

# Investigating the Opportunity for a *Smart Activity Bag*

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## ABSTRACT

As long as people have traveled, they have constructed bags to help them carry more items than their hands will hold. While quite effective at keeping things together, bags do a poor job of communicating when something is missing. We propose that there exists an opportunity for the HCI community to improve the quality of people's lives by creating bags that have knowledge of people's schedules and equipment needs, can sense their contents, and can communicate when something has been forgotten. To investigate this opportunity, we conducted a field study with six dual-income families. Through interviews and observations we investigated their experiences using bags to organize equipment needed for children's enrichment activities. Based on the findings we generated 100 concepts and conducted a needs validation session to better understand the best opportunity to improve people's lives with technical intervention. This paper reports on our field study and needs validation session, and shares insights on the opportunities and implications of a smart activity bag.

## Author Keywords

Smart bag, dual-income family, reminders, ubiquitous computing, mobile devices, research through design, speed dating, needs validation.

## ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

## General Terms

Design

## INTRODUCTION

Ever since people began to travel, they have constructed containers such as bags, so they could carry more items than their hands can hold. Today bags have become highly specialized and take many different forms ranging from

haute couture ladies' handbags to college students' backpacks to paramedics' supply bags to "wheelie" suitcases used for airplane travel. Bags assist people by creating an organizational structure, allowing people to more easily co-locate and transport equipment needed in different places and for different activities. Consider the diaper bag as an example. This bag keeps clean diapers, wipes, a changing pad, lotion, hand sanitizer, finger foods, chew toys, a change of clothes, and much, much more all in the same place (Figure 1). When a family is ready to leave, they simply grab the bag and head out the door, confident they have what they need to cope with the baby's needs.



**Figure 1.** New Mom with baby and the all important diaper bag.

While bags work well at keeping needed items together, people often experience breakdowns; forgetting an important item. As currently designed, bags do not communicate very well. It is often hard to tell from looking at the outside if a bag contains all the needed items. In addition, people can look into a bag and see what items it contains, but it is difficult to see what is missing. From a usability perspective, bags require people to "recall" all the items they need in order to see what is missing; and as Nielsen's heuristics for usability show, interactive products should rely on "recognition over recall" to reduce the load on the user's memory [23]. Getting back to the diaper bag example, while the bag keeps all the items together, it makes it difficult for users to recognize if a critical item, such as sanitizing wipes, is missing, and this can lead to a rather embarrassing and stressful parenting moment.

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CHI 2010, April 10–15, 2010, Atlanta, Georgia, USA.

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Recent advances in ubiquitous computing technology present an opportunity to reconsider how bags might function in support of people's lives. Imagine a bag that (i) can sense the objects within, the current time, and its current location; (ii) knows what items are needed for various activities; (iii) knows the time and place of these activities; and (iv) has the ability to communicate when everything is "OK" or when items are missing. This kind of "smart" activity bag can become a more active participant in people's lives, helping them to transport the *right equipment* to the *right place*.

Previous research and product development has proposed this kind of bag; however, this research has not given a clear picture of when and where a bag could help or of the form its communication should take. Our research intends to fill this knowledge gap in three specific ways. First, we want to gain a better understanding of the types, the triggers, and the contexts where breakdowns occur. Second, we want to gain insights into "appropriate" forms of communication between human and bag, which could influence the acceptance of this assistive device. Third, we wanted to connect the design of a smart bag to the philosophical design stance of *designing for the self*: the design of interactive products intended to help people feel they are becoming the people they desire to be [27].

In pursuit of these goals, we conducted user research with dual-income families, a group previous research has recognized as needing and desiring this type of technology [8, 9, 19]. Through interviews and observations we investigated their experiences using bags to organize equipment needed for children's enrichment activities. This revealed eight different types of breakdowns where they forget an item, and ten key touch-points where they regularly interact with a bag. Next, motivated by the fieldwork, we generated many concepts for a smart activity bag, exploring different forms of communication and looking at the social and contextual issues for the different touch-points. We documented these as storyboards and conducted a needs validation session [9] with families to better understand both where a smart bag could add value and to identify social boundaries that could limit a smart bag's acceptance.

