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The irony of the smart home: How the IoT shifts power balances and reinforces household values

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ABSTRACT

We consider inequalities within households to be an important step for increasing our understanding of digital inequalities perpetuated by smart homes. We argue that the key to understanding the use of the Internet of Things is household choreographies rather than individual practices. We specifically address different power relations between household members in regard to their use of IoT devices. Using interview data collected through five visits to 30 households in 15 months, we use abductive analysis to develop our framework that has three dimensions: materiality, accessibility, and harmony. We find that acceptance of the IoT's materiality by all household members is key, but household rules are also crucial to how well the IoT can operate. Parents can more precisely moderate their children, and data and privacy also require more moderation. In addition, the IoT can help complex household choreographies, but household choreographies that are too complex can hinder IoT use. Finally, we note that traditional gender roles remain prevalent in smart homes.

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Introduction

The Internet of Things (IoT) – collection of internet-connected devices such as lamps, doorbells, thermostats, vacuums, and washing machines – is becoming ubiquitous in households (Aheleroff et al. 2020; Aldossari and Sidorova 2020; Aliero et al. 2020; van Deursen et al. 2021). Ideally, the use of household machines would help alleviate the burden of certain tasks and distribute responsibilities more evenly as well as balance work-at-home and work-away-from-home (Fortunati 2018; Wajcman 1991). The IoT could be particularly promising due to its remote control and automation capabilities, which could alleviate and redistribute labor in the smart home. However, research on digital inequalities has shown that the positive and negative outcomes of digital technologies use are unequally distributed in society (van Dijk 2020) and that this gap is relatively increasing due to different skill levels (Helsper 2017). Consequently, as the digitization of society advances, individuals who have been less able to develop crucial digital skills such as those in lower economic strata (Gonzales 2016), with lower education (Scheerder, van Deursen, and van Dijk 2020), the disabled (Dobransky and Hargittai 2016), and the elderly (Blažič and Blažič 2020) are increasingly disadvantaged.

With the IoT, we might suspect a similar pattern (van der Zeeuw, van Deursen, and Jansen 2019, 2020) but also something new: most IoT devices are not used on an individual level as with laptops or phones but on a household level as everyday household devices. While most IoT devices in the smart home are still tied to the main account of an IoT user, this user is dependent on other household members for accepting and using the IoT. If the IoT does not fit the routines of their everyday lives, this dependency can become particularly inconvenient. In effect, it is not a matter of the IoT intermeshing with one person's everyday routines but with those of multiple people. Therefore, the research on the IoT should focus not on the only individual user but the entire household. Accordingly, contributing factors for inequalities should be established by examining how individuals are imbedded within households, before comparing individuals.

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The aim of our research is twofold. First, we explore IoT use embedded within households so that future research can properly assess how inequalities are created between households. Second, we explore the interplay between the power dynamics in the domestic sphere and IoT use. Here we explore the changes in the interplay between stereotypically masculine roles of technology use and stereotypical feminine roles of household responsibilities (Fortunati 2018; Strengers et al. 2019; Wajcman 1991). We also explore the changes in how parents and how deal with their "digital native"[1] children. To explore how such digitally mediated power dynamics are tied to household routines, we use the notion of household choreographies together with concepts from the dramaturgical perspective as the scaffolding of our analysis.

Theory

With the introduction of IoT in the smart home, researchers expect a redistribution of household tasks (Aheleroff et al. 2020; Aldossari and Sidorova 2020; Strengers et al. 2019). However, such expectations are generally based on technological characteristics of IoT devices, overlooking the social relations between people and their everyday lives – the social roles that are established, affirmed, and repaired to make life at home coherent, such as the “parent” and “child” or the “husband” and “wife”. Some people have difficulty with IoT implementation, as it needs to be installed, programmed, and used within preexisting material and social structures of the household to work effectively. Others have more difficulty with the changes they need to make in their social roles for the IoT fit in their everyday routines, as the ability to adjust varies with work schedules, number of people in the household, and other factors. Moreover, the flexibility of social roles is restrained by the mutual dependencies in establishing roles, reaffirming roles, and repairing each other’s role masks (Butler 2011; Goffman 1959). All everyday interactions at home we refer to as household choreographies, with our focus being on those that involve interactions with the IoT.

