walk while it charges. Thus, the charging activity is not connected to a smart system in the home, but rather a manual practice which entails moving the car. Even though they feel it is a bit of hassle, they have the electric car because of environmental values as they do not wish to pollute the city, and also a feeling that electric vehicles are ‘the future’. Karen furthermore stresses that she normally cycles to work, and if she needs to travel somewhere else in the country in relation to work, she mostly goes by train. They also try to limit the use of the tumble drier to only bed linen, leaving the rest of the clothes to dry on racks either in

one of the two bathrooms or one of the two balconies. Besides from this, they feel that they live energy efficiently in the new-build apartment and do not think much about lowering their energy consumption additionally.

Karen and Poul have had many problems with managing the heating system in their new apartment. They have both learned to use the system by reading the manual to start with, and then trying out the technology and different strategies to make it work according to their temperature preferences. They have been very confused about the technology and how it works because they sometimes feel that they cannot control the temperature; sometimes it has heated too much or been lowered too much either during the day or the night. Some of this confusion is also related to the demonstration project in which the apartments in this building were involved for a period during the first years after the apartments were built. The project was carried out by a Danish technology company and a university partner, and the aim was to experiment with controlling the heating remotely to avoid heating peaks, *e.g.* during mornings. However, Karen and Poul have been very confused by when their discomfort was related to the demonstration project and when it was their control of the technology. They have not tried to schedule a heating routine or use the vacation mode as they feel it has been much of a hassle to use the system to heat the apartment according to their comfort notions. Karen has mostly been in charge of using the technology and trying to figure out how and when it worked or not (*e.g.* by manually writing on paper noting the temperatures in each room). She also demonstrates how it works during the visit. She has been the one to contact the project partners to get assistance with the technology. Before, when they lived in their old house, Poul was in charge of the heating system with radiators that needed seasonal maintenance work.

5. THE GENDERED DISTRIBUTION OF DIGITAL HOUSEKEEPING

As the four cases illustrate, the distribution of household practices and digital housekeeping take many forms, and the degree of motivation, technological interests and competences vary greatly among the participants. The smart home set-ups in the households are quite different and have been implemented in different processes and for different purposes. Cases 1 and 2 represent more extensive smart home set-ups than cases 3 and 4, as the former have various forms of integrated SHT such as automated lights, voice assistants and smart gadgets. Cases 3 and 4, on the other hand, represent more modest smart homes, mainly consisting of the built-in smart heating systems which to some degree are also operated by outside staff. When comparing the four cases, it is evident that the division of tasks is more clearly divided in households containing 'frontrunners', whereas roles are more equal in the less tech-interested households. How this relates to different meanings and competences involved in the performance of practices is considered next.

5.1 TECHNOLOGICAL FASCINATION, RELUCTANCE AND DIVIDED RESPONSIBILITIES

Cases 1 and 2 both represent households characterised by a male technological frontrunner and a less tech-savvy woman. The male frontrunners were the main drivers of the smart home, selecting and purchasing the technology, installing and maintaining it, and were primarily or solely in charge of the digital housekeeping. They had the necessary competences and digital skills for programming, connecting the technologies, creating settings and getting new ideas for further technological installations. Common to these male participants was an outspoken interest in technology that they both experienced since childhood.

Implementing SHT into the household's everyday practices gave new meaning and motivation for Adam when he performed household practices, and Erik felt that SHT made his everyday life more fun and convenient. On the other hand, the female participants were reluctant to interact with the SHT and only found it valuable when it worked smoothly, without requiring new skills or forms of interaction (*e.g.* voice commands). The passion for smart technologies was not equally shared within individual households. For instance, Cecilie would learn the basic commands of their smart technology systems by using an app on her phone which was needed to make the technology work

in her everyday in order to avoid changing the practices too much. Nadia would slowly try to learn using the voice assistant by voice command, although she did not feel comfortable. Often, these female participants would rely on their male partners when they needed to integrate the SHT into their everyday practices. Erik said that the implementation of SHT had led to a clearer division of roles in their household because he would now spend more time on digital housekeeping (installing, maintaining, updating and adapting the SHT) and thus less time on 'traditional' housework.