In this paper we detail our design process, our findings, and we discuss the opportunities and implications for designing smart bags that improve people lives by helping them to more effortlessly get the *right things* to the *right places*.

## RELATED WORK

Related work falls into four different categories: Needs of dual-income families; reminder systems; smart bag concepts; and product attachment theory.

### Dual-Income Families and UbiComp

Dual-income families are an increasing segment of the US [24] and Europe [2, 11]. These families struggle to address the complex logistics and conflicting responsibilities of

school, work, family, and enrichment activities [2, 7, 11]. These families often experience breakdowns in their plans, such as forgetting objects that they need for different activities, and this one small oversight can lead to a cascading set of breakdowns, causing families to feel their lives are out of control [2, 7, 8, 11].

Previous research shows that dual-income families are a particularly good target audience for UbiComp technology. Unlike elders—another popular target for UbiComp systems—dual-income families aggressively adopt and experiment with new technology to increase their flexibility and to better react to dynamic situations [7, 11]. They desire systems that can give them a *feeling of control* over their chaotic lives, and parents particularly want technology that can help them effortlessly manage the "busyness" of their many activities [8, 9].

Previous research on UbiComp systems for dual-income families has identified an opportunity to support families by building an activity bag that can sense its contents and that has an awareness of the calendar [9, 19]. Lee et al.'s work also recognized the opportunity for a smart activity bag to free parents from the responsibility of packing; allowing children to take more responsibility for their own activities [19]. Our research directly advances this work by investigating both the types of breakdowns that occur with respect to activity bags and the social consequences of a bag that explicitly attempts to communicate reminders.

### Reminder Systems

UbiComp researchers have investigated many different reminder systems to help people, including families. These systems generally allow people to anticipate what it is they might forget and then to insert information they will need into the future context. Current digital calendars and mobile phones support reminders and alarms at pre-defined times. The ComMotion [21] and PlaceMail [20] systems sense the user's location and use this to trigger a reminder. Research systems have also investigated placing reminders at critical locations in the home, such as the front door [15, 25]. Finally, the CybreMinder system works by *recognizing* a "situation" and triggering an appropriate reminder based on the situation at hand [10].

Our research is inspired by and advances this previous work by proposing to attach reminders to a specific artifact—in this case an activity bag—that travels between different locations and serves different needs at different times. Instead of focusing on the details of "when" and "where," our research looks more closely at the kinds of things people need to be reminded of, the social consequences of a reminder system seeking attention in different contexts, and at this *assistive* technology's impact on the relationship between parents and children.

### Smart Bags

Some initial research and design concepts have emerged around the idea of a smart bag. The Torch Bag [14] uses

electroluminescent film woven into the fabric of the bag, in this case allowing the bag to function as an ambient display that reacts to local sounds. This work focuses more on how an electronic bag could function as a social object in people's presentation of self [12]. Students at Simon Fraser developed the LadyBag; a series of concepts for lady's handbags that use LEDs [18]. Like the Torch Bag, one use of the bag is for self-expression. However, their designs also indicated the use of an RFID system so the LEDs could work to communicate when an item is missing. An article from *New Scientist* magazine describes a speculative project from MIT to build a bag using smart textiles that could prevent users from forgetting their umbrella and wallet [5]. The researchers mentioned in the *New Scientist* article have also created the bYOB kit [22]. This construction kit allows end-users to design and build their own interactive bags using electronic textiles. The intention is to support self-expression by allowing end-users to make their own digital artifacts. Finally, Lee et al. focused on the needs of dual-income families. They developed a concept for an activity bag that uses sensors and light to keep family members from forgetting items [19]. The bag was intended to help parents pass some of the responsibility for the children's activities to younger children.

