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Washing with the Wind: A Study of Scripting towards Sustainability

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ABSTRACT
Within sustainable HCI research, we have witnessed a growing interest in studying interaction designs that support households to 'shift' energy usage to times when it is sustainably favourable. In this paper, we investigate shifting through a purposely provocative and scripted design, which challenges the idea that renewable electricity is an always-available resource for households to consume. To do so, we made electricity for washing laundry either free or not available. We conducted a detailed qualitative study with four families that experienced our intervention for a month. We present five themes that illustrate how families adapted, reflected, and formed new routines and expectations related to washing practices. We discuss the broader implications of combining scripting and provocation as a means to intervene, disrupt and understand energy consuming practices within the home.

Author Keywords
Energy consumption, scripting; provocation; sustainability; shifting; field study.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous;

INTRODUCTION
Designing interactions to support sustainable energy usage has received much attention from the HCI research community in the last decade [6,21]. Within this effort, various interaction strategies [50] have been suggested to steer household energy usage towards sustainability. Among these, *shifting* [48,50] presents interesting design challenges, as it differs from the traditional approach to sustainability of simply using less. Instead, shifting refers to moving energy usage to times when renewable resources are available. In this scenario, the householder is expected to play an active role by changing their energy-consuming practices [54,58] (e.g. heating, laundry, dish-washing) in order to respond to, for example, availability of electricity from wind turbines and solar panels. Towards this end, HCI studies have explored designs that raise awareness about favourable times to use electricity. Some investigated designs that visualise forecasted resource consumption on situated home displays [37,54,58,62], while others have looked more specifically on how to support shifting of domestic practices e.g. charging electric cars [7,10], heating [14,31], or washing [8,17,39].

However, most of the studies aiming to support shifting through such designs report that it is challenging to instigate and sustain practice change [11,51,61]. Based on this observation, we identified two design opportunities. Firstly, it appears that the everyday practices we attempt to change are often not disrupted enough, as most designs do not make people reflect on their broader energy consumption practices. Secondly, many of the energy-consuming appliances people interact with in their homes are not actually scripted to help people act sustainably [50]. For example, when the typical default setting for a washing machine is a high-consuming program instead of an eco-friendly one, people must intentionally deviate from the suggested script to use a low-consuming program.

In this paper, we address these two design opportunities for shifting through an intervention called 'the Box'. The Box extends the interaction with a washing machine by deliberately making it hard to use outside times of renewable energy availability. Both opportunities were instantiated in the design of the Box, inspired by literature on provocation [3] and the concept of *scripting* from the work of Akrich [1] and Pierce et al. [50]. In short, the provocative elements we designed with the Box allowed us to disrupt the washing practice of four households. In combination with a script purposely designed to guide households to use sustainable energy, these provocative elements allowed householders to reflect on and change their washing practices.

The paper is structured as follows. First, we present related work on shifting and scripting. Next, we present our study, including the scripted design and the four participating families. We then continue with our findings that are organised in five themes, and we discuss the broader implications of our results on shifting and scripting within the domain of sustainable HCI.

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RELATED WORK

Shifting as a sustainability strategy

The design of digital interactions and interventions that support and encourage sustainable energy use is a challenge we researchers and practitioners have engaged with for at least a decade [6,19]. Work within HCI has predominately focused on how to change behaviour by raising awareness through eco-feedback designs [21] or support sustainable change through intelligent and automated agents [55].

Attempts to design eco-feedback have shown potentials of raising people's awareness towards sustainable consumption, especially if people are already motivated [74]. Eco-feedback designs are typically framed on the assumption that sustainable behaviour can be shaped by providing people with the 'right' kind of information like Strengers' Resource Man [64,65]. Most work in this area looks at the different design challenges surrounding materialising invisible and intangible energy resources and tailoring feedback on the consumption of these [47]. In order to achieve this, designers and researchers have visualised past and forecasted consumption data on mobiles [38,59] or in-situ displays of electricity [45,58,62,67], heating [16], water [22,46], and food [15,74]. Others have also explored ambience and art [24,56], lighting [33,34], and physical materials [9,36,68] as feedback techniques.

Despite these efforts, other studies show that the impacts of eco-feedback are difficult to maintain over time [11,66]. DiSalvo et al. [19] highlight that one reason for these limited results is because most work within this area sees the user as the main problem, where design solutions attempt to improve user behaviour, rather than focusing on impacting people's everyday practices. This view is supported by other works [23,35,51,61,66] suggesting most decisions involving energy usage are usually not informed by rationalities concerning resource consumption but rather connected to a *"larger, complex sets of social and cultural practice"* [11]. Thus, there is a mismatch between the intentions of eco-feedback designs and the real-world actions of people. This has led to a growing critique in sustainable HCI [51] highlighting a need to go *"beyond persuasion and shift from prescription to reflection"*.