The framework of choreographies itself has been inspired by Loke and Kocaballi (2016), which combines the notion of inscriptions from actor–network theory with social and material influences on movement. Studies using a choreography framework can be divided analytically into micro, meso, and macro levels (Parviainen 2016; Parviainen, Tuuri, and Pirhonen 2013). Studies on the micro level – inspired by choreographies on dance and the work of Laban (1966) – focus on movements such as finger swipes or the feel and weight of using devices. Studies on the meso or local level mostly focus on bodies in social interaction, e.g., people hiding behind phones to avoid eye contact (for a discussion on urban choreographies see Parviainen and Ridell 2021). Studies on the macro level mainly focus on large-scale activities, e.g., thousands of people contributing to the Wikipedia. Our research is aimed at the meso level – local routines and how they are mediated by the IoT within the household.

To further explore household choreographies, we use concepts from the dramaturgical perspective. The dramaturgical perspective has most famously been developed by Goffman (1959). Its theorization of impression management has been widely used in the research on the use of digital technologies (e.g., Djafarova and Trofimenko 2019; Maares et al. 2021). However, Goffman (1959) also gave considerable attention to the power dynamics between teams of performers and their use of stage arrangements to gain an upper hand. According to Goffman, the prime motivator of performers is their fear of losing face – or the mask of a role – together with the embarrassment that comes with it. Consequently, many of such power plays are tied to the expectations of how people are supposed to act, through tact or etiquette, to safeguard their social position (Kuzmics 1991). We see this in: the IoT enthusiast promising to deliver the comforts of the IoT, but other household members finding it a hindrance; parents whose children gain a taste of power over them by being more proficient in controlling the IoT; homemakers who feel that their roles are under threat of being undermined by IoT devices. Losing face, in other words, exposes the discrepancy between reality and the power ascribed to the performer.

Informed by the dramaturgical perspective, we can describe household choreographies along dimensions of materiality, accessibility, and harmony. We developed these dimensions through abductive analysis (Tavory and Timmermans 2016), meaning that we directed part of our interviews to expectations regarding gender roles and digital natives, and subsequently we engaged in an iterative process between analyzing interview data and reviewing the literature. First, we discuss how the materiality of IoT devices affects social roles within households – materiality dimension. Second, we discuss how access to IoT devices and IoT data is moderated – accessibility dimension. Third, we discuss how the IoT is made to fit into existing patterns of behavior with the time and effort available – harmony dimension.

Material dimension: Materiality of regions and arrangements

Goffman talks of a backstage – the behind-the-scenes region for relaxation or preparation for actions on the front stage. In her study on the internet in everyday life, Bakardjieva (2005) describes the use of wired spatial arrangements, where internet users designate a region, such as the basement or a corner of the living room, for a desktop computer and all computer-related tasks. Similarly, Scheerder, van Deursen, and van Dijk (2020) found that lower-educated individuals often have their wired spatial arrangement in a game room, whereas higher-educated individuals have it in a home office. Such regions are loosely tied to social roles, whether for leisure or work, and allow for a retreat from other roles in family life (Lincoln 2013; Livingstone 2007). On the other hand, the IoT is experienced by the whole family due to its pervasive presence in the household. In fact, the IoT often centers on the living room, a region where *several* performers distinctly identify themselves (Goffman 1959; Tutt 2005). Whereas the internet al.lows one to retreat to a spatial arrangement to perform different roles, the materiality of the IoT invites all household members to integrate it into their everyday choreographies.

Moreover, there are no spatial arrangements specifically for IoT devices; rather, they need to be fitted within a preexisting material structure with other domestic technologies. Often, this implies that the household needs to be adjusted to meet the new material characteristics of the IoT. Such is the case with smart vacuum cleaners that work better robotically when the floor has been cleared of wires and other items they can get stuck on (Sung et al. 2007). The potential use of a technology, in other words, is inscribed heavily in the material properties of the device (Latour 1992). Further, whereas nondigital devices have a relatively static place in household choreographies, software updates continuously inscribe IoT devices with new qualities that require socio-corporal renegotiations. In effect, for effective IoT use, regions must be arranged for and by all the performers in a household choreography and they must be continuously maintained.

Moreover, distinct spatial arrangements for the internet sets distinct power relations between specific roles. For instance, a powerful office worker turns into a subservient and caring parent at home, or a digital native who ranks high with online video games in the gaming room turns into a dishwasher in the kitchen. With the ubiquitous materiality of the IoT, the power relations of household roles are more convoluted. Consequently, power over the IoT (mostly accumulated by one's digital skills) carries over to the distribution of power in the household as users move between regions. As such, the office worker or the digital native might suddenly intrude into the homemaker's roles by controlling the devices that make the home. However, the IoT enthusiast can lose face when it fails to deliver because of misalignments. For instance, when lamps cannot be controlled digitally because they have been switched off manually. This would create the embarrassment of the type people have when visitors enter messy parts of the host's home (Warren 2010).