Our research is strongly motivated by this previous work that indicates an interest for interactive bags and for bags to assist people in remembering objects. Our work advances this previous work by investigating the specific types of breakdowns people experience in their interactions with bags, and by investigating people's reactions to different communicative forms across the various contexts.

### Product Attachment Theory

Our research employs the philosophical stance of *designing for the self* [27]. This stance is based on product attachment theory that describes how people learn to love their things through a process of creating meaning. Product attachment theory focuses on how people use artifacts in a process of self-construction [3]. Two of the important concepts in this process are narrative and social role [1]. Specifically, people appear to develop strong attachments to products that play a key role in the stories that make up their life story [16]; products that become life companions [26]. People are also strongly influenced in the selection of products they incorporate into their lives by their sense of self; an idealized image of their self in a specific social role [16], such as mother, daughter, teacher, wife, etc.

In *designing for the self*, interaction designers look for opportunities for products to intentionally help people *become the person they desire to be in a specific role* [27]. In the case of this smart bag research, building on the work of Lee et al. [19], this design stance provides a focus on how bags might function as mediators in the relationship between parents and their children, as children seek to be more mature and independent and parents seek to make their children self-sufficient and successful in life.

### DESIGN OVERVIEW

This research project directly extends the previous work of Lee et al. [19] on smart bags for dual-income families. We took a research through design approach [28], engaging in the process of making things as a way of generating knowledge. The previous research had proposed the concept of smart bags as helping people not to forget, but this research had not detailed what or why this forgetting was taking place. We liked the focus of dual-income families and on enrichment activities for two reasons. First, dual-income families are often interested in technology that can reduce breakdowns and make them feel more in control of their lives. The focus on the children's enrichment activities comes from the fact that forgetting equipment needed for these activities is often a trigger for a breakdown in their plans. Second, the rich fieldwork previously conducted on dual-income families as well as the previous concept work for a smart bag for these families provided a strong foundation for our research to build upon. Our intention here is not to suggest that dual-income families are the only audience interested in such devices, and in fact we hope and expect that the findings will generalize to many different groups.

We had two main goals in our research. First, we wanted to get a clearer understanding of how families use activity bags to help organize the equipment children use in their enrichment activities such as soccer, ballet, etc. We wanted to know where and when the bag is used, and we wanted details on the kinds of breakdowns that happen around the bag. Understanding how families currently use bags can reveal the underlying needs that technology can meet to improve the quality of their lives. Second, we wanted to identify hidden social issues associated with the smart bag concept. Intelligent products such as this do not yet exist, so it is difficult to anticipate the kinds of social mores that will develop around their use. We wanted to gain more insights on what the critical social issues involved in its use might be in order to reduce the chances of making a product end-users will not accept. To address the issue of understanding how families currently use their bags, we observed and interviewed dual-income families. To gain insights on issues of acceptance and social use, we generated concepts and conducted a needs validation session [9].

### FAMILIES' USE OF ACTIVITY BAGS

We recruited six dual-income families to participate in this phase of the project. For this study we limited our definition of dual-income to mean families where both parents worked full-time outside of the home. We imposed this requirement to keep our focus on dual-income families with the strongest need for this kind of technology. We also limited our selection to families with children between the ages of 6 and 15. We used 6 as a lower bound as this is the age when many children begin participating in enrichment activities. We imposed the upper bound of 15, because at 16 many children begin to drive, dramatically changing the strategies that families use for moving children and equipment

between various activities. Finally, we limited our selection to families where the children participated in at least one enrichment activity and where the family used some type of activity bag to help keep the children's equipment together.

