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Smart Homes, Families, and Control

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Abstract

For many years technology researchers have promised a smart home that will provide the appropriate assistance to improve human experience. While technology researchers have focused on how people can control devices in their homes, our ethnographic research and findings by other social scientists have revealed that families want more control over their lives. We believe a smart home should provide families with a feeling of control over their lives: being relieved from breakdowns in their daily routines, and getting emotional satisfaction from the things they value – identity, time, and relationships. In this paper, we explore the roles that a smart home can play for families to regain control over their lives. We present our human-centered design research on dual-income families and suggest insights about the potential roles of a smart home based on this research.

Keywords

Smart home, control, family, human-centered design

Introduction

For many years technology researchers have promised a smart home that, through an awareness of people's activities and intents, will provide the appropriate assistance to improve human experience. However, before people will accept intelligent technology into their homes and their lives, they must feel they have control over it (Norman, 1994). To address this issue, social researchers have been conducting ethnographic research on families, looking for opportunities where technology can best provide assistance. At the same time, technology researchers studying "end user programming" have focused on how people can control devices in their homes. We observe an interesting disconnect between the two approaches – the ethnographic work reveals that families desire to "feel in control of their lives," more than in control of their devices. Our work attempts to bridge the divide between these two research communities by exploring the role a smart home can play in the life of a dual-income family. If we first understand the roles a smart home can play, we can then more appropriately choose how to provide families with the control they desire, extending the control of devices to incorporate the control of their lives families report.

Our research takes a human-centered design approach to explore the needs, goals, and desires of families. This approach includes contextual interviews, cultural probes, the generation of concepts based on the needs discovered, and a concept validation that evaluates if our proposed solutions meet families needs, as well as if our understanding identifies real needs. This work has resulted in two main insights into the role of the smart home. First, a smart home can play an important role in transitioning families from feeling out of control to feeling in control. The smart home can provide this service by helping families avoid breakdowns caused by deviations in daily routines. Second, a smart home can help make dual-income families feel they have mastered the complexity of their lives. Here, the smart home can provide opportunities for family members to give "gifts of time and attention" to one another around activities that support the construction of a family identity. These gifts make family members feel better about themselves and the roles they play, and potentially increases the emotional connection between the family members.

Related Work

The large number of studies of the family (Beech *et al*., 2004; Darrah *et al*., 2001) has produced a substantial corpus of knowledge. Some studies have focused on communication patterns in the home (Crabtree *et al*., 2003), the use of refrigerator magnets (Taylor & Swan, 2005), the adoption of communication technology (Frissen, 2000), or the general use of domestic technology (Venkatesh *et al*., 2000). Field studies have covered a broad spectrum of families, including families with both stay-at-home moms (Crabtree *et al*., 2003), and, like our study, dual-income families (Beech *et al*., 2004; Darrah *et al*., 2000; Davidoff *et al*., 2006A).

The dual income family is of particular interest to us. Dual income families currently comprise 43% of the population of the United States (Hayghe, 1989). They represent both a significant marketing opportunity and a population in need of serious support. As dual income families move away from the stay-at-home mom model, they are exposed to a surprising amount of stress. Also, their aggressive adoption of communication technology (Frissen, 2000), we believe, indicates that they will be early adopters of smart home services that they see can enhance their lives.

The demands of work (Beech *et al*., 2004; Darrah *et al*., 2000), home life (Darrah *et al*., 2001) (Elliot *et al*, 2005) and enrichment activities (Davidoff *et al.*, 2006) combine to oblige dual income families to lead highly-structured lives, with almost no unscheduled time. Families often compensate for this complexity by establishing routines (Tolmie *et al*., 2002), offloading some of the responsibility for remembering every event-related detail. But despite detailed routines, breakdowns are inevitable. Children get sick, things get forgotten, and traffic causes delays. During these breakdowns in routines, parents feel particularly out of control, and victim to their environment. This loss of control stresses families both physically and emotionally. During these situations, families report that their goal is just to make it through the day (Davidoff *et al*., 2006).

