

CHAPTER TWELVE

DESIGNING FOR CONTROL – FINDING ROLES FOR SMART HOMES

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1. 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 say they need.

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 needs validation that evaluates the overlap between the needs we observed and the needs families perceive in their own lives. 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 increase the emotional connection between family members. We review our design process and provide reflections on how the focus on emotional experiences helped us identify opportunities for a smart home. Finally, we discuss issues around automation that were revealed in our study and suggest how designers can tackle these problems.

2. 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 et al. 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. 2006).

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) drive 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 and circumstances. 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.

3. 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. Needs validation sessions where families provided feedback on our application concepts.

3.1 Contextual interviews and cultural probes

We conducted three-hour contextual interviews with 12 dual-income families. All participants were recruited via bulletin board flyers and postings on community sites in the area near Pittsburgh, Pennsylvania in the U.S. Each participant family had an average of 1.9 children, and the average age of the children was 12 years (see Table 12-1 for detailed information of participants). 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 level of stress, principal activities, immediate needs, preoccupations, and on how rushed they felt.

To analyze our data, we coded our interview notes and photos, and clustered them into emerging categories. We created maps of homes that detailed families' activities and the artifacts they used based on the interview notes and the activity logs. For each family we created three distinct timeline types: the typical day (e.g., week days), the day when non-routine activities are scheduled (e.g., child's picnic), and the deviation day when the scheduled activities cannot be executed due to unexpected

events (e.g., sick child, snow day). These models helped us see the detailed patterns of families' routines.

Family	Mother	Father	Children
A	Not provided, Administrative assistant	Not provided, Carpenter	15, son 18, son
B	47, Department manager	48, Art gallery director	9, daughter 15, daughter
C	41, Professor	39, Teacher	1, son 5, daughter
D	38, Business manager	41, Marketing manager	5, son 8, daughter 10, son
E	Not provided, Professor	Not provided, Carpenter	15, son
F	45, Secretary	46, Truck driver	15, daughter
G	32, Surgeon	31, Graduate student	5, son
H	36, Project manager	34, Graduate student	1, daughter 5, daughter
I	52, Nurse	53, Steam fitter	15, son 19, daughter
J	49, Administrative assistant	50, Manager	15, daughter 20, son
K	54, Events coordinator	55, Salesman	21, son
L	43, Legal secretary	46, Landscaper	11, daughter 15, daughter 17, daughter 19, daughter

Table 12-1. Demographic information on participating families.

The cultural probes allowed us to understand emotional experiences that people have with their family members and their homes. (For definition of emotional experiences, please see Desmet et al. 2007). We grouped these as negative experiences (e.g., stress from managing multiple activities, anxiety caused by the fear of potential breakdowns, frustration from messy, cluttered house) and positive experiences (e.g., pleasure of seeing family after work, calmness of morning coffee ritual). These two categories guided us to focus on both reducing negative experiences and enhancing positive ones. (For more examples, please refer to Figure 12-1 to 12-6).



Figure 12-1. The cultural probe photo of Family C's kid's shoes on a table, an unusual location for shoes. The mother reported that *"The kids' shoes are often the last thing we attend to on work/school days, and it sometimes requires a full-house search to find them."* She also expressed that *"I don't like cranky children, lost shoes, squabbles over hair-brushes and clothes, no available food for making breakfasts and lunches, and being pressed for time in the morning. These make me anxious and irritable; get me off to a bad start. This stresses me out and make me rue the day that I decided to have kids."*



Figure 12-2. The cultural probe photo of Family L's four lunch boxes. The mother indicated that she feels rushed when packing individual lunches for her four children during her busy morning routine. She stated; *"It is very time consuming. Everyone likes something different, so I want to make sure everyone gets what they want."*



Figure 12-3. The cultural probe photo of Family B's pendulum clock is emblematic of the feeling of being in a hurry. The mother explained that *"the loud tick-tock is a constant reminder that time is rushing forward...It makes me glance at the time over and over again. It's a weird mix of comfort and stress. I grew up with pendulum clocks, so it has a homey sound, but I also associate it with rushing in the morning."*



Figure 12-4. A cultural probe photo of Family H reveals parents' conflicted feelings from the tension between doing jobs as parents and doing those for herself/himself. The father reported that *"I often have to make the girls' breakfast and lunch the same time I make coffee, so it's often a struggle to get things done but I try to get the coffee started before I make their breakfasts, which I feel kind a selfish a bit."*



Figure 12-5. The cultural probe photo of Family F's daughter and dog. The mother expressed the happiness and relief she experiences when she returns from her work and is greeted by her daughter and dog in the window.