Accessibility dimension: Accessibility of the stage and stage-time

Since digital devices are often tied to accounts, sharing these devices can be slightly more difficult than sharing nondigital devices. Rainie and Wellman (2012), for instance, show that more choreography is needed when a computer is being shared, and several email accounts are used to keep messages separate. Most households are choreographed by formal and informal social rules to mediate things such as privacy, screen time, and costs for online services per individual (Bakardjieva 2005; Plowman 2015). Such rules tend to reflect important moral values of the household (Haddon and Silverstone 2000; Silverstone, Hirsch, and Morley 1992). Choreographies of access to devices, in turn, are inscribed by the expectations of its primary functions (Loke and Kocaballi 2016) and by the ongoing negotiations of rules about the devices and their regions of use (Tutt 2008). However, regulation of access to the IoT impinges the accessibility of common household appliances or devices needed in everyday household tasks. Therefore, instead of switching between accounts within household ensembles, multiple accounts need to be tied together to share IoT devices conveniently in a household choreography.

Sharing access to the IoT has two main implications for social roles in household choreographies. First, the time of access. With the IoT, access to everyday devices can be regulated online, remotely, and automatically, e.g., lowering of the shower temperature to reduce long showers. Such use of IoT for a greater exertion of parental power can reinforce parent-child roles in the household, e.g., turning on of child-lock feature that disables radiator button during set periods. However, digital native children might find their own pockets of power when they outperform their parents with digital skills, e.g., children might turn

off the hot shower water when they feel it is their turn, stealthily switch their bed light on/off without much physical movement. However, the notion that digital natives are more skillful is contested (Selwyn 2009), and smart household appliances do not always capture the same levels of interest of children as digital entertainment does.

Second, the data are related to the main account, but its owner is not necessarily the main user. Consequently, the nebulous effects of algorithmic decision-making processes mostly affect the person behind the main account rather than those using it. Household members need to decide who will be in the digital spotlight and carry responsibilities of privacy and data protection for other household members. Consequently, those in the digital spotlight might lose face when IoT data expose something that they had kept in their private sphere. This can happen between household members who share accounts and account data (Ur, Jung, and Schechter 2014) or when data are exposed to other audiences and third parties such as insurance companies (Amaraweera and Halgamuge 2019).

Harmony dimension: Intermeshing of technology and routines

Even when the stage has been arranged properly and the performers are well-timed, the technology needs to be intermesh with routines for harmonious choreography. When that occurs, the effort put into the device to work properly is matched by the expected output of the device (Loke and Kocaballi 2016). On the other hand, when people do not smoothly intermesh with technology, their interface becomes disruptive (Lupton 2016).

The IoT needs to resonate with the social roles and the people's abilities to carry out those roles while using it. For example, homemakers often find IoT devices lacking adequate precision for carrying out their tasks compared to their own homemaking skills. This may happen either due to their unrealistic expectations about the capabilities of their IoT capabilities or programming errors in their devices. In such cases, the limitations of the IoT reaffirm the value of traditional domestic labor and their homemaker role. For traditional homemakers roles who are less skilled and have fewer expectations, it may be easier to develop a harmonious choreography with the IoT.

IoT use by children may fall into harmony more naturally with their choreographies, because they grow up with IoT devices and have few expectations to uphold. This can become a source of embarrassment for the parent who needs to put more effort into using the IoT. On the other hand, children can be much less harmonious with household choreographies than parents would want them to be. Even by simply making a mess out of their room, children can make the choreography inharmonious. In such cases, preparing the household for the IoT could actually result in more work for the homemaker.

Methodology

At the beginning of 2019, we recruited 30 Dutch households with IoT devices to participate in our research. Our recruitment criterion was that the household have at least one IoT device (e.g., smart lights, thermostats, doorbells, locks), preferably at least one of them measuring biometric data (e.g., activity trackers). Although this selection criterion proved rather constraining in 2019, we still sought to maximize the variation in our sample by household size, number of IoT devices, rarity of IoT devices, educational level, field of work, and social influences by neighboring participants, family, and colleagues. We used flyers to recruit participants, four schools distributed our recruitment letter to parents, and we used online platforms to spread our recruitment message. During the later stages of recruitment, we asked participants who had already signed up if they knew of others willing to be contacted for our study. All participants were invited to sign up formally via our website, which included a more detailed description of the project, how their data would be used and stored, and conditions for their reward for participating (400 Euros to participate for 15 months). Table 1 provides an overview of our participants and their household compositions. For each household we interviewed nine women and 21 men as the main participant who signed up for the research, but with 11 participants their partner joined the interview.