Below is a summary of the individual families:

- Ballpark family:* 11-year-old boy, plays baseball  
11-year-old girl, plays baseball  
13-year-old boy, plays baseball
- Catcher family:* 12-year-old boy, plays catcher on baseball team
- Swim family:* 11-year-old girl, swims
- Frisbee family:* 10-year-old girl, day-camp with many sports  
15-year-old boy, plays ultimate Frisbee
- Tennis family:* 7-year-old girl, plays tennis
- Soccer family:* 7-year-old boy, plays soccer

We visited each family in their home, beginning our interactions with an informal interview. We then shifted to directed storytelling, asking families to share stories of when their bag had helped with an activity and stories of when they had experienced breakdowns. We specifically asked them about how and when they pack the bag; where they place the bag; where items in the bag live between sessions; when they forget items; what causes the items to be forgotten; when and how they know what is needed in the bag; and who has responsibility for packing the bag. We asked participants to show us how they pack the bag by having them enact a “real” situation, and we asked them to give us a tour of their home, showing us where all activities related to interacting with the bag took place.

Following the interviews, we arranged a time to observe the family using the bag “in the field.” We attended different activities including baseball games and tennis practice, observing the behavior of both the children and parents.

After completing the interviews and observations, we reviewed our notes and photos, generating findings for each family. Using sticky-notes, we made affinity diagrams that revealed larger themes across the families. We created flow models [4] to reveal how artifacts move in and out of the bag, and how information moves between family members regarding the use of the bag. We also made sequence models [4] detailing use of the bag at specific touch-points. Through these activities, we were able to capture where and why many of the breakdowns happen.

### Findings and Insights from Fieldwork

Our fieldwork resulted in five key sets of observations:

- Bag selection and commitment
- Touch-points for interaction
- Types of breakdowns
- Strategies for reducing breakdowns
- Cooperation between parents and children

### Selection and commitment

Families employed a wide range of strategies for selecting and committing to the type of activity bag. Several families used bags designed for a specific activity. For example, the Ballpark family used baseball bags that have clips that allow the bag to be hung on the cyclone fence at the ballpark (Figure 2). The Catcher family has a child who plays catcher on a baseball team, and they use a bag designed for hockey goalies because its size can accommodate the many pieces of protective gear catchers need. Other families used the same bag for several activities or did not assign any specific bag to an activity. The Swim family purchased a “designer” tote bag for their daughter, which she would repack in order to use for swimming, soccer, sleeping-over, school, etc. In addition, the Tennis family used whatever bag was available such as grocery store bag.

*Insights:* Families' preferences for so many different types of bags indicates a need to conceive of a smart bag system that is general enough to function across many different bag designs. In addition, it appears that for some families, a smart bag would need to support more than one activity, such as soccer and ballet.



**Figure 2.** Ballpark family using their activity bag during a game. Notice the bag clips to the fence and the items in use are stacked below the bag.

### Touch-points

We observed several key touch-points for interacting with the bag across the six families. These include:

1. Packing the bag in the child's room the night before an event
2. Packing the bag approximately an hour before the event in the child's room and in other areas of the home such as the kitchen and laundry room
3. Placing the bag near an exit point in the home such as the back/kitchen door or the bottom of the front hall stairs.
4. Packing last minute items such as cold water in the kitchen or near an exit.

5. Picking up the bag at the point of exiting the house and loading it into the car
6. Interactions at the field or activity center during the event
7. Retrieving the bag at the field or activity center immediately following the event and placing it in the car
8. Transporting the activity bag from the car into the home following the event
9. Placing the bag in a storage location such as a car trunk or closet between instances of the event
10. Removing and adding items to the bag while it is in its storage location.

*Insight:* A well-designed smart bag would need a model of activity lifecycle and of the locations and tasks in the family schedule. This way it could modify its behavior based on current or upcoming touch-points. A significant challenge occurs when a bag is used for more than one activity. Smart bag designers would have a few choices to address this: (i) they could choose to only support one activity; (ii) they could ask the user to explicitly indicate which activity to monitor for and then focus on the appropriate touch-point; or (iii) they could attempt to have the bag infer the most appropriate activity based on the time, bag's location, and bag's content, and then provide the appropriate reminders. This third option seems particularly difficult.