Figure 12-6. The cultural probe photo of Family H's table next to a front door, where every family member places and organizes things to bring to work or school. The father revealed that the state of the table is like a barometer for their lives in which a chaotic and disordered table meant the family was out of control.

3.2 Concept generation and needs validation

We generated smart home concept applications that addressed the needs we identified in our fieldwork and other ethnographic research performed with dual-income families. In a brainstorming session focused on this fieldwork and research, we produced one hundred and one concepts, which we clustered into seventeen themes including activity monitoring and scheduling, home security, and enhancing family relationships. We then further abstracted this list into five high-level application areas: activity management, logistical backup, opportunistic reminders, health and meal support, and family awareness. (For more about the fieldwork and cultural probes, please see Davidoff et al. 2006.)

To gain some perspective on our concepts, we conducted a needs validation session. In this method, designers document their concepts as storyboards showing situations users recognize and technology interventions that address the underlying need. Following the presentation of each storyboard, a facilitator begins a discussion around the underlying need. The goal of this method is to see if there is an overlap between the observed needs from the fieldwork and the needs participants perceive in

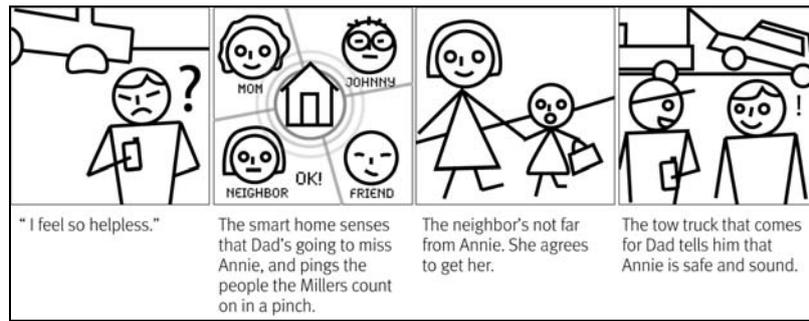


Figure 12-7. A storyboard taken from our needs validation depicting a family in need, and how a smart home might help them.

their own lives. (For more details on needs validation, please see Davidoff et al. 2007.)

In preparing materials for our needs validation sessions, we encapsulated forty application concepts from the five different concept areas within twenty-two storyboards. Each storyboard documented a specific situation where the smart home might intervene in families' lives to provide them with assistance (see Figure 12-7). 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. We presented the storyboards and asked families to estimate the previous impact of the proposed situations on their lives. In addition to probing on the underlying need, we also probed families' receptivity to our proposed solutions.

3.3 Design implications

The outcome of the fieldwork, concept generation, and needs validation helped us form a conceptual model of how desires, busyness, and feelings of control interact. In addition, it revealed two main opportunities for the smart home to improve the quality of people's lives: (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.

Our conceptual model illustrates how parents desire to feel in control of their lives and to effortlessly demonstrate for their children a mastery of the busyness that comes with participation in many activities (Figure 12-8). Following this model, parents attempt to be good parents by enrolling their children in enrichment activities such as soccer, piano, Chinese lessons, or Sunday School to help them gain the skills they will need to compete and the knowledge to continue the family culture and traditions. The addition of new activities leads to increased busyness: more responsibilities to transport children and equipment and to address conflicting activities and commitments. The increase in busyness makes parents feel completely controlled by their schedules that allow for very little free time. Parents find themselves constantly scrambling to stay on top of things, but when deviations in the normal routine occur, they experience a cascading set of failures, and feel their lives have become out of control. The very action they have taken to feel like a good parent—enrolling their children in activities—has now become the source of their feeling like a bad parent.