In an effort to overcome some of the shortcomings of eco-feedback designs, we have recently witnessed attempts to automate some of the decision-making on energy consumption through smart home technology. Almost all of these attempts are examples of automatic agents that manage and assist people to follow different consumption strategies. Examples are the commercial NEST thermostat studied by Yang et al. [69,70], Alan et al.'s Tariff Agent [2], Yun et al.'s Intelligent Dashboard [73], and Jensen et al.'s HeatDial [31]. These are all examples of smart agents that assist households to either reduce or shift resource consumption. While these studies show a promise of the agents' automatic abilities to sustainably manage energy use, they do also report a loss of engagement over time that leads to missed opportunities for householders to act sustainably. To combat this, studies have explored designs that encourage engagement, such as the proposed recommender system ThermoCoach by Yang et al. [28,71], Fischer et al. [20] situated sensing technology that tailors energy advice, and Clear et al.'s [14] study of 'drifting' thermal comfort zones in effort to support heating practices. However, most of these studies also report that when smart technology becomes embodied in people's lives, we as designers are challenged on how to design interactions fitting within the messiness of everyday life [5].

Scripting towards sustainability

Shifting is an energy conserving interaction strategy [48,50] that recently has attracted significant attention within HCI studies. Design solutions to support shifting are often envisioned through smart grid technologies and dynamic price schemes [13,48]. But as explained by Costanza et al. [17], it can be challenging to obtain 'in the wild' experiences of people interacting with these envisioned technologies. One way is to envision future scenarios [55] and explore them through prototypes. Recent HCI studies have engaged in such endeavours. Some through the design of eco-forecasts [37,49,54,58,62], while others have engaged with designing interactions that are directed towards specific energy consuming appliances, e.g. washing machines [8,17], electrical vehicles [7,10], and heating appliances [14,16,31].

Towards this end, Pierce et al. [50] suggest that *scripting* can be used as a conceptual tool for researchers and designers to help define what constitutes 'normal' behaviour when designing sustainable interactions for appliances. Pierce et al.'s concept of *scripting* is based on Akrich's notion of a script [1]. According to Akrich [1], a *script* defines the process of designing and inscribing a vision or scenario into the use of a technical object [1], that is more explicit to the *"values, social norms, and ethics*" reflected in the designed object. This highlights an opportunity since by adequately scripting our designs, we can be more explicit about communicating sustainable values and norms through the interaction with energy consuming appliances [50]. For example, in a typical car, the dashboard provides feedback information to drivers about condition of the engine (revolutions per minute - rpm) through a dial. Pushing the engine too much (high rpm) is highlighted through a red area on the rpm dial. Thus, the car's dashboard is scripted to protect the engine, instead, for example, to assist the drivers in adopting a more eco-friendly driving behaviour.

THE STUDY

In this study, we designed and deployed a scripted design we call the Box. The purpose of the study was to get 'in the wild' experiences of a scripted design aiming to intervene in an established energy-consuming practice (washing) and script interactions with the washing machine for shifting.

The Box

Inspired by Akrich's [1] and Pierce et al.'s [50] concept of scripting, we purposely scripted an interaction design aiming to intervene in laundry practices. While the works of Costanza et al. [17] and Bourgeois et al. [8] explore how to make shifting washing times more convenient and effortless, the aim of this study is different. The aim of our scripted design is not to provide easy and convenient support for changing washing times, but to help households reflect upon it. So, instead of focusing on how to make shifting effortless, we focus on making shifting more disruptive by utilising provocation [3] and scripting [50]. We choose to intervene in laundry practice, because it is a practice rich of household routines and social norms, and because other studies have previously identified washing as a practice that people are willing to shift [12]. In order to script shifting as a disruptive element in the practice, the Box highlights a new 'right' behaviour to householders, summarised as:

> *"If it is not absolutely necessary, the washing machine cannot be used unless electricity is produced from renewable resources".*

Our design is comprised of a physical device and a smart wireless electricity plug (Energenie). The Box consists of a 7in large screen, two small LED screens, and a physical interactive button (Figure 1). For its physical form, we opted for a bulky, old-school, physical style inspired by the work of Bardzell et al. [3] on critical design and provocation. More details on how we utilised provocation in our design are described in [53].

Figure 1. The Box: a) current electricity status, b) override button, c) override button presses, d) savings account, and e) 12 hour colour-coded clock.

Every half an hour the Box checks the local wind conditions through an online weather service. We framed the design on the assumption that when there is a lot of wind, electricity is mostly produced from wind turbines and thus comes from renewable resources. When wind is blowing electricity is characterised as green in the design, and when not, as red. This information is materialised as a colour-coded clock that projects the next 12 hours (Figure 1E). While electricity is red, the smart electricity plug disrupts the washing practice by completely disconnecting the washing machine from the grid. When electricity is green, the washing machine can be used without disruption.

The only way to use the washing machine while electricity is red is to push an override button (Figure 1B), and 'declare' that there is a necessity to do a wash. For this, we purposefully adopted the emergency button metaphor to script a sense of reluctance on pressing it, as we wanted households to realise that it is something it should not be pressed without considerable thought. Finally, the Box also projects through a LED screen how many times the users pressed the override button. In Figure 1C we can see an example where the override button has been pressed 9 times. This LED screen then materialises the number of times households deviated from the new imposed norm and 'violated' the rules.

Our script also brings in a disruptive price schema in relation to how electricity consumption is typically priced in Denmark. When electricity is green, each wash costs nothing and the amount of money the household would normally pay for electricity to power the washing machine is added to a savings account. On the other hand, when the washing machine is used in a red slot, then the cost of a wash is double the normal amount, and the cost is deducted from the savings account. The cost of each laundry is calculated based on the electricity the washing machine consumes, measured via the smart wireless electricity plug. The Box materialises the savings account through a second LED screen. In Figure 1D we can see an example where the savings are 121 in Danish Kroner, equivalent to approximately 19.5USD.