#### Breakdowns

We observed eight different types of breakdowns in families' interactions with their activity bags. While each breakdown itself was small, a single breakdown could lead to a cascading set of breakdowns. For example, dropping off a child at baseball and discovering her bag is not in the car forced deviations in the parents' carefully scripted plans. In addition to the child being late, this breakdown could cause the parent to be late getting to their next event or could force the parent to hastily arrange for someone else to either pickup or drop-off another child.

The most common breakdown was forgetting to pack "last minute items" such as water bottles. Family members waited to do this so the water would be fresh and cold. In general there is flurry of activity at the last minute as family members rush around to get out of the door on time, taking people's attention off this need to pack. All of the families had repeatedly experienced this breakdown.

Another common breakdown stemmed from removing items when at home, between instances of the activity. Items were often removed for servicing. For example, dirty clothes and equipment were regularly removed for cleaning. Water bottles were removed in order to clean, refill, and refrigerate. Items were also removed for use in the home. For example, the Ballpark family and the Catcher family both recounted stories of breakdowns happening when batting gloves and baseball mitts were removed at home so the children could play baseball between games.

Older children included non-activity related items in their bags such as wallets, money, mobile phones, and house keys. These are similar to last minute items as they are packed at the last minute, but the reason for packing them at the last minute is quite different. These items were forgotten in transfer when they were not moved from street clothes to the bag when dressing in appropriate activity clothing, or they did not get transferred from one activity bag such as a school backpack, to the current activity bag.

Occasionally, families would experience a breakdown triggered by forgetting a non-routine item. The environment often triggered a need for things such as sunglasses for days it was sunny and rain coats and umbrellas for days it rained. Additionally, non-routine items would also include non-routine equipment needed for a specific instance of an activity, such as when a coach requests that players bring their own soccer ball to practice. The most common type of non-routine forgetting revolved around the occasional responsibility of bringing a snack for a whole team.



**Figure 3.** Photo of items the daughter from Swim family regularly keeps in her bag.

In a few instances, families would actually forget the bag. This was a significant breakdown that could easily result in a complete inability to participate in the activity. The Catcher family routinely kept the activity bag in the mother's car so they could leave for an event without looking for it. However, when the Dad's car was used for a pickup, the bag never got transferred back to the Mom's car, so when the next event occurred, they drove away from home with the activity bag still in Dad's car.

Another type of breakdown revolved around the removal of items. Things like perishable food, wet bathing suits, and smelly athletic shoes would occasionally be left in a closed bag, adversely affecting both the bag and its other contents.

Similar to the removal of items for servicing, families also experience breakdowns around items regularly kept in the bag that would occasionally be consumed; items such as sunscreen, money, medication, snacks, etc. These items would be used during the course of an event and then the families would forget to check their status and replace or replenish them before the next event.

Finally, the last type of breakdown involves leaving items at the location of an event. The most common forgotten item was water bottles, but families also shared stories of forgetting balls, and even forgetting to take the bag home with them.

*Insights:* A well-designed smart bag would need to have different rules for what is missing at different times and touchpoints. A challenge is both for the system to know and for the user to be able to explicitly state an approximate time before a touch-point that something should be considered missing. For example, non-activity items should not be considered missing until the last minute, but serviced and used items, like uniforms and baseball mitts, might be considered “missing” the night before an event during initial packing. Additionally, the smart bag would need to know which items needed to be removed at any of the various touch-points. Things like wet bathing suits remaining in a bag for a whole week have the potential to damage other items stored in the bag as well as the bag itself. Ideally, the bag should be able to sense its location as well as the location of users both to infer the current touch-point and to infer if the bag has been left behind. This also indicates the need for the bag to communicate with people who are not nearby, perhaps via text messaging. Finally, the need to create reminders when the rules change, such as when a coach asks players to bring special equipment to a specific practice, indicates a need for programming in the field. Users need to be able to add exceptions as they arise. Following this line, it would probably also be good to allow users to augment the regular rules as they learn over the duration of the activity, which items they actually need that they may not have anticipated when initially planning and setting up the bag.

