Why don't families get along with eco-feedback technologies? A longitudinal inquiry

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ABSTRACT

Eco-feedback domestic technologies have gained momentum over the last decade. Yet, while a wide range of research prototypes and commercial products has been proposed, their acceptance by families is still limited. In this paper we report on our findings from interviews with 15 dual income families, during a year-long deployment of an eco-feedback technology that attempted to inquire into the factors that prohibited its adoption. We found the non-adoption of our system to be rooted in a number of systemic failures, relating to the physical context, the families' social dynamics and the roles assumed by family members, as well as families' priorities and the non-negotiability of their routines. Motivated by prior work and our empirical findings we propose three distinct dimensions but also phases in the adoption of eco-feedback technologies: *orientation*, *incorporation* and *social integration*, and discuss how these may hint at different barriers in the adoption of eco-feedback technologies.

Author Keywords

Eco-feedback technology, families, sustainability.

INTRODUCTION

Domestic environments are one of the greatest contributors of CO_2 emissions and, thus, have attracted substantial interest in the environmental HCI community. In a survey we conducted in January 2012 we found 72% (23 out of 32) of research articles concerning eco-feedback technologies that were presented in the CHI, Ubicomp and DIS conferences to relate to domestic environments. To date, research in eco-feedback technologies has largely focused on changing individuals' behavior through psychologically grounded principles derived from theories of motivation and behavior change e.g.[6, 8]. Yet, concerns over the long-term impact of such persuasive designs are increasing [3, 5, 12, 16] and researchers call for an emphasis on how eco-feedback technologies integrate with the cultural and social practices in the studied environments [9, 16]. Furthermore, researchers stress the need to perform long-term ethnographic studies [5, 14].

Especially the domestic environment and dual-income families present substantial complications for the adoption of eco-feedback technologies due to the diversity of its members in terms of age, needs and daily routines, their busy schedules and their need for comfort [1, 7, 9, 16]. Sustainable practices are often associated by families with a compromise in quality of living [6, 9, 12, 13, 16], while researchers have found that some practices are non-negotiable by families [12, 16]. In other cases, the feedback provided failed to challenge existing practices and users accepted the baseline consumption as a goal to maintain throughout time, even when not being the most efficient strategy to follow [12, 16]. Wallenborn et al. [17] found that while electricity monitors changed participants' energy perceptions, this did not lead changes in their behaviors.

In this paper we attempt this body of work through performing a longitudinal inquiry into the adoption of an eco-feedback system. We report on interviews with 15 dual income families during a year-long deployment of an eco-feedback system. Building upon prior frameworks of product adoption and our findings, we propose three distinct dimensions but also phases in the adoption of eco-feedback interfaces: *orientation*, *incorporation* and *social integration*, and discuss how these may hint at different barriers towards the adoption of eco-feedback technologies.

A FRAMEWORK OF ECO-FEEDBACK ADOPTION

Silverstone and Haddon [15] attempted to conceptualize the dimensions of adoption of information technology in domestic environments. They suggested three dimensions, but also moments, in the process of technology adoption: commodification, appropriation and conversion. *Commodification,* they argued, refers to all activities from both producers and users that result in specific claims for a function and an identity for a new product. As users participate in the commodification process, they form expectations about ways in which the product could become relevant to their lives. In *appropriation,* users accept enough of the relevance of the product and they gradually *incorporate* it into their life routines. Finally, in *conversion,*

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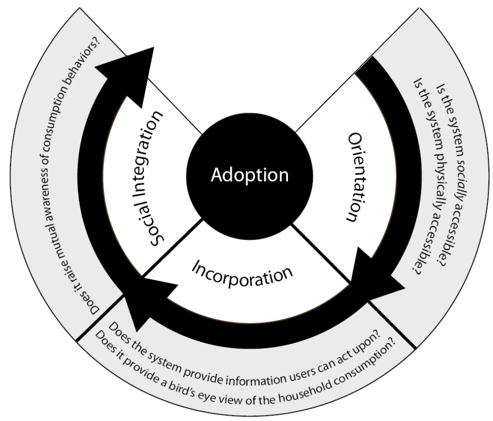

Figure 1. Framework of the adoption of eco-feedback technologies inspired by Silverstone and Haddon [15] and Karapanos et al. [10] frameworks. Identifies 3 phases but also dimensions of adoption: *orientation, incorporation* and *social integration.*

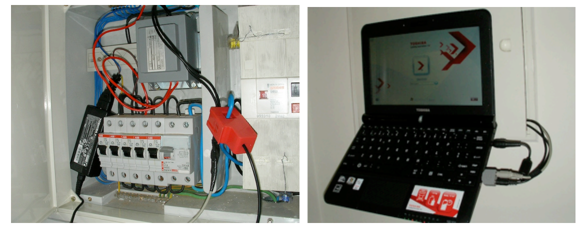

Figure 2. The prototype [3] consisted of a netbook and an ADC converter, next to the mains fuse box which in all participants' apartments was located in the main corridor.