In terms of hardware and software, we bought an off-the-shelf case for electrical equipment which we modified to fit the LED screens, the 7in screen and the button. All components are connected to a Raspberry Pi with a GrovePi shield that runs our python code. Finally, inspired by the Bourgeois et al. [8] study that reported that contextual control - interacting in situ - led to a deeper engagement, the Box was placed on top of peoples washing machines.

METHODS

The study was conducted a field study with four families who experienced the Box for a month each. Our motivation for introducing the Box into the lives of the participating families was to intervene in already established washing practices and provoke households to reflect on their practices. Thus, the Box acted as a technology probe [28] allowing us to collect insights on how practices were carried out during the intervention. Since washing clothes is a practice consisting of rich household routines and various social norms, we view each family as a separate case that is highly unique with quite complex social and physical structures [72]. Finally, we position our work as a research through design [18,75] study, as the design itself (the Box) is means to do research on an area of interest (shifting for sustainability).

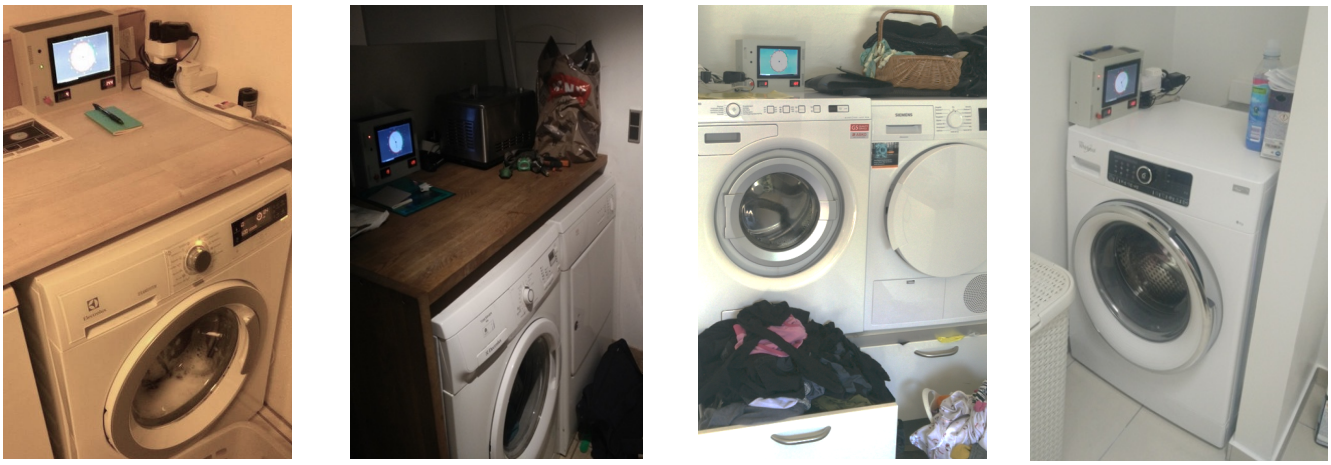

Figure 2. The Box in situ in each of the four households. From left to right, families 1, 2, 3 and 4.

Participants

The recruitment of participants was achieved via snowball sampling through our social networks. There were three requirements each family had to fulfil to participate, namely: (1) the laundry room should have had access to a wireless internet connection that the Box could use to check the wind conditions and characterise the status of the electricity; (2) the possibility to install a smart plug between the washing machine and the connection to the grid to enable the Box to control and monitor the power supply; (3) heterogeneity in the family's characteristics in relation to their washing needs and routines (how often they washed, when they washed, who washed, etc.).

Out of ten families that volunteered for our study, we managed to recruit four of them. In the six families, we did not recruit, we were not able to install the smart plug that controlled the power supply in five of them, and one did not have wireless internet. The four recruited families lived in Denmark, where it is expected that electricity supply is very stable, and electricity prices are inflexible and reasonably cheap compared to other parts of the world. Each of the recruited families had different routines and habits of their washing practice, and the physical location of their washing machine also varied – see Table 1.

In the first family, Sam was responsible for doing most of the washing, while Marcy would occasionally help. The family had high laundry needs since they all worked out most days during weekdays and weekends. They usually dried their laundry in a tumble dryer. In the second family, Gaby was in charge of the laundry, while Scott would occasionally chip in. Out of three children, only one permanently lived at their house, while the other two would visit every second weekend. They also had a large dog that would yield enough dirty laundry for one wash a week. They also did their drying in a dryer. In the third family, Diana was in charge of the family's washing, while Robert would do some washing when necessary. If the weather was nice, they dried the clothes outside. If the weather was bad, they normally dried it inside as they tried to avoid using the tumble drier. In the last family, Kate was mostly in charge of washing. Both Kate and Peter worked out 3-4 times a week, so they usually produced three washes a week. They did not have a dryer, so weather permitting, they would dry clothes outside or otherwise use a drying rack inside. In all three families with children, none of the children participated in washing chores.

Throughout this paper, we refer to the participants by their pseudonyms and family number – see Table 1.