All 30 households were visited five times during a 15-month period by the first author. The first visit started with a repetition of the aims of the research as stated on the recruitment website, description of how we would handle their input as sensitive data, as well as us making it a point to emphasize to the participants that they could stop their involvement at any moment during and after the research. Each of the following visits started by asking participants if they had any questions or concerns about the research and a request for permission to record the interview using a GoPro Hero 7 (for audio-visual data). At the end of the visits, participants were asked if they had questions about the interviewer or the research, or if

Table 1. Participants' household composition.

	Sample households *n* = 30
Type of income	
Single income	9
Dual income	21
Children	
None	6
Below 12	10
Above 12	11
Moved out	3
Residential accommodation	
Apartment	3
Terraced house	15
Attached house	8
Detached house	4
Household size	
1- person	1
2- person	9
3- person	6
4- person	12
5- person	1
6- person	1

there was anything else they would like to address. Each visit had a specific theme: IoT adoption, economic incentives and rationalizations, shifting power balances and responsibilities, creativity and playfulness, and data privacy. Most of the data for this study comes from visits dedicated to the topic of shifting power balances and responsibilities, but the topics did overlap. This is especially true when children were discussed in visits on creativity and data privacy.

For the main visit of this study, which focused on shifting power balances and responsibilities, we started the interview by asking about the general distribution of household roles, specific distribution of tasks, and responsibilities. It is a limitation in our study that for 18 participants we did not manage to collect interview data from other members of their household on this topic – shifting power balances and responsibilities. We then focused more on using the IoT as technology in the domestic sphere. Additionally, concerning children, we asked parents to imagine the future when their children have grown to adolescents or adults to determine if they felt prepared in their role as parents. It also helps to contrast their expectations with memories of their own childhood and how they give meaning to their present actions (Livingstone and Blum-Ross 2019). We did not interview children separately. Total interview time for each household lasted on average 2:18 hours (Min = 1:24, Max = 3:14) and on average 28 minutes (Min = 11, Max = 69) for each visit, but we found this to be highly dependent on the complexity of the IoT devices and the system used.

The audio-visual data were analyzed with Atlas.ti. The data analysis followed a process outlined by Tavory and Timmermans (2014) for abductive analysis to increase attention to gaps in existing theories and surprising findings. In the first phase of data familiarization, the data were coded and organized according to the interview structure constructed beforehand. The next phase consisted of an inductive procedure with the focus on circulating incidents and cases to keep the analysis grounded in empirical data (Glaser and Holton 2004). Finally, with extended memos, our findings were substantiated with the relevant literature. We use pseudonyms for the participants quoted in the findings section. These quotes were selected because they are concise and insightful without disclosing too much personal information.

Findings

Choreographies of materiality

The IoT is more intrusive in the household than the regular internet because more people are directly affected, in contrast to computer use. While interest by an IoT enthusiast can introduce a household to it, its ubiquitous materiality in the household makes it difficult to limit it to a person's hobby alone. The difficulty in the arrangement of its materiality in a household is illustrated by Peter, who, when moving into his newly built home, decided to go without light switches. He has 12 groups of dimmable lamps without individual light switches. However, all the lamps are connected to the internet and operated via Apple HomeKit. While such an arrangement dovetails nicely with his interests in digital technologies, since it is situated in the home, having lights without switches has consequences for the choreographies of other household members. As he explains:

> I do enjoy it too, but that is some of the problem. It is not just a hobby project because it is in our home after all. Recently, I changed something in the HomeKit, the position of the button for switching the lights on and off. Right away my wife goes: "Hey, what is that? It does not work". That is it. She finds it quite difficult to deal with, but once it works, using an app and pressing a button, it immediately becomes the default. All light switches are immediately forgotten, which is very easy. But, if it does not work, it is also immediately a problem. So that makes it from a hobby … Well, it is fun, I can have fun with it, but if it does not work or the server goes down, then I immediately have a problem.