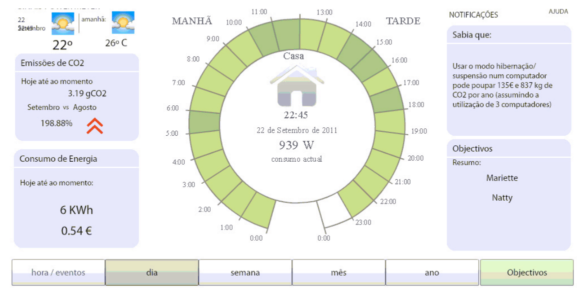

Figure 3. The eco-feedback interface presented information relating to the household's overall consumption per day, week or month, and in terms of KWh, cost and CO_2 emissions.

users accept the product as part of their self-identity and employ it in their social interactions.

Karapanos et al. [10], inspired by Silverstone's and Haddon's framework of domestication attempted to conceptualize the temporal development of users' experiences with personal interactive products. They conceptualized temporality of experience as consisting of three main forces, i.e. an increasing *familiarity, functional dependency* and *emotional attachment* that motivate the transition across three phases in the adoption of the product: *orientation*, *incorporation* and *identification*.

Inspired by these two frameworks and through the analysis of our empirical data, we identify three distinct dimensions but also phases in the adoption of our eco-feedback system (see figure 1). *Orientation* refers to users' initial exposure to the eco-feedback system where interactions are primarily driven by curiosity. *Incorporation* signifies that the eco-feedback system is becoming part of the family's daily routine and family members reflect on their own behavior. *Social integration* signifies that the eco-feedback system affects the family's social environment through raising mutual awareness of each family members' consumption behaviors and consequently inducing feelings of accountability on individuals. Each dimension may hint at different barriers towards the adoption of eco-feedback technology.

THE STUDY

Participants were part of a larger sustainability project and chosen from the overall city consumption database (about 50 000 consumers). The research team selected a building that corresponded to the average city consumption pattern from which 30 families volunteered. From this sample, 15 families were interviewed three times over the course of a year-long deployment of an eco-feedback system (figure 2 & 3). The households had from 2 to 5 family members, where 11 of them had children, being the average 2 children per family. Parents had a range age from 27 to 51 years old (M=39.79, SD=6.46). Both were employed and 13 (of 15 families) had college degrees. The early income ranged from 10k to 250k euros.

Interviews started with a warm-up discussion where we asked families to share their experience with the system, what they learned from it and to recall particular examples of interacting with it. Other questions targeted information about the system's usage, for instance the most and least frequent users, reasons to use it, most relevant information, problems or positive aspects and feelings when interacting with it. In addition, questions related to the system's impact in the family's daily lives were included, namely, noticed changes in the household routines, in their energy consumption levels or even in their concerns or strategies to address these.

Qualitative data were analyzed using Affinity Diagrams, a technique that helps in identifying emerging themes and concepts through identifying similarities and differences across individual statements [2]. Individual statements were printed and posted to a wall. They were then clustered in hierarchical themes followed by theme labeling. The first stage of analysis focused on reasons subjects pointed out when interacting with the provided system. The emergent themes were then reorganized and categorized according to the adoption dimensions.

FINDINGS

Overall, we found families' interactions and adoption of the system to relate to three dimensions: orientation, incorporation and social integration.

Orientation

Social inaccessibility

We found *social inaccessibility* to act as a barrier towards the adoption of the eco-feedback system.

Social inaccessibility related to the predefined roles of family members. Often, some family members would take over the task of checking and controlling the energy consumption as seen in [14], while others would feel less responsibility for the task: *"There are certain things I leave for him to do and other things I take care of myself. I was curious to use it and I would use it but not as often as him"* (Family 15, Wife), *"He would check more because he would be more curious (husband) and me I would let him give me the report of it. He would summarize the information"* (Family 1, Wife).

Curiosity faded away and information lost its value

We found initial interactions to be dominated by curiosity such as checking once high consumption was reached, or finding out the consumption of specific devices: *"He would go there to see the impact of these machines in the consumption at that exact moment in the graph"* (Family 1, Wife), *"In the beginning it was pure curiosity, we would plug in the devices and check its consumption, to learn our consumption and our devices"* (Family 15, Husband). However, we saw a 60% decrease in interactions over the first 4 weeks of use [11]. Next to that, we found that information quickly lost its value in everyday life except from moments that involved a change in the family's routine such as a rapid change of the climate commanding the use extra electrical devices, the purchase of a new device, or having guests at home: *"My wife would check whenever we had an idea that something was different (...) Or if there was a colder time and we needed to have more devices to warm the place"* (Family 5, Father). As seen in [4] the system provided some level of education to the householders about their energy usage and which devices/appliances consumed the most energy.