Family	Demographics	Household Roles	Laundry routines	Location
F1 *Competitive*	Sam, 61, electrical engineer Marcy, 49, process coordinator Three children: 16,18,20	Sam in charge of washing, while Marcy occasionally helps Marcy in charge of paying utility bills	~10 washes per week Wash daily and during weekends	Basement
F2 *Laid back*	Scott, 51, carpenter Gaby, 46, dental surgery assistant Three children:14, 17, 19 large dog	Gaby in charge of washing while Scott occasionally helps Gaby in charge of paying utility bills	~8 washes per week Wash in bulks during the weekend	Entrance
F3 *Determined*	Robert, 59, surgeon Diana, 49, student Three children: 6, 11, 17	Diana in charge of washing while Robert will wash when he needs clothes Robert in charge of paying utility bills	~7 washes per week Wash in bulks during the weekend	Entrance
F4 *Young ones*	Peter, 28, software engineer Kate, 25, nurse	Kate in charge of washing while Peter occasionally helps Both in charge of paying utility bills	~3 washes Wash randomly	Bathroom

Table 1. Demographics and laundry routines (pseudonyms are used).

Data collection and analysis

The Box was deployed in the four families for a month. We positioned it on top of their washing machine, as seen in Figure 2. To obtain an in-depth understanding of how the scripted design influenced each household, we conducted eight semi-structured interviews, two with each family, which we systematised via interview guides [42].

Both adults from each family and two researchers participated in the interviews. The first interview was conducted before deployment and questions included topics of existing laundry practices and household routines. At the end of the first interview, the families were introduced to the Box. During this introduction, we explained to them what shifting is and how it is facilitated by the Box. The families were being told to use the Box in any way that suited their needs. In our setup, the savings account for each family started at 100 Danish Kroner (~16USD). The second interview was conducted at the end of the deployment period. In this interview, we discussed each family's experiences of washing with the Box, and if and how it had influenced their washing practices.

Apart from data collected through the interviews, we also logged their interactions with the Box, including the washing machine's power consumption, the number of times the emergency button was pressed, and a snapshot of the status of the clock every 30 minutes. Since it was impossible to collect data on when participants looked at the Box and decided not to use their washing machine without violating their privacy, we provided each household with a diary and asked them to write down these instances, along with any additional thoughts and/or suggestions. Furthermore, for each deployment, we had an open email and SMS line with the families in case they wanted to contact us. This led to few entries of how the Box was experienced. Each of the eight interviews was fully transcribed. We conducted a content analysis using an emergent coding approach [43] on all the transcribed interviews focussing on the practice of washing and its energy consuming implications. We used this analysis to develop a thematic understanding of how the families experienced living with the Box, how they understood their interaction with the scripted design, and how they adopted their routines to the intervention. The results are structured into five overall themes discussed below.

FINDINGS

First, we would like to highlight some of our logged results, and then we present our qualitative findings from our analysis. From the interaction logs we discovered that family F1 and F4 pressed the override button 3 times, family F2 pressed it 19 times, and family F3 did not press it at all. All families also saved money according to our scenario. Based on the order of presentation in Table 1, each family saved 43, 18, 22 and 20 Danish Kroner respectively (~6.9, 2.8, 3.5, and 3.2 USD). These results demonstrate that the families did indeed engage with the Box, and let the scripted design become part of their washing routines during the study. In the following, we present the five themes that emerged from our analysis on the qualitative dataset.

Awareness and engagement

Overall, our analysis showed that the presence of the Box created a large amount of curiosity, awareness, and engagement within all families. To accommodate this, all the scripted design elements of the Box played a significant role. Unsurprisingly, the design element that influenced awareness most was the colour-coded clock. This element made the participants aware of shifting being an environmental challenge as the participants fittingly understood this design element as something symbolising when renewable electricity was available for washing: *"the green states that we are both sustainable and economical aware"* (Diana, F3). Visualising shifting as a forecasted colour-codes clock was also experienced as a clear-cut strategy to follow. For example, Sam (F1) undoubtedly understood the green colour code as:

> *"Well, time to do a wash. It's clear to go, good to go. Like you know, like the traffic light."* (Sam, F1)

Likewise, Diana (F3) *"wanted to wash when it is green as it would be the logical thing to do"*, while Peter (F4) stressed that when the clock "*finally shows a green slot then you know you should do a wash because otherwise it might take another week without being able to do any washing"*. Using forecasted information as a means to raise awareness is also reported in other studies [37,54,58,74]. However, choosing to script shifting as 'normal behaviour' in the Box was also supported by cutting the power supply off during red time slots and making the override button the only physical interactive element. Both these design elements had a high impact on how the families engaged with the scripted design, as it made shifting wash times *"easy and simple to follow"* (Diana, F3), and *"easy to understand"* (Gaby, F2). Moreover, by designing the override button using the emergency metaphor, we also made all families reluctant to press it *"because it states that we wash at a bad time"* (Kate, F4). This was further enhanced by visualising the savings and showing the times the override button was pressed through the LED screens raising awareness of deviated behaviour:

> *"Without those two small displays, it is just an overview of green or red. Without them I wouldn't care as much and just wash. If no one is counting and you pressed the button five times but 'forgot' the fourth, then it would not be 'bad'. So, the displays create awareness when you look at it."* (Peter, F4)

The third family decided not to press the button at all and only to do their washing during green slots. To achieve this, they almost abandoned their old washing routines, and washed only when renewable electricity was available:

"It became a sport. We wanted to see if it was possible – and now we can say – yes it was possible to be 'ruled' – be ruled by the box." (Diana, F3)