Demands on time also force parents to compromise the quality of activities that contribute to their sense of identity – to how they see themselves as parents. Activities such as cooking provide a chance for dual-income parents to feel they have made something for their children and provide an example of what good parenting is. However, in dual-income families, parents often feel like poor or inadequate parents because they do not have time to cook and often must "heat and serve" quick dinners (Beech *et al.*, 2004). The demands of their day constrain parents' ability to achieve their sense of who they are and who they would like to be. In this sense, too, parents find it difficult to achieve a sense of control over their lives.

Control, from the perspective of smart home research, tends to focus not on life control, but on control of devices. Smart home systems often enable the home to automatically turn on lights (Mozer, 1998), control a thermostat (McCalley *et al.*, 2005), close the blinds (Jahnke *et al*., 2002), or provide a single user interface for control over all home appliances (Ducheneaut *et al.*, 2006).

Even systems that recognize that families will desire unique services and individual ways of implementing them, approach the problem in terms of devices. Using such metaphors as puzzle pieces (Humble *et al.*, 2002), or magnetic refrigerator poetry (Truong *et al.*, 2004), these end user programming systems allow individuals to combine different artifacts into newly-derived services.

Design Process

We followed a user-centered design process to explore the needs of dual-income families around the activities of *waking up* and *arriving home*. We chose these time windows because pilot fieldwork revealed that these were often the busiest moments of the day, involving significant coordination amongst all family members.

Our design process included:

1. Contextual interviews with dual-income families in their homes
2. Cultural probes exploring family emotions, including their most and least favored experiences
3. Concept generation based on our data gathered, and other ethnographies of dual-income families
4. Concept validation session where families provided feedback on our application concepts

Contextual interviews and cultural probes

We conducted three-hour contextual interviews with 12 dual-income families. The interviews included directed storytelling, artifact walkthrough, and role-playing activities. All family members were asked to participate. We focused questions on their routine activities, use of artifacts during these activities, and their strategies for dealing with breakdowns in routine.

Following the interview, we left families with cultural probe packages for one week, hoping to gain insight into the emotions associated with waking up and arriving home. The packages included a camera, a book of stimuli questions, and a journal to log their responses. We also left families with an activity log. The log asked families to comment on their stress and rush levels, principal activities, immediate needs, and preoccupations.

Concept generation and validation

We then generated smart home concept applications that addressed the needs we identified in our fieldwork. We produced one hundred-one concepts, which we clustered into seventeen themes ranging from activity monitoring and scheduling, to home security and enhancing family relationships. We then further abstracted this list into five high-level application areas: activity manager, logistical backup, opportunistic reminders, health and meal support, and family awareness.

More complete description of these findings is beyond the scope of this paper. But to see more about the fieldwork and cultural probes, please see Davidoff *et al*., 2006A.

Within this set of five application areas, we encapsulated forty application concepts within twenty-two representative storyboards. Each storyboard documented a specific situation where the smart home might intervene in families' lives to provide them with assistance. (See Figure 1) Our storyboards deliberately obfuscated a clear technical implementation, obliging participants to focus more on the service delivered than on any particular method of its delivery. Concept validation sessions consisted of semi-structured interviews with families. We presented the storyboards and asked families to estimate the previous impact of the proposed situations on their lives. Our aim was to validate if the needs we observed matched the needs as families perceived them. We also probed families' receptivity to our proposed solutions.