Incorporation

Limited actionability of the information

We found that users experienced difficulties in interpreting or acting upon the feedback information, often due to lack of specificity (only aggregate information was presented per hour/day/week) or due to a lack of a reference point (e.g. comparing to prior or optimal behaviors): *"This tells me the colors. But I don't know what are the normal ranges, consumption levels for a three-bedroom house with 3 people. If for example you added the devices it would be more helpful for me"* (Family 4, Father). This was being further reinforced once families would notice no substantial impact in their electricity bill: *"I think he was not interested because he didn't see the consumption being reduced. He is the one who takes care of the bills"* (Family 11, Mother).

Families' busy lives

The families participating in the study were dual-income with an average of two children. During the interview sessions, parents would often explain that their interaction with the system was affected by a lack of time and that the system added an extra burden to their already busy schedules: *"We have a lot of things, we prioritize our things and this (looking at the eco-feedback system) was left behind"* (Family 3, Mother), *"It's not that I don't care because I care about the environment but I have so many things to do during the day, in our routine, that it leaves me little time to think about these things and go there and check it"* (Family 1, Wife).

Social integration

Social impact of the eco-feedback system

We found that family members were able to make far-reaching inferences about each other's consumption behaviors and bring these into dialog [c.f. 1], partly due to the rich knowledge of one's family routine. For instance, individuals often were able to infer the activity and the family members involved out of aggregate household consumption data and time of the day. In some cases, the system gave family members the ability to support their arguments with data, as in one case where children complained about the fathers' use of his personal computer in response to his criticism on their use of console games.

Overall, family members employed their own means for inducing accountability in individuals' consumption behaviors, such as commenting on others' behaviors, adapting one's own behavior to set the example, leaving subtle messages (e.g. a parent placing environmental magazines at a visible location), or even employing creative ways to do so, e.g. *"I use some tape in the switch so they don't use it every time they come"* (Family 10, Mother).

IMPLICATIONS FOR DESIGN

Based on these findings, we draw a set of design guidelines to support the design and deployment of eco-feedback systems in domestic environments:

Is the system socially accessible to all family members? Family members naturally assume roles and responsibilities in the household. To a certain extent, this may be leveraged by eco-feedback technologies, for instance through empowering certain family members in motivating sustainable practices in the remaining family. It may, however, also lead to asymmetry in the awareness and perceived responsibility of different family members over their consumption behaviors. We propose that eco-feedback technologies should deliberately affect those family dynamics to achieve systemic behavior change. For instance, eco-feedback technologies may challenge norms about who is responsible for what, and may provide a discussion space where all family members feel integrated to decide on their strategies to achieve behavior change. As suggested by [14] the system should allow for the construction of personal consumption language within the family unit.

Does the system provide information users can act upon? Our prototype did provide information families came to understand and relate to their routines. However, in some cases, they lacked the ability to come up with useful strategies or day-to-day actions where the information could be addressed. When designing eco-feedback technologies, we suggest questioning: is the information the system provides meaningful for families and can they learn from it? What can families do to improve their efforts? Eco-feedback technologies should help families define how they want to make use of the system; they should help users feel proactive and clarify their motivations for sustainable consumption. For example, stimulating playful interaction, exploration of energy as well as the critical reflection of their behaviors, are potential factors to promote lasting engagement with these systems [13].

Does the system provide a bird's eye view of the household's consumption? The daily routine of families is filled with a number of tasks. Keeping their schedules up to date and getting things done are some of the family's priorities. A system that is placed into a household should respect the family rhythm and if possible support family members to achieve their goals. We recommend that eco-feedback systems should provide glanceable information considering the interactions that are afforded by the location in which they are placed within the household.

Does the system raise mutual awareness of family members' consumption behaviors? Our study revealed that even with simple – aggregate – energy consumption information, family members are able to make far-reaching inferences about each others' consumption behaviors and employ mundane but effective approaches in enforcing accountability across all family members' behaviors. We propose the eco-feedback technologies should leverage such practices and support family communication rather than assuming single individuals and personalized feedback.

CONCLUSION

We presented an overview of how families integrated (or not) an eco-feedback technology in the residential context. These reflections were based on interviews performed with families that were exposed to an eco-feedback system in their homes. We found multiple systemic failures in the course of the adoption of the system. We recommend that designers of eco-feedback domestic technologies should pay emphasis on the social norms that families abide to such as the different roles of family members. Next, we suggest three distinct dimensions but also phases in the adoption of eco-feedback technologies: *orientation*, *incorporation* and *social integration*, So far, our knowledge is restricted to the earlier stages of the adoption. To achieve long-term behavior change, we need to inquire into the design qualities that support the incorporation and social integration of such technologies within domestic settings.

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