Since the IoT is materially intrusive, it is more affected by household power dynamics and vice versa. Whereas a regular internet enthusiast can move to another region, such as an office or game room, IoT intrudes movement in shared regions and choreographies. As Peter continues, "The WAF, you know – the

wife acceptance factor – must be quite high. So, it just has to be a button on and off and for the rest it does not matter that much". Regardless of gender or idiomatic expressions that play on stereotypical gender roles, the IoT must fit the movement of other household members. However, Peter says little about a "child acceptance factor", giving us the impression that the power to veto the materiality IoT – the absence of light switches – is absent with Peter's children. A similar view of acceptance can be found with Anna and Bernard, who both work in IT, have one child and are generally fond of digital technologies:

> When we get something new, it depends a bit on who buys it or who picked it. But Bernard does that more than I do and when it is new, he will find out how it works and sets it up. But then I am the one who continues to use it. Usually, in that order and not so much that I figure it out and set it up and he just uses it. He's more of the tinkerer to get it working and I am truly the consumer.

While both Anna and Bernard are accepting of the IoT, Anna makes a distinction in their roles as the "tinkerer" and the "consumer". This is not so different from Peter, including their alignment with gendered roles. The "tinkerer" has new forms of power in the household through the IoT. The "consumer," in turn, is tied to regions of the household, such as that of the homemaker. In other words, the materiality of the IoT plays out differently among household members. The "tinkerer" keeps the IoT running stable, while the "consumer" distributes power through household choreographies via dynamics of acceptance and expectations. The role of children is mostly passive.

Material programming of the household

As the IoT is materially ubiquitous in the household, creation and maintenance of the material conditions that are facilitative of IoT use becomes a joint effort. While children are passive in the adoption of IoT, they are expected to keep the household IoT friendly. For instance, in the case of Peter's lamps, if one of the household members switches off a lamp manually, he has to manually switch it on again before he can control it remotely. More broadly, the average household is filled with material features such as light switches, which could hinder the potential of IoT use and thereby result in "tinkerer's" loss of face. Therefore, the "tinkerer" is motivated to mobilize a joint effort of all household members, including his children, to deal with such features. That is, the IoT prompts choreographic movement from the members of the household. For example, talking about robot vacuum cleaner, Robert, a father of two, explains:

> So, we have a robot vacuum cleaner from LG. We use it downstairs and upstairs for closed spaces. How it works is that you make sure that there are no cables or shoes with laces because they will get stuck in them. What also makes it more difficult is a carpet, say a thick carpet. It gets stuck there too. For the rest, it can simply vacuum independently.

The simple if-this-then-that programming structure takes a more material form with the IoT. For example, if the vacuum cleaner comes across shoelaces, then it will eat them and become stuck. The IoT works best if everybody commits to some degree of material programming. This makes the programming of household regions to optimize the IoT a joint effort. Peter's later decision to remove manual light switches is one way of ensuring that everybody is on board with an IoT-based choreographies of materiality.

The alternative becomes more explicit when certain aspects of the household are unprogrammable. For instance, Anthon, who has a background in plumbing, is aware of the risk of household appliances when away from home. While Anton has some IoT devices, such as smart lights, he is cautious about using other household appliances, as he explains:

> We have the approach here, only turn the washing machine on when you are at home. Yeah, because should something happen, it is usually with the washing machine. If there is a fire, how often is it that the washing machine or dryer has not been working properly. Or a leakage, I have also had that once. If someone is home, you can immediately press the button.

Most importantly, the household rule to not use the washing machine without the possibility for physical intervention overrides the benefits of programmed IoT. This is where choreographies of materiality intersect choreographies of access. Not only are most IoT devices designed to limit physical intervention, as Peter's and Robert's experiences illustrate, the physical movement and interventions also need to be limited for IoT to work effectively. For Anton, however, reprogramming the household rules to fit the materiality of IoT do not accord with a core principle – minimize risk. The experiences of Peter, Anna and Bernard, Robert, and Anton illustrate that the materiality of IoT invites household politics.

Choreographies of access

One of the prominent attractions of the IoT is that it could make the home more comfortable. Generally,

this means fewer button-press events and more automation. Such is the case with Peter, whose IoT-based lighting system has greatly reduced the need for effort, one has to do little beyond tapping on some buttons on a mobile application. This affects his children, who are growing up in a household without access to manual light switches. When asked if his children would ever complain about the lack of light switches, Peter responded:

> No, but recently they were staying with my parents and they leave the lights on everywhere. Well, I cannot truly blame them because they do not have to think about it at home. They just go to the toilet; the light comes on and after one or two minutes when they are gone it goes out. So, there are no complaints, except from other people: "your children leave the light on everywhere".