### *Strategies*

Families employed a variety of strategies to reduce the chances of forgetting. First, many of the families committed to a single bag and kept as many of the items as possible within the bag at all times. Second, families often used the bag itself as a reminder of the activity, placing it near a doorway. Third, some families made check lists of necessary equipment and then reviewed the list to confirm they had all of the equipment they needed. Fourth, to reduce the breakdowns around last minute items and needed items that are not routine items, families often placed a note on top of the bag, or they would even place an empty water bottle on top as a reminder to both fill it and take it. Finally, a few families kept extra items in the bag to help avoid breakdowns from items removed for use or service. As an example, Ballpark family kept an extra batting glove in the bag in case they forgot to repack the regular glove, which would be used for playing baseball at home.

One additional behavior we observed falls between a strategy and a breakdown. We saw several examples where new items would be added to the bag because this was easier than finding the item in the bag. For example, in the

Swim family, the daughter’s activity bag had three deodorants (Figure 3). When packing the bag it was easier for the daughter to add a new deodorant rather than to conduct a detailed search to see if a deodorant was present.

*Insights:* Families’ willingness to make checklists indicates some willingness for preplanning, which in the case of a smart bag would be the programming of rules for what is needed at specific times. In this way, the bag could function as a more dynamic checklist. In addition, feedback from the bag communicating that a desired item was in fact in a bag could help encourage people to keep looking, giving them confidence that their effort would not be wasted.

### *Collaboration between Parents and Children*

We observed several different approaches to sharing the work and responsibilities associated with the bag. In general, the children under 8 relied completely on their parents to pack the bag. Children between 8 and 11 shared this responsibility with their parents. For example, in the Ballpark family, the son would pack the bag, but the mother would use a checklist to make sure all the items were packed. In the Frisbee family, the father would remind his daughter to get her bag ready before the event. In the Swim family, the 11-year-old daughter would proactively ask her Mom about the schedule of activities in order to help prepare the equipment on time. Finally, in most cases, children 12 and older took almost complete responsibility for packing.

Families also developed routines to support the flow of equipment as it enters the house following an activity and then re-enters the bag. In the Ballpark family, when the son returned from baseball he would place the empty water bottles and dirty clothes on the kitchen island. The parents would then service these items and stage them for the next event. In the Swim family, the daughter would place her wet bathing suit in the dryer, and her Mom would return it to her when it had been dried.

*Insights:* A well-designed smart bag would need to support sharing of responsibilities between parents and children. In addition, it would need a way to target reminders specifically to a parent or a child if it inferred a breakdown in coordination. The rules describing the coordination would also need to be open to change, allowing the child to assume more responsibility as they grew older.

### **NEEDS VALIDATION OF DESIGN CONCEPTS**

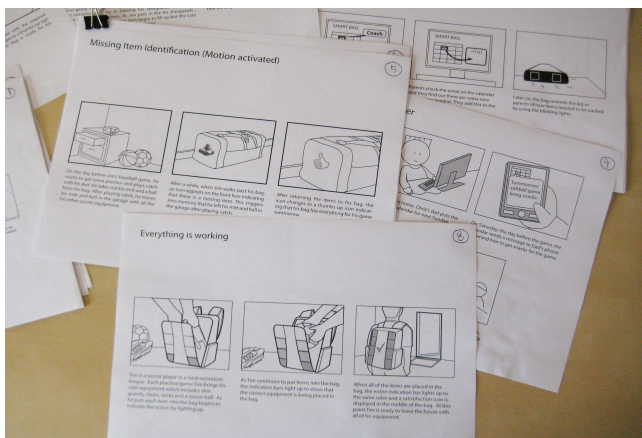
Based on the findings from our fieldwork, we began generating concepts as scenarios of use. We produced 100 concepts that explored different bag forms; forms of communication and interactions between the parents, children, and the bag; the ten different touch-points; and the eight types of breakdowns.