The SHT not only added new practices in the form of digital housekeeping, but also made changes to existing practices. The robot vacuum cleaner, for instance, changed traditional cleaning practices as vacuuming was now done by managing an app and involved communication between the partners. Also, the plant sensors that Adam had bought to send notifications when the plants needed watering changed the watering practice. Adam explained how he had come to enjoy vacuuming and watering plants after adding smart technologies to these traditionally manually performed practices. Thus, traditional housework is changed with SHT implementation and also the meanings ascribed to household practices. Adam had not become more engaged in vacuuming because of heightened cleaning standards, but rather because of his technological interest and enjoyment.

5.2 SHARED RESPONSIBILITIES AND TECHNOLOGY AS ENABLER OF COMFORT

In cases 3 and 4, the SHT set-up mainly consisted of the integrated smart heating which was installed through an energy demonstration project as part of building the new apartments. Thus, the implementation was carried out by outside professionals who held the necessary skills and knowledge about the technology, and the participants had not themselves taken initiative to install SHT. Both households had varied experiences with the technology and were frustrated when it did not work. None of the participants was interested in tinkering with the SHT for fun and enjoyment. They only regarded the technology valuable in terms of comfort enhancement, as well as convenience, if they could make the technology work. In contrast to the frontrunners, these participants were not curious about exploring or experimenting with the technology as such.

The smart heating was appreciated when it worked smoothly, adding comfort to the households and saving them time or energy. Nanna and Allan described time as a valuable resource to them and considered SHT ideal when saving them time. They did not enjoy housework and when at home they preferred to relax. Therefore, housework should be easy to overcome, also in relation to time. Most housework activities were shared, but also considered something to just get over and done with and something they wished to minimise. In the same way, digital housekeeping was in general not particularly enjoyed by the participants in cases 3 and 4 but was an occasional necessary practice that both genders would perform on quite equal terms. Male and female household members took turns sharing the responsibility for managing the heating system, shared the successes when it worked and the frustrations when it failed. The outside responsibility was furthermore outspoken, for instance, when Poul and Karen talked about having limited control with the system because the outside operators would manage it, turning the heat up and down. In both cases they also needed to contact the outside operators for help with controlling the system. This sometimes led to a feeling of lack of control, but it was also appreciated, for instance by Nanna, who spoke about not thinking so much about heat adjustment anymore.

In sum, the participants in cases 3 and 4 primarily valued the technology when it provided comfort and convenience, operating easily and invisible. Besides time savings, the environment was also mentioned as a value in these households' consumption practices. To manage the technologies, they would sometimes do workarounds or apply alternative methods, such as Karen checking the thermostats with pen and paper. Thus, the digital housekeeping was performed quite differently than seen in the cases of the frontrunners, as these held other competences, forms of knowledge and motivation for engaging with the technology than less tech-interested users. In study 2, digital housekeeping was more evenly distributed between male and female partners than among the couples in study 1.

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5.3 THE IMPORTANCE OF MEANINGS AND COMPETENCES IN (GENDERED) DIGITAL HOUSEWORK

The above analysis illustrates different competences and meanings connected to the implementation of SHT, which not only implies changes in the material arrangements of the home but also influences which competences are necessary in the performance of household practices, as was also shown by Aagaard (2022). These competences and meanings reflect how household practices are affected differently as the materials change by the introduction of SHT. Comparing the cases illustrates the link between internal gender dynamics and the distribution of household practices, including digital housekeeping, as the householders represent different competences and meanings in relation to SHT, affecting gender roles in the household. The meanings ascribed to traditional and digital household practices have implications for how, why and by whom the practices are performed. While participants with less technological interest reluctantly perform practices of digital housekeeping, frontrunners on the contrary enjoy spending considerable amounts of time programming, tinkering and playing with the technology. In this way, digital housekeeping can be a joyful activity for some practitioners, while for others it feels like a hassle or a duty. In the households counting frontrunners, the digital housekeeping was a male domain, implying a clearer gendered division of also other household responsibilities. As Erik said during the interview:

> I think the roles have just become more affirmed. I would say, at least in our home, it has always been me who takes care of all technical and technology. And since we've added more technology to our everyday lives, then I've been granted a bigger part of those tasks.

These cases of SHT implementation indicate that household responsibilities can become more divided and gender roles more reinforced when the interest, competences and ascribed meanings to the technology are unequally distributed. On the other hand, in the less tech-interested households, the distribution of digital household practices and traditional household practices was more evenly distributed as the competences and meanings towards SHT were also more similar among the householders.

The four cases represent different SHT set-ups: households with smart heating systems and households with a combination of various forms of SHT. These technologies in themselves afford particular forms of use. Heating is seldomly associated with fun and gadgets, but rather considered as something that should just work smoothly in the background, providing comfort and not require too much interaction, as has been shown in studies on heating practices and technologies (*e.g.* Larsen & Gram-Hanssen 2020; Madsen 2018). The SHT set-ups with various devices, on the other hand, require more work as the devices need to be integrated in order to function together. Some of these devices can also be described as gadgets as they relate to entertainment or creating a certain mood or atmosphere in the home with lights and music. These material differences underpin different meanings of the smart home. In the smart heating households, the technology, when working, played a quite invisible role in the participants' everyday lives, requiring less interaction than other technologies in the more extensive smart homes. For instance, the smart lights and digital voice assistants involved daily interactions via voice commands and app operations. Considerations of sustainability and energy consumption were quite absent among the frontrunners while being a more outspoken concern in the smart heating households.

6. DISCUSSION

Feminist technology studies have demonstrated the gendered construction of technology and how it has been associated with masculinity throughout time (Wajcman 2010). The home and domestic practices, on the other hand, are traditionally viewed as women's domain (Berg 1994; Mechlenborg & Gram-Hanssen 2020). While the findings of this paper in some respects reflect these insights, they simultaneously reflect a degree of contestation to traditional gender norms, *i.e.* in cases 3 and 4. The variation between the four cases relates to the point that:

> men and women practice their housework [...] as modes of resistance or conformity to conventional and contradictory discourses on gender and morality.
>
> (Pink 2004: 16)

Thus, masculinity and femininity are not bound to be associated with technological power and subordination (Berg 1994), but are continuously renegotiated in people's everyday lives. In study 1, men were in general the main digital housekeepers, which is a tendency also reflected in existing research (Kennedy *et al.* 2015; Strengers *et al.* 2019). In study 2, however, the digital housekeeping was to a much higher degree shared between male and female household members. These differences between the two groups (frontrunners plus reluctant; reluctant plus reluctant) found expression in terms of different competences and meanings at play. In this way, gender was performed differently in the two groups in relation to practices of digital housekeeping, but also to traditional household practices. For example, in cases 1 and 2, household practices such as vacuuming and watering plants were changed by adding smart technology to the practices (and new competences). This changed both the way the practice was performed and who performed it. The analysis therefore indicates that in order to overcome gendered divides and digital inequality in the home, it is necessary to consider competences and meanings in everyday practices as well as the gendered ideas of the technology itself.