However, while three families went far to change their washing routines to fit with the colour-coded clock, the second family was more reluctant to do so. They deviated the least from their old washing routines and pressed the override button 19 times *"because the green slots just never fitted into our plan"* (Gaby, F2). However, they were left in no doubt what scripted design was envisioning – especially if a red slot was currently active and the power was cut off when they wanted to wash:

"But you swear at it because... ah it could have been more fun to wash in the green period – because we lose points every time we press the button, no?" (Gaby, F2)

The two displays made all the families experience the scripted design as a game that illustrated some 'benefits' and 'consequences' of washing during green and red time slots. However, because the Box was experienced as a 'game to beat', it made all the households more engaged to wash only when renewable electricity was available. For example, Marcy (F1) started to take a keen interest in checking if the washing machine ran in green slots because:

"I'm getting really competitive now with the washing. We have only saved money so far. Not spent any. Seeing the prices really makes me competitive." (Marcy, F1)

However, the incentive to shift washing times was different for her husband Sam as *"the prices don't say to me that much. But the green and red colours really turn me on"*. He was motivated to *"do the right thing"* and despite experiencing some frustrations, he mostly washed when renewable electricity was available as it was *"intriguing to try and be one step ahead of the Box"*. However, what is interesting to observe is that it was not the desire to *"earn money"* that motivated him, but rather a desire to participate in the *"game"*. In general, while the savings account raised some awareness about washing being an energy consuming activity, it also had another effect. Some were surprised by how cheap it was to wash, even though the price was doubled during red time slots. This was for example expressed by the second family:

"I actually thought it was more expensive to wash. We have done this for a month now and we have saved about 3$. 3$ is less than a burger meal!" (Scott, F2)

These findings illustrate that various design elements (feedback, metaphors) can be used to raise awareness and engagement with sustainable challenges, like shifting, by purposely scripting disrupting elements into routinised interactions with energy consuming appliances.

Disrupting and adapting

The scripted design clearly disrupted the way the four families planned their washing. Before the intervention the families washed when it fitted with their busy family life. Now, they were reliant on the availability of renewable electricity for the next 12 hours. Thus, trying to shift washing times also meant that the families had to plan carefully, meaning they established new routines. Before the deployment, the families either used the status of the laundry basket, or the time of day as indications on when to wash. The introduction of the Box changed this, and the families started to use the Box as a planning mechanism:

"We have experienced big fluctuations from green to red. But we decided not to press the button. We have been stubborn [...] We went from letting the washing basket deciding when to wash, till where the box decided when we should do our washing." (Diana, F3)

The colour-coded clock played a big part in assisting them to adapt to this new disruptive planning mechanism. That meant that they got engaged with a new habit of frequently probing for the status of the Box, like Diana (F3) who *"checked it 3, 4 times a day I think"*. The same routine occurred in all four families. In the first family, Sam told us that he developed a new routine, summarised as *"go home from work, go down and check"* and Gaby (F2) told us that *"when I was at home and had nothing else to do I would go and look at the machine"*. Robert (F3) had previously been washing his own shirts, usually the day before a business trip. Now, he made a habit of checking the status *"3-4-5 days before since now it is the time to wash"* because he could never be certain when a green slot would come up.

For these probing strategies, the location of the Box played a significant role. The second family's washing facilities were next to the entrance, so it was easy for them to probe the status of the Box when getting in and out of the house. The was also the case for the third family. Its location in the entrance made the Box *"natural to look at as you enter the home and then you can decide what to do"* (Diana, F3). The fourth family's machine was located in the bathroom, and they made it a routine to check its status since *"you cannot avoid it"* (Peter, F4).

Our findings also suggest that new routines were created through the presence of other appliances and materials, which were related to the Box and contributed to the way it was used. For example, the Sam (F1) noticed, after going up and down the stairs a couple of times, that he could see the reflection of the clock on the utility's room door and thereby get a quick overview *"because there is a reflection on the door you can tell if there is a lot of green or red"*. Checking this reflection in the door was appropriated into an everyday routine as he would often check the status of the Box from the top of the stairs. There was also a similar situation within the second family, who reported that they started using the emitted light of the Box at nights, instead of the hallway light, as it could light up the hallway. Additionally, Scott questioned the sustainability of our design as *"it properly uses a lot of electricity to send out that light – properly everything we saved on washing."*

While most of the families were not interested in jeopardising their sleep at night by changing sleeping routines, this did not hold back the fourth family in their effort to adapt. They had observed that green slots often occurred during the nights and early mornings. To accommodate this, they started to routinely check the Box at night and wash early in the mornings instead of washing after returning from work, as they used to. It had the consequence that Kate would get up earlier than normal just to use the washing machine, even on days she was off work:

> *"We just had a week where it was red all the time… Otherwise, is has been green between 1-2ish until 7am. And sometimes it has been green all the way till 9 in the morning… But you can see it in the evening – now it is green again in the night"* (Kate, F4)

This theme illustrates that disrupting scripted designs can lead to adaptations of existing established practices, and the formation of new routines. This is interesting because it shows that by simple design means it is possible to go beyond the limitations of eco-feedback systems [21,37,66]. However, our findings also demonstrate that a scripted design can be appropriated in several ways that do not necessarily fit the designed purpose of the script. This is illustrated in the next theme.