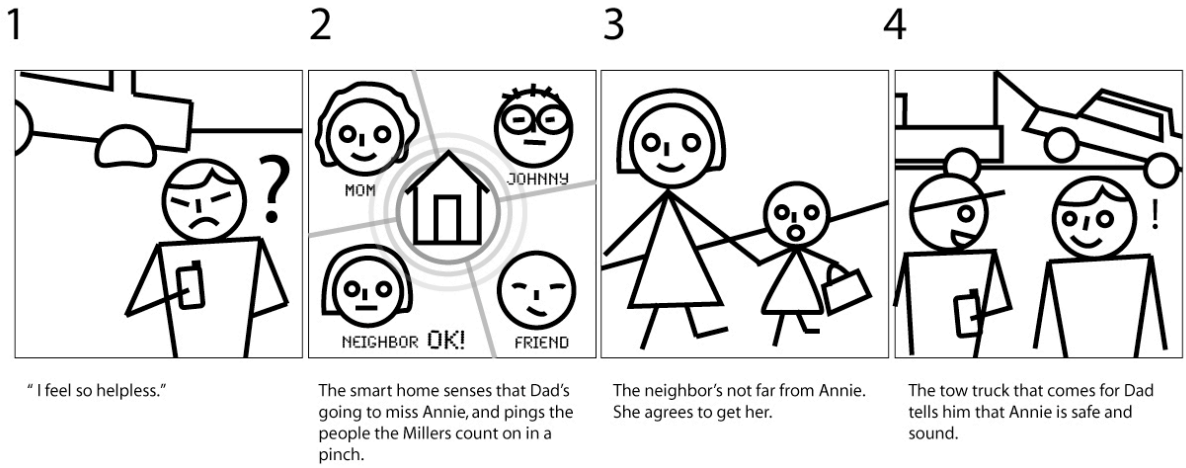

Figure 1. A storyboard taken from our concept validation depicting a family in need, and how a smart home might help them.

Design Implications

Our research revealed two main opportunities for the smart home to play a role in transforming families from feeling their lives were out of control to feeling in control: (1) helping families avoid breakdowns caused by *deviations* in the daily routine, and (2) providing opportunities for family members to give their time and attention to each other, especially for activities that support the construction of a family identity.

1. Help families avoid breakdowns in routines

Both our research and the findings from the other ethnographies reveal that breakdowns caused by the need to deviate in the daily routines are one of the major stressors that make families feel loss of control. It is the routines that allow families to carry on the synchronous choreography of their lives without having to constantly invent and agree on a plan (Tolmie *et al.,* 2002). Deviations from routine cause stress by making family members both improvise in response to deviations and potentially miss the timing of their responsibilities. Deviations can be planned, such as a spouse away on a business trip, requiring the other parent to assume duties that are not normally their own. Or deviations can be unscheduled, such as a sick child who cannot go to school. All these planned and unscheduled deviations could potentially lead to breakdowns and almost certainly lead to stress. The following story from our fieldwork helps illustrate a breakdown and its consequences on families.

> *Little Billy has a soccer game every Wednesday evening. Usually Dad takes Billy and watches him play. But today it is a little bit different. It is Billy's turn to bring oranges for the whole soccer team. Even though Bill put a note on the fridge an entire week earlier, Dad misses the note and goes to the soccer field without oranges. After the first half of the game, everybody gathers for snacks and wonders why there are no snacks prepared. The coach asks Billy why he did not bring oranges. Billy is so upset with his Dad. He feels sorry for disappointing his friends and is embarrassed of his family. He also feels that his friends will think his family is not "organized" and does not care about him. To get the oranges, Dad goes to the grocery store and misses the second half of the game. But he doesn't recover from the feeling that he let his son down..*

As illustrated in this story, a seemingly small deviation caused by a predictable event can lead to breakdowns in daily routines and cause emotional damage to families. Even the possibility of a breakdown can cause families a great deal of anxiety. Thus, dual-income families would benefit from both functional support to cope with potential breakdowns, and emotional support to be relieved from fear of breakdowns. We believe a smart home could address these needs by providing important reminders and alerts during critical family activities. We describe these individually below.

Reminders for Deviations: During our concept validation session, participants really favored our concepts around smart home reminders, especially when it helped them cope with changes to the daily routine. One concept particularly resonated -- reminding a mom to purchase food for her child's school snack day while she was shopping for groceries. In this case, it was not just a reminder of the unusual responsibility, but the match between this unusual event and the opportunity to take action at the appropriate time. These types of reminders can function in a wide range of circumstances, from small deviations, such as not knowing where needed ballet slippers are, to more critical deviations, such as remembering to pick a child up at an event that is not typically a parents' responsibility. Providing this service helps parents feel they are regaining control of their lives both by reducing the chance of breakdowns and by lowering their stress level about the possibility of breakdowns.

Alerts of Unscheduled Deviations: Even when families have carefully planned their days, external forces can cause unexpected deviations. Occurrences like changes in weather, unplanned meetings, traffic, or a sick child can cause families to begin to improvise workarounds on the fly. A smart home can play a role in reducing the stress from fear of these events by monitoring routines and alerting families to sensed deviations.