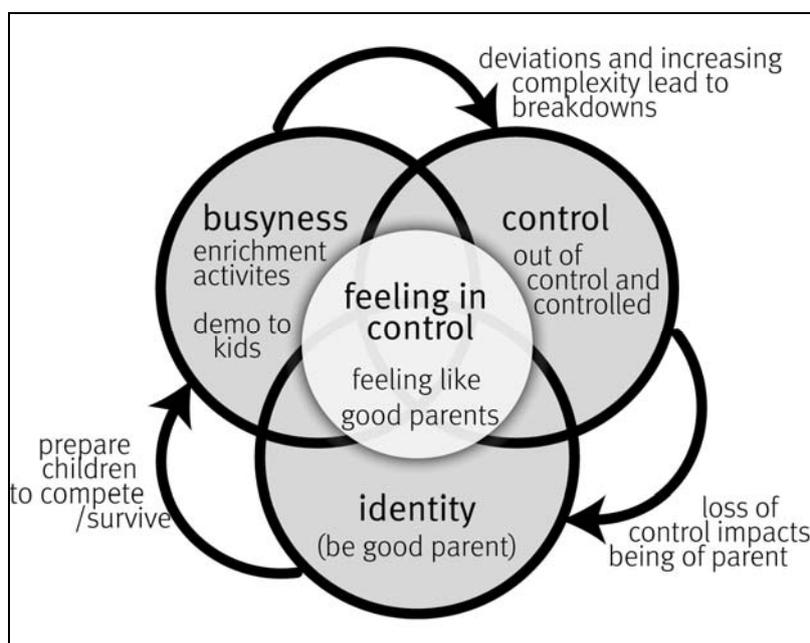


Figure 12-8. A conceptual model that illustrates how parents desire to feel in control.

3.4 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 from daily routines are one of the major stressors that make families feel a 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 because it is not in his routine to check for note before a game, and he 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.

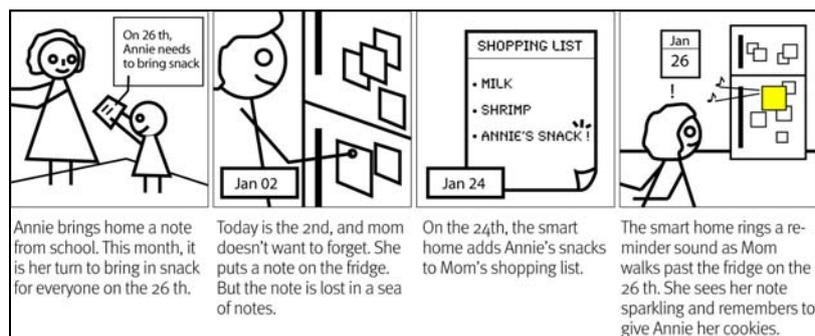


Figure 12-9. A storyboard that illustrates how a smart home may provide a reminder for deviation.

Reminders for deviations

During our needs validation sessions, 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 (Figure 12-9). 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 needs validation sessions showed that families were positive and receptive to the concept of a smart home as safety net. In the scenario (Figure 12-7), 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 alleviates some of the feelings of fear and stress of breakdowns that families feel. 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 neither parent could not stay home to watch their sick child, a smart home proactively displays how many times other families have helped out, enabling the parents to be sure to evenly spread their last-minute favor requests.

3.5 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 us 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 children'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 needs validation sessions 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. These activities provided opportunities to have quality interactions with their children, and to teach children skills

necessary for succeeding in life. 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 perform parenting activities in the way they desire.

In our needs validation, parents also expressed they would like to have more information that could enrich their activities as parents—recipes, school information, etcetera. One scenario involving educational support provides a good example of this need (Figure 12-10). 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.

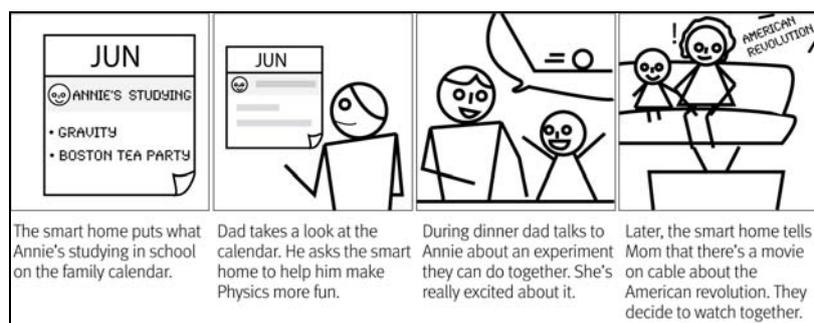


Figure 12-10. A storyboard that illustrates how a smart home may provide an educational opportunity for parents.