Khalid & Razem (2022) in a similar way used practice theory to investigate the nexus of gender, domestic space and energy technologies in everyday practices, addressing power dynamics and gendered relations in households. Focusing on Global South contexts, they found that energy technologies such as lightning and air-conditioning and appliances such as washing machines can both signify domestic control for women according to their position in the household, at the same time as the energy infrastructures, spatial outline of homes and household technologies can take part in upholding a patriarchal structure and division of gender roles. Even though some of the working women in the study found liberation in energy technologies and appliances, in the form of freeing time to have both paid and unpaid work, this technological development has not changed gender relations and divisions of work in countries such as Pakistan and Jordan. This is following Cowan's (1985) seminal work that showed the technologic development to result in 'more work for mother'. However, Khalid & Razem (2022) also conclude that it is necessary to address the differences in access and needs between different groups of women according to the context of their role in the household in an attempt to reach both equality and sustainability.

Related to this, one should:

> take better account of chore-doing and the gendered nature of energy consumption both to avoid negative unintended consequences for the gendered division of labour, but also to improve the design and implementation of smart electricity systems.
>
> (Johnson 2020: 2)

In continuation of these arguments, the present analysis calls for specifically taking competences and meanings into account in the focus on chore-doing or housekeeping and in the development of SHT. This approach can contribute to strengthening future feminist investigations of the relation between gender and technology and their mutual shaping of each other.

7. CONCLUSIONS

Four household cases illustrated how the distribution between digital and traditional housework varies. This revealed how different technologies shape social practices and how differences in competences and meanings have implications for the gendered use and implementation of smart home technology (SHT). Comparisons of household usage of SHT identified different characteristics of these competences and meanings by analysing how gender is performed differently in participants' everyday practices. The gendered distribution of digital housekeeping and other forms of housework is impacted not just by gender but more specifically by gendered forms of knowledge, competences and meanings ascribed to everyday practices and how these are performed, including the technologies in use. Gender is neither static nor naturally inherited,

but rather performed in different ways. Furthermore, SHT and tech savviness are not inherently a masculine domain. More specifically, technological engagements and digital and traditional forms of housekeeping are distributed according to household dynamics and negotiations, configured by the interplay between competences and meanings in the performance of practice.

The introduction of SHT changes the competences needed in practices and the meanings attached to them. Thus, SHT requires new forms of tech competences in performing everyday practices such as heating, lighting, vacuuming and controlling music. Also, the meanings of these practices related to comfort, cleanliness and convenience are changed by the new technologies. Both competences and meanings related to the use of SHT in everyday practices are gendered in different ways according to gender roles and negotiations within households. These changes are induced into traditional housework practices but are also at play in new practices of digital housekeeping. Therefore, the design, functionality and intentions with SHT need to include differences of gendered housekeeping as well as the gendered vision of SHT and its users. It is thus critical to consider competences and meanings in everyday practices to avoid digital inequality and accommodate a sustainable transition of everyday energy consumption for different members and different household types.

NOTE

1. Empirical findings from this study have also been used by Aagaard (2022).

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COMPETING INTERESTS

The authors have no competing interests to declare.

DATA AVAILABILITY

Anonymised interview transcripts will be publicly accessible and stored in a data archive.

ETHICAL APPROVAL

Research was performed in accordance with the Declaration of Helsinki and was approved by Aalborg University, complying with data management guidelines. All participants were informed about the purpose of the research projects and gave their written consent to participate, having their personal data protected in accordance with the European Union's General Data Protection Regulation (GDPR). Written informed consent was obtained from all research participants and personal data (including participants' names) were anonymised. The names used in this paper are pseudonyms. All participated voluntarily and did not receive any gifts or economic compensation for their research participation. Interviews were conducted via physical meetings in the participants' homes, except for two interviews in study 2, one of which was conducted by Skype and the other by telephone.

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A.1. APPENDIX A

Table A1: Summary of interview participants in studies 1 and 2.