Unscripted routines

So far, our findings have revealed that new routines were formed based on what was deliberately intended via the scripted design. However, our findings also show that there were also some routines that were created without our intention. While some of these routines turned out to be more sustainable, others would challenge the meaning of sustainable washing within some of these families.

Some of the new routines were related to other activities embedded in the families' washing practices, like drying clothes, while others were connected to how they used the washing machine. Sam (F1), for instance, started to use more sustainable programs on the washing machine, although this was not part of the scripted design. Before the deployment of the Box, he did small, quick washes to "get things out of the way", but now he often had to wash in the nights to fit with the green time slots, so he switched to using the long, low consuming 'Eco6' program:

> *"The thing I didn't do before was to use the long Eco6 program that lasts 3:30 hours. Now I put a wash late at night, head down in the morning and put them in the tumble dryer. I suppose I have been doing more washes late in the evening than I was doing before."* (Sam, F1)

The families also reported that because they tried to wash in the green slots made them think of ways to better appropriate the use of their washing machine. This resulted in some of them considering the size of the washing loads:

> *"I think I have been more aware of filling the machine when we finally could wash. So, I have properly filled the machine more than you would otherwise have done. I have certainly filled the it to the brim making the portion as big as possible."* (Kate, F4)

Despite efforts to use the washing machine more efficiently and sustainably, the scripted design sometimes contradicted itself, and this led to new routines that can be considered unsustainable. Unlike the first and fourth families, the second family started to use a short program more often. They had, for example, experienced an entire week where every time they checked the Box, the status was red. In their effort to only run the washing machine during green time slots, they postponed all washing to the weekend. However, when the weekend came, Gaby (F2):

> *"I had so many loads of washing, so, I had to choose a short program, which actually uses more power than the long program. But I had to do this to get all the washing done."* (Gaby, F2)

Thus, the scripted design started to challenge the meaning of a sustainable washing practice, as it sometimes contradicted what the families believed was environmental practice. Trying to adapt to the scripted design also created dilemmas about sustainable washing practices in the other families too. For example, the second family were very environmentally conscious and did most of drying outside. However, they had difficulty in synchronising drying clothes outside with the available green time slots:

> *"There have not been many designated green times slots where we could dry it outside, because when it is green, the outside weather has not been drying weather. That meant we had periods with poor indoor air quality because the clothes were dried inside because otherwise we have used the power of the dryer. So the question is - what is the right thing to do?"* (Diana, F3)

The same issue was experienced in the young fourth family. They thought that synchronising washing tasks was even more problematic because they had no electric dryer and relied only on the weather to dry clothes. In the first family, this issue of synchronising washing and drying made Sam *"sometimes ignore a green slot because I had a lot of clothes to tumble dry and fold"*. This resulted in missed opportunities to use renewable electricity because not all the washing-related appliances followed the same script.

This demonstrates the importance of looking at the entire practice and related practices when designing and evaluating scripted interactions as people will shape the use of such designs in unforeseeable ways.

Collaboration and reflection

In the first interview, all families reported that one person was mostly responsible for the laundry. This did not change much after the deployment of the Box. For example, Sam (F1) informed us *"that was my job before, so we wouldn't change it"*. What did change though, were the activities and the level of reflection surrounding the laundry practice.

While the colour-coded clock introduced a clear-cut strategy to follow, the scripted design also introduced a certain amount of uncertainty as to when it was possible to wash beyond the forecasted 12 hours. This meant that some of the family's washing needs now had to be discussed among the family members. In the second family, Scott got more involved with washing than before. While he was *"a man that can figure out stuff by himself",* he was now often asked to check for green slots and then start washes early in the morning before leaving for work.

This collaborative reflection of the washing also happened within the fourth family. Here Peter would often ask to be informed about their savings after each wash because *"now it is visible – that is fun!"*, and he also started *"to check if any clothes needed washing when green slots came around"*. In the first family, the parents often talked about the status of the Box, particularly when it was red, as Sam would immediately inform Marcy that *"the damn thing is red"*. They also often discussed the status of the Box in the car, while coming back from work, since *"it was always a bit of mystery, what it was going to be"* (Marcy, F1). Although Marcy did not take more active part in washing, she would now help to check the status of the Box. Furthermore, our findings also illustrate that the decisions the parents took in relation to the Box, affected the entire household. This for example was explained by Robert (F3):

> *[…] Our son has been annoyed that we did not wash exactly the clothes he wanted. We had to explain to him why we unfortunately couldn't do so."* (Robert, F3)

These findings demonstrate that the scripted design started to influence practices beyond individual change. One reason for this was because the presence of the Box opened up for discussions and reflections within the entire household – a quality of eco-feedback that Hargreaves et al. also report on [25]. Secondly, because we introduced disruptive interaction elements via the Box, planning washing became a collaborate task more family members engaged in. Moreover, these findings also demonstrate the potential of using provocative probes to obtain valuable insights within families [29] to help designers and researchers understand how scripted designs are reflected upon and adapted into practices of the entire household.

Challenging expectations

Because the scripted design introduced disruptive elements into the washing practice that influenced all members of the household, the intervention started, surprisingly, to challenge existing expectations related to washing. Most noticeable was the families' expectation of *cleanliness* and their understanding of how clean clothes should be. This is interesting because as Shove [60] argues, expectations of cleanliness have sustainable implications for e.g. washing.