As such, the IoT brings new light to the notion of "always online" (Turkle 2017) to the degree that offline access events, such as manual light switches, are easily forgotten. However, when children first obtain access to the IoT, it can give rise to childish choreographies. Such is the case with Chris and his children, who also have their lamps connected to the internet. As Chris explains:

> In the beginning, they just had great fun to switch lights on and off from their bedroom. That got pretty annoying, but that was already a few years ago. Maybe they would use it slightly more sensibly now. But they do not ask for it either.

IoT-based access to the lamps was quickly disabled because it became too annoying for Chris. Choreographies of access via mobile devices or IoT accounts can be moderated more specifically than a manual switch, if parents have those skills, for instance, by giving access between certain times digitally. Cases such as that of Chris show that use of remote access enabled by IoT devices reinforces power equations between the roles of parents and children as the rule-maker/enforcer and the rule-follower, respectively, regardless of their digital skills.

Access of accounts and data responsibility

The operational ease that children might experience seemingly naturally with the IoT might also be a cause for concern to parents. That is, the IoT can be so easy to operate to the point that it makes its users vulnerable. This is explained by Kristine, mother of two children:

> I have one of those Fitbits and they say, "Oh, we want that too!" but then I think that they do not see what the consequences are if you share your data, for example. It is so easy, you just move one slider back and forth, and everyone can watch … I think that is a very worrying thing. It is so easy for them. In terms of user-friendliness, I think that many people with a disability benefit a lot from it because it is truly made a lot easier. It is easier to scroll back and forth in an app than having to read a whole manual. I do not see either of them doing that. But on the other hand, I think there is also many dangers in them. They are very easy prey …

The data sharing data Kristine refers to is the geofencing data she learned about accidentally when exploring the settings on her Fitbit. Remarkably, given the prevalent discourse on digital natives, this concern was voiced only explicitly by Kristine during the interviews. Perhaps because she has children with special needs and is more exposed to their cognitive vulnerabilities. In contrast, the presumed knowledge of children as digital natives, especially by their own parents, is often less than realistic (Helsper 2020).

Without the heightened awareness of children's vulnerabilities, such as in the case of Kristine, people are generally unaware of what harm unauthorized access to IoT data can do. This is reflected in the response of Anna, who uses the account of her husband, Bernard, to control the smart heating:

> With personal data it is of course really very different than data about whether I turn up my central heating in the morning between seven and eight or something. I think that if they want to know that, be my guest! I do not understand why they would want to know that, but I also cannot think of many problems with that if someone knows that about me.

When asked if that would not be personal data, Anna responded: "I mean, it is not personal data but it is data that comes into your personal life a little bit, you know." Accordingly, different perspectives on personal data and privacy translate into different assessments on risks and vulnerabilities. When people are more aware of risks and third-party audiences, data responsibility becomes more of an issue. Again, turning to Kristine, she explains how reluctant she is to share her device because she is unsure about who is looking at the data:

> I think: "Nice, I will go and see how I sleep and then I have an image with that" and then I say to my husband: "I think you have a sleep apnea, maybe you should put it on for a few days to look of how many … " But if you know that a health insurer is looking at that data and it might see some very serious ailment … Then, I think: "Do not do that".

Kristine's privacy concerns with IoT devices began with her role as a parent and later extended to her role as a partner. By being the "tinkerer" and "consumer" of her Fitbit, Kristine controls choreographies of access with the device and, in effect, who gets to be in the digital spotlight when data are being collected from her household. The similarity between Chris and Kristine is that they both distribute access in household choreographies, either by reducing operational access or reducing data access. This, in other words, means less sharing between devices or sharing devices with fewer people within the household.

Choreographic harmony

Once the household has been arranged for choreographies with the IoT in terms of materiality and access, household members need to harmoniously intermesh with the IoT. Choreographies become more complex when the homemaker's roles are divided among household members rather than being fulfilled by one person. The IoT, consequently, can be used as a tool to facilitate shifts in power distributions between partners in households. We see this in the experience of Edward and Jane, who both work full-time. When asked if his Nest thermostat helps on that score, Edward said:

> Yes, that is also an important reason we have it. We both work in jobs where we sometimes have to continue working, but sometimes that is till eight o'clock in the evening. So, it is useful to be able to postpone the program. That happens a few times a week. I think that is handy.