PSEUDONYM(S) AND AGE (YEARS)	HOUSEHOLD SIZE	RESIDENTIAL TYPE	EXAMPLES OF SMART HOME TECHNOLOGY (SHT)	SETTLEMENT/ LOCATION
Study 1				
Adam (34), Cecilie (34)	4 household members (2 preschool children)	Owner-occupied detached house	Automated lights, smart alarm system, robotic vacuum cleaner, smart speakers, digital voice assistants	Suburb
Nadia (28), Erik (29)	4 household members (2 preschool children aged 4 and 2)	Rented apartment	Automated lights, smart speakers, digital voice assistants	City
Sara (23)	3 household members (1 male partner and 1 preschool child)	Rented house	Automated lights, smart alarm system, robotic vacuum cleaner, smart heating, digital voice assistants	Village
Frederik (48), Charlotte (45)	4 household members (1 school-aged child, 1 adolescent)	Owner-occupied detached house	Automated lights, smart speakers, digital voice assistants, temperature and humidity sensors	Outskirts of city
Mikael (39)	4 household members (1 female partner, 1 preschool child, 1 school-aged)	Owner-occupied detached house	Automated lights, smart alarm system, robotic vacuum cleaner, smart speakers, digital voice assistants	Outskirts of city
Oliver (29), Anna (27)	1 household member (they live separately; the interview was conducted in Oliver's home)	Cooperative apartment	Automated lights, smart speakers	City
Hans (52), Susanne (?)	4 household members (1 preschool child, 1 school-aged)	Owner-occupied detached house	Automated lights, smart speakers, digital voice assistants, smart alarm system	Village
John (52), Connie (47)	4 household members (1 school-aged child, 1 adolescent)	Rented house	Automated lights, smart speakers, digital voice assistants, smart alarm system, homemade gadgets	Suburb
Karl (32), Eva (29)	2 household members	Rented apartment	Automated lights, smart speakers, digital voice assistants, smart heating	City
Kasper (48)	1 household member	Cooperative apartment	Automated lights, smart speakers, digital voice assistants, smart alarm system	City
Martin (47), Tina (47)	4 household members (2 school-aged children)	Owner-occupied summer house	Automated lights, smart speakers, digital voice assistants, smart alarm system, smart heating, robotic lawn mower	Village
Markus (35)	2 household members: (1 female partner (35))	Rented apartment	Automated lights, smart speakers, digital voice assistants	City
Nikolas (29), Laura (29)	2 household members	Owner-occupied detached house	Automated lights, smart speakers, digital voice assistants, smart alarm system, smart heating, robotic vacuum cleaner	Town
Peter (65)	2 household members (1 female partner)	Owner-occupied detached house	Automated lights, smart speakers, digital voice assistants, smart alarm system, smart heating, robotic vacuum cleaner	Outskirts of city
Ida (31), Andreas (33)	2 household members	Rented apartment	Automated lights, smart speakers	City
Study 2				
Poul (70), Karen (62)	2 household members	Owner-occupied apartment	Smart heating	City
Kristian (70)	1 household member	Owner-occupied apartment	Smart heating, smart alarm system	City

(Contd.)

PSEUDONYM(S) AND AGE (YEARS)	HOUSEHOLD SIZE	RESIDENTIAL TYPE	EXAMPLES OF SMART HOME TECHNOLOGY (SHT)	SETTLEMENT/ LOCATION
Nanna (46), Allan (40s)	3 household members (1 adolescent)	Owner-occupied apartment	Smart heating, robotic vacuum cleaner	City
Thomas (49)	1 household member	Terraced house (cooperative ownership)	Participated in project with smart heating technology, air-to-air heat pump	Town, island
Svend (70)	1 household member	Owner-occupied town house	Participated in project with smart heating technology	Town, island
Niels (64), Susan (61)	2 household members	Owner-occupied detached house	Participated in project with smart heating technology, air-to-air heat pump	Town, island
Marianne (75)	1 household member	Owner-occupied town house	Participated in project with smart heating technology, air-to-air heat pump	Town, island
Johannes (70), Ruth (69)	2 household members	Owner-occupied detached house	Participated in project with smart heating technology	Town, island

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