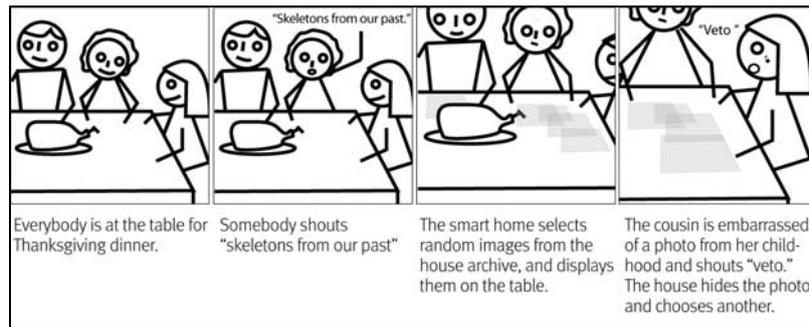


Figure 12-11. A storyboard that illustrates how a smart home may reinforce family bonds by supporting easy creation and retrieval of memories.

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 needs 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 (Figure 12-11).

4. Discussion

In this section, we review our design process and provide reflections on how the focus on emotional experiences helped us identify opportunities for a smart home. We also elaborate on issues of automation that were revealed in our study and suggest how designers can tackle these problems.

4.1 Emotion

The focus on emotional experiences allowed us to expand our design scope beyond the traditional pursuit of improving productivity. By taking into consideration both negative and positive experiences of families, we generated smart home concepts that addressed not only problems in their daily routines, but also concepts that provided more opportunities for pleasure from things that families enjoy.

In particular, our contribution is that we explicitly identified the overlap between parents' core concerns and their emotional experiences from daily activities. Desmet et al. suggests that people get greater emotional satisfaction from cars with appearances that match people's values than from ones with non-matching appearances (Desmet et al. 2004). Similar to this study, we sought to address activities that contribute to parents' positive self-images to maximize the positive effects that a smart home can have. This focus helped us prioritize the myriad of families' emotional experiences observed in our fieldwork and address experiences that people really value.

4.2 Automation

Automation has lessened some of the burden of human labor and made human tasks more efficient (e.g., washing machine); yet automation cannot be an answer to all the problems that people have. Some tasks would simply resist automation. People desire to perform tasks that they enjoy or tasks that are important in constructing their positive self-images. For example, our needs validation sessions revealed that parents do not want to automate activities that are meaningful to them as parents, such as selecting children's clothes in the morning, even though they are time-consuming and stressful. Thus, it is critical for designers to understand the lines that distinguish tasks that people want to automate from the ones that people do not.

Designing an automated system requires more than just a distinction between tasks. To design a system that assists tasks where people desire the convenience from automation, designers need to carefully consider what is an appropriate level of automation to employ. Some tasks require more involvement of human control than the other tasks. For example, people may want to have options to choose what route to take to go to a destination rather than following the one route that their automatic navigation system recommends. However, in other circumstances, people may just want to give full control to the system like a central air conditioning system and not bother with the details of interaction. This may be also affected by people's context such as busyness. People may want an automated service when they are busy, but want to perform tasks by themselves when they have some free time and place an important personal value on that task.

As a design method to help designers understand the right level of automation and the influence of contexts, we propose a user test with hypothetical scenarios, each representing a different level of automation for the same task (Table 12-2). By a different level of automation, we mean how much involvement the system requires from people. For example, low automation can be a system that offers a complete set of decisions about how to complete a task, medium automation represents a

Automation	Scenarios of smart home intervention		
	Last-minute meeting and a parent cannot pick up his/her child.	Parents need to bring snacks to school for his/her child's school activity.	All the family members gather for a holiday.
High level	A smart home arranges a ride and informs the parent.	A smart home adds snacks to a shopping list and schedules shopping.	All the family members gather for a holiday.
Middle level	A smart home contacts friends and neighbors, and relays their responses to the parent.	A smart home adds snacks to a shopping list and prompts the parents to schedule shopping.	A smart home takes photos of the family during the gathering.
Low level	A smart home provides the parent with the list of people and their schedules.	A smart home displays that the parents need to add snacks to a shopping list.	A smart home asks the family whether to take photos of them when it judges that there is an active event.

Table 12-2. Exemplary scenarios that describe different levels of automation offered by a smart home system

system that executes a particular task completion upon human approval, and high automation is for a system that automatically performs some task-related action and informs the human of this action only if asked (Sheridan 2002). Testing these scenarios with people will allow designers to learn whether people want assistance, and if so, what levels of automation people desire.

5. Conclusion

In this paper, we have presented two roles that we believe a smart home could play in family life: regaining control over their lives and providing opportunities to improve family life. These two roles represent different ways that a smart home could help families regain more control over their lives. We derived these roles from an ethnographic study of dual-income families and a needs validation session, where we evaluated concepts developed based on the findings of our ethnographic study. Most of the research on smart homes and 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 plan 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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