Edward and Jane regularly adjust the thermostat from a distance for economic and environmental reasons. The IoT, as such, can help mitigate the complexity of dual-income households. However, household choreographies that are too complex can also hinder IoT use, especially predictive programs. Such is the case with Alphonse and Marie with their two children, who also have a smart thermostat:

> Those programs for the heating do not work here because I work in three shifts. Look, if everyone leaves at eight in the morning and come home at five, you can say between eight and five turn the temperature to nineteen degrees and at four o'clock turn the temperature to twenty. But that does not work here because of my three shifts.

When there are too many users and rapidly changing schedules, technological capability for algorithmic decision-making is left unused. Baldly put, some households have too many people for the IoT to work harmoniously. In other words, the IoT aids complex working schedules, yet household choreographies that are too complex can limit IoT use.

Moreover, the ability to control the household is also an important factor in households where traditional homemaker roles are mostly fulfilled by one person. Judith, one such person, explains why she does not have any IoT devices other than her smart thermostat and activity tracker:

> Maybe it is also because I'm more of a person who likes to be in control myself. Yes, I think we are already handing over so much. I have the same with the self-driving cars. I'm skeptical about that too. That I think "well, would you really want all that?" What's left for yourself then? I think that it also makes you very lazy as a person. That you no longer think about things for yourself, because a thing is already doing that for you. Yes, why do you have to hand over everything? You would still want to keep control over something yourself.

Judith's hesitance to give too much control, and therefore distribute her power, to "things" suggests that the IoT intrudes on the homemaker's domain. Similarly, when Erik, an IoT enthusiast, was asked why he did not invest in household products to help his wife, Ellen, to alleviate household tasks, he said:

> I do not know if such a vacuum cleaner gets into all the nooks and crannies. I would like it, but I think my wife has something like: "I will just do that myself. I want to know that it is done properly".

Erik's impression of Ellen as a homemaker reaffirms traditional gender roles and the locus of control in the household. In contrast to Peter, who explained that the IoT is not just a hobby, Erik makes a clear distinction between the IoT as a hobby and the seriousness of household labor. Interestingly, while the IoT can alleviate the homemaker's household labor, Judith and Erik find that they are skeptical and distrusting of the IoT for such tasks. That is, in cases with strong feelings about homemaker roles and the household as their region of work, the IoT can signal a loss of control over these roles and regions.

Motivations and choreographic fit

As with Chris, whose children kept switching the lights on and off at inconvenient times, most parents responded similarly by saying that their children show little interest or motivation in using the IoT after they have played with it for a while. This is mirrored by

Elliot, who makes this observation about his younger colleagues and his two children:

> The younger generation are sometimes not that preoccupied with it. It seems as if they missed that. We are still setting up our own networks or installing a router by ourselves, but many people cannot even do that anymore because everything seems to work apparently. No, and sometimes you get "Oh, I do not have any internet". Okay, but no one will think, "Well, I will just pull the plug to start over" or something.

IoT use could be close to second nature for digital natives; however, the motivation to control the IoT and shift from a "consumer" to a "tinkerer" seem lacking. They seem to be taking always being online aspect of IoT for granted, much like Peter's children who grow up without light switches. Peter, however, does value the idea that his children develop digital skills. As he explains:

> Programming is slowly coming into view. The oldest is eight. I do not know when she will get that at school. I have not seen that yet. But I would find it important that they can program. That they at least have the idea that there is something behind it and that they can influence it.

Further, while most parents expect the idea of more technologically proficient digital natives, some parents aim to develop skills to match the competencies of their children in the future. As Mike explains:

> I might still want to learn to program myself because I also see that it is becoming increasingly … That a technical knowledge of what is being developed in IT, that that is quite useful. Yes, that will certainly be important for the children.

For Mike to achieve a choreographic fit of IoT in the household, not only would he need to reprogram the house, the house rules, and the balance of power between his partner and with their children, but he would also need to enhance his own abilities to keep a sense of control or power in the future. This is different for Peter, who already has used considerable programming skills in setting up his smart home.

Conclusion

In this study we sought to provide a better understanding of IoT-related digital inequalities within the household. We asked how power dynamics in household choreographies influence IoT use at home. Through abductive analysis, we found that the IoT affects members of the household differently in accordance with the unequal distributions of power in the household. We showed that using the IoT should be considered a household practice, rather than just an individual practice, and as a potential contributor to digital inequalities between households. We summarize our main findings along the three dimensions we used in our analysis.