Following concept generation, we chose to conduct a needs validation session. This is one of the two processes used in Speed Dating, a design method that assists in the transition from ideation (generating many ideas) to iteration

(refinement of a selected idea) [9]. Needs validation helps to reveal the overlap in the needs a design research team has observed during fieldwork and the needs target users perceive in their own lives. In addition, this method helps reveal social boundaries that when crossed will cause target users to reject a new technology. Needs validation and speed dating help when working in a design space that has few conventions to guide development. Since people have had no experience with using smart bags daily, no design conventions currently exist to provide design patterns for acceptable behaviors. Instead of assessing the worth of a specific concept, needs validation works better to reveal higher-level themes that support a reframing of the problem and of the preferred state the target audience desires.

In a needs validation session participants look at storyboards that describe common situations and show technical interventions that lead to a possible “preferred state.” The general idea is to allow participants to get a small taste of what the future could be and then to verify that the underlying need is worth fixing.

To conduct a needs validation session, we clustered concepts into themes, and then through a critique, we filtered them to 15 concepts that best covered the problem and solution spaced. We documented these 15 ideas as storyboards and shared them individually with 5 of the families from our fieldwork study during meetings in their homes (Figure 4). For instance, one storyboard we presented dealt with notification for missing items. A family sets up a schedule on the bag so that the bag is aware that there is a soccer game in one hour. The bag sensing that something is missing lights up and shows a question mark icon with the text “Item missing”. They check the bag and realize the missing item, and then they put the item into the bag. The icon changes to a thumbs up sign indication that the bag is ready for the event.



**Figure 4. Storyboards from our needs validation session with families**

We showed the concepts one at a time and immediately asked if the family had ever experienced a situation similar to the one described in the storyboard. If yes, we pushed them to provide details of when and where. As we

addressed each concept, we allowed the family to offer their own input on the value of the concept and to reflect on if this seemed to be a likely and desirable future. While participants often inquired about the underlying technology, we kept the conversation focused on the underlying need and vision of the future.

Our 15 concepts specifically addressed the following design ideas:

- *Reminder Triggers*: scenarios involved users setting timers, reminders triggered by timers and location, reminders triggered by motion near the bag, and reminders triggered by touch
- *Communicative forms*: scenarios showed the bag communicating with icons, text, light, sound, voice, and vibration when issuing a reminder.
- *Bag location and interaction*: scenarios involved support for finding the bag itself. In addition, it should allow users to remotely interact with the bag via a PC and a mobile phone.

#### Findings and Insights from Needs Validation

Findings from the needs validation session fall into four overlapping categories: general feelings about the bag; forms of interaction and communication; triggers for reminders; and issues around specific touch-points.

In general, participants resonated strongly with the idea of a smart activity bag that could sense its contents and provide reminders. Participants immediately recognized that a smart bag would be valuable for many more activities than children’s enrichment activities. The main value they reacted to was in the bag’s ability to reduce the number of breakdowns that occur, and that all participants had experienced. Additionally, the parents resonated with the underlying idea that the bag could help children to take over responsibility for their own activities. They especially liked that young children could take over the responsibility for packing before an event.

The scenarios showed users interacting with the bag through PCs to both setup the bag and as a channel for reminders. In responding to this, many participants stressed their desire to interact directly with the bag instead.