Particular two families changed their understanding of what clean clothes were during the one month deployment period. As the third family had restricted themselves to only wash during green slots, their new washing routines started to influence their expectancy of clean clothes. What is interesting here, is that these new expectations of cleanliness became a relevant topic for the entire family including the kids that did not participate in any washing activities:

> *"Normally the girls always have freshly clothes on every day for school. But now – if the clothes are not dirty, they can wear them for another day"* (Diana, F3)

Furthermore, the Sam in the first family reflected a lot on which temperatures would make their clothes clean:

> *"I suppose I have been hypocritical about washing temperatures in the past. You can wash in 30° now with the detergents we got [and still have clean clothes]."*

This expectation of cleanliness also influenced the parents and their routines of washing. For example, would Robert (F3) reflect upon the cleanliness of his own clothes. That meant that some clothes did not need to be urgently washed after a first wear as normally happened before the introduction of the Box. Instead, he sometimes would wear the same clothes multiple times because he wanted to wait with washing to suit the scripted design:

> *"I worked with the chainsaw in the garden the other day. I would normally have washed my clothes immediately, but then I realised they can wait."* (Robert, F3)

This new understanding was then diffused to the entire family, and they started separating clothes into the ones they could postpone and the ones that were more urgent to wash. Sam (F1) developed a similar routine. Previously he would go to each of the children's room every day after returning from work to look for dirty clothes. He would then immediately put on a wash in an effort not to let dirty clothes pile up in the laundry baskets. This meant that the children of the family were used to have their clothes cleaned almost immediately after they had used them by the 'washing fairy'. After being introduced to the Box, Sam reported that he often was thinking about the necessity of having all clothes clean all the time:

> *"Well, do I need to do it? Is there anyone wanting these clothes at that particular moment? And in most occasions, they weren't important."* (Sam, F1)

What these findings demonstrate is that by disrupting existing routines through provoking scripted designs it is possible to challenge existing expectations related to practices, which also have sustainable implications like, for instance, cleanliness. This is interesting because as Shove argues [60], it is by challenging these kinds of expectations that change practices beyond individual behaviour.

DISCUSSION

Overall, our study demonstrate that the Box served its purpose as an intervention in two ways. Firstly, by introducing a purposely provoking scripted design to four families, we managed to disrupt established washing

practices that both sparked reflections and created new routines and expectations of that practice. Secondly, the scripted design allowed us to get deep and insightful understandings of the richness, diversity, and complexity of the four families' washing practices. The main contribution of this work lays in the five themes presented in the findings and the combination of scripting and provocation as a means to disrupt and understand energy consuming practices within the home. We now discuss the implications of these findings for HCI researchers and practitioners.

Provoking routines and expectations

Purposely scripting an energy-consuming appliance to shift energy consumption is not an easy task from a design point of view. The door of a refrigerator may be scripted for *trimming* (to be closed) [50], but this can be easily embedded within domestic routines as it requires a minimum amount of effort, and poses a small challenge from a design point of view. At the same time, as a research community, we tend to engage with designing and evaluating the sustainable benefits of our interventions by focusing on how effective, effortless, and convenient these benefits come about and use this as a criterion for evaluating the successfulness of our designs [2,32,70]. However, as our findings show, more complex practices like washing, pose other challenges of scripting sustainable values as a default into the interaction of energy-consuming appliances. While we framed 'the right' shifting behaviour via the different interaction elements of the Box, our findings demonstrate that household's routines are encompassed by social norms and expectations that shape how people use energy consuming devices.

Nonetheless, what the presence of the Box managed to do, was not only to raise awareness of shifting (other eco-feedback studies show the similar results [37,54,58]), but also to intervene in established routines and spark reflection that challenged expectations that involved the entire household. These findings are in line with the Hargreaves et al. study [25] illustrating when families are provided feedback, consumption becomes a reflective "negotiation that is a social and collective rather than individualised" [25], and the design "stages experiences and debates" [44].

Moreover, our findings demonstrate that by combing scripting and provocation, the participants started to adapt to the scripted design by reflecting upon their washing practices and other interrelated practices too (e.g. drying clothes). And interestingly, all families got engaged with washing at times when renewable energy was available, even though they all believed in the beginning that adapting to the scripted design would be an inconvenience. Some even stated that they got positively surprised with themselves for managing to change their washing routines, and this change felt to them like a natural thing to do. Through these reflections, new laundry practices emerged, such as starting to use a long, low-consumption laundry program at night to accommodate shifting. Likewise, expectations, like cleanliness, were also challenged, leading to other sustainable implications (apart from shifting), e.g. trimming of washing loads, lower washing temperatures, water consumption and reflections on how to use other related appliances, such as the tumble drier.

These changes were not accomplished by scripting the interactions with the Box to be as effortless as possible. Instead, we believe this was accomplished by purposely provoking and thus disrupting established routines through the scripted design. By combining different provocative and scripted interaction elements (the emergency button metaphor, cutting off power), we also added some complexity to the interactive elements themselves [30]. This complexity made shifting a 'game to beat' that family members wanted to engage with (similar findings reported by Bourgeois et al. [8] and Costanza et al. [17]). This also led to the development of new routines such as checking the status of Box whenever there was a chance, despite not being designed to be efficient and convenient (most participants had to physically walk up to their washing machine, and plan far ahead).