Our concept validation session showed that families were positive and receptive to the concept of a smart home as safety net. In the scenario (see Figure 1), Dad is supposed to pick up his child. But he has a flat tire and cannot contact anybody. The smart home provides an alert to family members noting that Dad's whereabouts are unknown, and he cannot pick up a child. While this extreme case may not happen often in real life, the presence of a smart home that takes actions in emergency situations reassures families from fear and stress of breakdowns. In addition, participants also valued the support that a smart home could provide with coordination activities and the ability to coordinate alternative schedules. In another scenario, for example, when both parents could not stay home to watch their sick child, a smart home proactively displays how many times other families have helped out, enabling the family to be sure to evenly spread their last-minute favor requests. It also saves families.

2. Providing opportunity for the *gift* of time and attention

Even successfully managing their routines was not sufficient for families to have a feeling of control over their lives. They desire to carry out their routines in the way *they* want to and to achieve an expected quality of life through that action. Let's say for example that a parent

manages to leave the house on time in the morning, but ends up rushing their children, or even yelling at them in the process. This results in making them feel like poor parents because they have started both their child's and their own day on the wrong foot. The required end is achieved, but the manner of its completion contributes to a feeling of lack of control. Here, a smart home could provide families with opportunities to regain that control over these circumstances by providing them with more time to enhance the things that they value —their identity, their time, and their relationships. We describe this in more detail.

Make parents feel like good parents: Parents in dual-income families often find it hard to spend time with their children and complete all of the tasks they have assigned themselves. This imbalance between family and work often makes parents feel like bad parents. A smart home might help parents accomplish their myriad of chores so that they might be able to better focus during their time interacting with their children. But our concept validation session revealed a careful line that automation needs to consider. Participants indicated that activities such as waking up their children, choosing outfits, dressing small children, and cooking were a lot of work, and stressful, but also make parents feel like good parents. Thus smart home designers need to be wary of simple automation as a universal answer to all possible problems. It is important to understand which activities make parents feel good about themselves as parents and which just feel like work.

We found parents really want more time for doing activities that are important to them – that are closer to their sense of identity. To create more time for parents and enhance the qualities of parenting activities as a result, a smart home could assist with mundane tasks. For example, while automating cooking might remove the opportunity to feel like good parents from parents, an automated shopping list could cut preparation time and prevent mistakes such as forgetting to buy essential ingredients. This "gift of time" could create new opportunities for parents to do parenting activities in the way they desire.

In our concept validation, parents also expressed they would like to have more information that could enrich their activities as parents – recipes, school information etc. One scenario involving educational support provides a good example of this need. In the scenario, a smart home notifies parents about subjects that their children are studying, and suggests possible ways to participate in their education such as aiding with simple scientific experiments that could complement what children are learning in school. This allows parents to naturally

initiate dialogue with children and engage in their education in a constructive way, and provides an opportunity for parents to engage children and bring learning out of the classroom and into the world.

Increase emotional connectedness: Emotional bonds are a central driving force that ties all family members together. These emotional bonds are reinforced by "family activities," such as Sunday dinner or vacations together (Darrah *et al*., 2001). During our concept validation, our families welcomed a smart home service that could facilitate and enrich these activities. For example, a smart home could enable easy creation and retrieval of memories. This could ultimately reinforce the emotional bonds among family members.

Conclusion

In this paper, we have presented two roles that we believe a smart home could play in family life. These two roles represent different ways that a smart could help families regain more control over their lives. We derived these roles from an ethnographic study of dual income families and a concept validation session, where we evaluated concepts developed based on the findings of our ethnographic study. Most of research on end-user programming focuses on the control of devices. However, what dual-income families really want is control over their lives – being relieved from the stress of breakdowns in the daily routines, and getting emotional satisfaction through the things they value. We believe a smart home can help families regain their control over their lives by helping families avoid breakdowns caused by deviations in their daily routine, and providing opportunities for family members to give their time and attention to each other, especially for activities that support the construction of a family identity. In the future, we plan to build a smart home that plays these two roles. We also hope to evaluate how well it is incorporated in family lives and how much it helps families feel in control over their lives.

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