First, based on the choreographies of materiality, we can contrast households by the acceptance factors of partners who have "consumer" roles regarding the IoT. Because IoT use relies much on the joint effort of all household members and their choreographic movement, the lowest common denominator in IoT "consumption" determines the complexity of IoT set-ups and, in effect, the range of IoT-related outcomes. While the power to accept the IoT is not observed formally with children, informally, they can object to the IoT by not programming their environment for proper IoT use by cluttering the household. Moreover, household rules about safety and risk can override the benefits the materiality of the IoT can deliver. For example, the rule for not using household appliances when away overrides the IoT's remote access capabilities. In other words, the household's ability and willingness to accommodate the materiality of the IoT determines how well the IoT is implemented.

Second, when considering choreographies of access, households are divided by operational access and data access. The IoT needs to be accessible for everyone because it often replaces common household devices. On the other hand, the exploitation of operational access to the IoT, as with pranks, calls for more mediation between parents and their children. Here, digital skills (van der Zeeuw, van Deursen, and Jansen 2022) are a crucial factor for operating IoT devices and understanding what they can do. Additionally, most IoT devices are shared between members of the household, yet data responsibilities tend to be reserved for the role of the "tinkerer" even though they concern the region of the "consumer". Exposure to risk is an important consideration because understanding of the potential exploitation of IoT data is still vague for many people. Consequently, differences arise between households considering how well they can avert such exploitation.

Third, households differ in how harmoniously they intermesh with IoT devices. Remote access and programming of the IoT can provide flexibility often called for by dual-income households (Fortunati 2018). However, choreographies that are too complex limit the effectiveness of IoT devices, such as different members of the household working in different shifts. Additionally, not all household members are enthusiastic about losing control over the domestic sphere

to the IoT. Either because IoT use reflects poorly on the homemaker as a lazy person or because the quality of the IoT is not up to standard, some households are averse to its use.

By analyzing different shifts in power relations in the smart home, we find that household choreographies, rather than individuals alone, determine how well equipped households are to use the IoT. However, the interplay between household choreographies and the IoT is bidirectional. This means that as much as power relations affect the IoT, the IoT also affects power relations in the smart home. We hope our contribution inspires future research to consider the importance of power relations within the household and their interplay with new technologies.

Limitations and future research

Our contribution is limited in terms of making conclusive remarks about a larger population. However, we did find indications of larger cultural patterns, and we hope future research will look further into this. One recurring pattern we found was that lifestyles are typically associated with educational levels, which could be explored further in future research. Educational levels could increase the acceptance factors of all household members or create more awareness of the risks of digital data and the ability to protect oneself. Such research could provide new insights for addressing digital inequalities.

IoT-related inequalities between households could be caused by differences in white-collar jobs and blue-collar jobs. The difference for IoT outcomes for those working a 9-5 job with overtime might be greater than those working in shifts. Further, the ability to digital skills is associated with white-collar jobs and higher educational levels. Conversely, risk assessments of household appliances through blue-collar work experience might restrain the use of IoT use.

Our analysis relies on the framework we introduced. However, if we remove this scaffolding, two additional points that emerge in this study become more evident. First, the exposure of young children to the IoT and how this could give them an advantage over unexposed children. Acts of cleaning up and decluttering, for example, expose children to an if-this-then-that programming structure that blends the material with the digital via the IoT. The ease of making the IoT fit with their everyday choreographies, as a product of early exposure, could benefit these children later by making them more attentive to the strategic potential of digital devices than nonexposed children.

Second, while we have tried to remain gender neutral, notions of gender differences in relation to the IoT remain prevalent, e.g., "wife-acceptance-factor". In our sample, instead of the "consumer" role, only two women out of 29 households (disqualifying the single-person household) had more of a "tinkerer" role than their husbands. Our sample suggests that control over the IoT and the smart home remains gendered toward men, whereas control over the household and its domestic sphere remains gendered toward women, as normative gender roles. Control over the IoT also invades on social roles that previously controlled particular regions. Further, we found that the IoT exasperates the effects of household politics and inequalities within the household. Strongly socialized gender roles are reaffirmed by the IoT, while for others, the IoT helps manage choreographies in their work-away-from-home mode. This suggests that there are outcome gaps between households.

Note

1. Although the notion of "digital native" and the high level of digital skills it implies are highly debatable (Selwyn 2009), increased exposure to the internet does increase basic digital skills (Hargittai 2010, 2020; van Deursen and van Dijk 2011).

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