Together it highlights that the assumed expectation of sustainable change is something that must come about as effortless and convenient as possible (perspective often penetrating our research and design evaluations efforts) might not be the only evaluation creation for our sustainable interventions. Thus, we believe the way forward is perhaps not to design these kinds of interventions as effortless and convenient as possible, but to provoke and disrupt practices in ways that open up for new interpretations and expectations.

Scripting and research through design

Usually, in research through design studies, a possible outcome is an extended understanding of a situation. We create interventions and then acquire insights into a research domain based on how our interventions are experienced. We will not touch upon how provocation was facilitated in the scripted design since extensive reflections on the relation between provocation and research through design are reported in [53]. However, from our research through design effort that utilised scripting in a provocative intervention, we collected a number of 'lessons learned' that we will highlight in the following.

When designers attempt to script specific behaviours into designs, they sometimes also unintentionally design for imaginary actors with specific values, norms and ethics [1,50]. Thus, they make assumptions and these assumptions find their way into their designs. What this and others studies [63] illustrate, is that a scripted design will, to some extent, be experienced and appropriated differently, independently from the intentions and assumptions of a designer [27]. For example, in our scripted design, we assumed that a sustainable washing practice implies washing should be aligned to times when electricity is produced from wind turbines. However, when looking

holistically at washing as a practice, different weather conditions will dictate different actions to be sustainable. While wind may be good for running the washing machine at the 'right' times, windy weather can sometimes be bad for other activities (drying clothes outside) as windy weather often carries rain. Thus, some of our assumptions contradicted specific households' efforts to move towards more sustainable routines (e.g. using the wind to dry clothes, instead of the tumble dryer). Such challenges to our design assumptions are an excellent point of discussion with participants to better understand a research domain.

Despite the few instances where there was a mismatch between our design assumptions and how washing was carried out, our study also demonstrated that a provocative scripted design can be used as a probe [29] to understand a practice in a family better. This is particularly relevant for research through design studies [18,70] aiming to either understand an unknown practice or explore possible future scenarios for known ones. Thus, a scripted design needs to be prototyped, evaluated and reflected upon in order to understand how it is adapted in practice (also highlighted by Silberman et al. [61]).

We want to highlight a dilemma related to our decision to script for shifting, which occurred to us after the interviews with the households. Our motivation with the Box was to move the burden of negotiating the 'right' shifting decisions from households to designers through a purposely scripted design. However, by doing that we also put the burden of acting out shifting onto the households. But should shifting be a concern of households? This issue is also highlighted in Strengers' [63] study of feedback systems attempting to align household's electricity consumption. Here the system introduced a feeling of danger within the households, as accountability of shifting was transferred to them (shifting is a not a problem most households face in everyday life, but a problem electricity providers are challenged with). We believe this highlight competing dilemmas researchers and designers should expect when conducting their research through design process. The outcome of such studies is not only one-directional (we not only collect enough insights a domain), but omnidirectional (our findings allow us to reflect on our research). Thus, scripted interventions should also be treated as a point for critiquing our own research aims and values.

From disrupting to sustaining change

As the purpose of this study was to obtaining rich insights of scripting for shifting we purposely disrupted a targeted practice. What we usually want to achieve in a design process, is not only to disrupt a practice, but to sustain change. This transition is not always straightforward.

To produce a product that encapsulates the findings from our interventions, we need to have the interrelated practices in mind. For example, in our case, we did not design for the whole washing practice, but we only focused on a part it; washing clothes. Thus, we ignored that participants needed to dry their clothes as well. Although this was useful in the level of intervention since it allowed for insightful discussions with our participants, such an issue would have been difficult to tolerate in a product; our households would probably have rejected it. We believe the only way to overcome this challenge, is to adopt a practice-based approach [51] and make the practice the unit of design [40]. This way, we may be able to move from detailed understandings of a domain, to sustained practice change. For this reason, we recommend to try to design holistically for a practice, in a similar way as Kuijer et al. [41] (bathing), Pink et al. [52] (heating) and Bates et al. [4] (shifting heating) and study the implications long-term as Hasselqvist et al. [26] (transport).

Furthermore, to better design products that facilitate these sustained changes for the years to come, it is important to gather knowledge that goes beyond the novelty effect our participants' might experience through our interventions. For example, in our case, we collected enough data from our intervention as our participants experienced it for an entire month. But we cannot be sure if and how the observed changes in the washing practices will be sustained. One way to overcome this is to move towards even longer studies that allow participants to deeply engage with our interventions and for us researchers to gain richer understandings of our intervention, as recommended by Rogers and Marshall [57].

CONCLUSION

In this qualitative study, we deliberately disrupted existing laundry practices of four families through a purposefully provocative, scripted intervention called the Box. The four families experienced a situation where electricity was either for free, or not available based on how it was produced, as well as, a new 'norm' for sustainable behaviour.

The main contribution of our paper is our findings. They show that the four families not only shifted their electricity consumption, but the scripted design also provoked changes in their existing washing routines as well as the creation of new ones. The process of adapting and reflecting upon the scripted design raised awareness and engagement that challenged existing routines of an energy consuming practice. Furthermore, we contributed beyond our findings by discussing the broader implications for HCI researchers and designers. Our discussion highlights that by purposely provoking established routines we can challenge expectations that both have energy consuming implications (cleanliness) and how such changes could be designed and evaluated (going from effortless and convenient towards provoking and disruptive). We believe these contributions to be useful to researchers and practitioners beyond the sustainability domain.

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