In terms of communicative form, participants did not like when the bag used icons. They indicated icons would be too abstract to capture the very specific kinds of items they needed to pack. Text was most preferred, but parents of young children commented that reading would be a problem. In general, all participants felt that a bag with a voice might be a bit creepy, especially if it talked to participants at the activity. However, they felt it might help very young children who could not yet read. Participants really liked the idea of communication through lights integrated into the form of the bag. However, they did note that this would be a problem when the bag was in a closet or when used outside in bright sunlight. They were a bit less enthusiastic about sounds, noting that these would also not work if the bag was in a closet and could also fail in the

noisy environments of the home and many of the activities. The use of vibration in the handles and shoulder strap, meant to be a subtler reminder, did not get a strong reception. In general, participants felt that by the time they touched the bag it would be too late for a reminder, and they felt that the vibration would fail to get their attention.

*Insights:* The strong preference for direct bag interaction raises a challenge for smart bag designers, as tasks like programming the bag with the schedule of events and the reminders needed at different touch-points would most likely benefit from a large screen, a keyboard, and a mouse. This issue needs to be further resolved using methods like experience prototyping to gain more insights on their resistance to using a PC as an interface. In terms of communicative form, our strongest hunch coming out of the sessions is that smart bags should use light patterns integrated into the bags physical/visual design to gain the user's attention, but that the bag should also have some means, such as a screen with text, to indicate precisely what is wrong.

In terms of triggers for communication, participants reacted well to the idea of timers. They did caution that the timers would need to be specified by the user as not everyone packs the bag at the same time, and different days would require reminders at different times. Motion seemed interesting as it made the bag seem more aware and more technologically advanced. Participants liked the idea, especially for smaller children. However, they did note that it would be annoying if the reminder was given to the wrong person based on their movement near the bag. Several parents stressed that the bag needed to communicate with their child and not them. Finally, participants were less interested in touch as a method of triggering a reminder. They felt if they remembered to touch the bag, then they did not really need a reminder.

*Insights:* The use of timers goes right to a larger interaction design challenge of control. Timers allow users to take explicit action and feel in control, but they also force users to spend their time and attention detailing when and possibly where (bag location) each reminder should trigger. Participants' reaction also raises challenges around sensing people. Clearly, the bag will not function well if it triggers visual reminders people cannot see; however, if the bag is "smart" enough to sense people, then participants want it to know which people it is sensing and to focus the communication on the appropriate person.

Participants had strong reactions to four of the ten touch-points. At packing time, participants really liked that the bag could provide a weather prediction for the time of the event. They felt this would help with packing and planning. For last minute items such as water bottles, participants felt that the timing of the reminder was critical. Too early would be annoying, but too late would only add to the stress as people are trying to leave. One participant suggested that it would be nice if the bag could locate the various items

that had been used at the activity. They commented that not only was it hard to remember to take items like hats and water bottles, but that it was also difficult to find these when they are surrounded by so many similar items. For the arrival back home and the reminder to remove an item such as a wet bathing suit or half eaten sandwich, participants suggested that a snooze button would be nice as they were not always able to immediately address this need. They also suggested that the bag might notify them via a mobile phone if an item is not removed within a specific amount of time.

*Insights:* The reactions across participants reveal that the bag needs to be aware of the different touch-points and to change its behavior accordingly. This could be done with just a timer, but it seems that having the bag sense its location would really help. One unresolved issue is the granularity of location, such as the difference between a child's room possible on the second floor and the kitchen on the first floor. Additionally, the change in the behavior across the touch-points indicates additional complexity in programming the bag. However, that complexity might be handled by presenting the programming task as a flow chart, where the user simply describes the few rules needed at any specific touch-point.

#### DESIGN OPPORTUNITY AND IMPLICATIONS

The needs validation sessions revealed a strong desire from both parents and children for a smart activity bag that could reduce breakdowns, confirming the insights of Lee et al [15]. In reflecting on how to operationalize a smart bag, we generated insights around required functions, on the opportunity to frame the bag as a mediator in the relationship between parents and children, and the connection between the bag's visual and interaction design in relation to the identity of the child and the family. Below we detail the opportunities and implications around these themes.

The main functional purpose for the bag centers on a need to reduce breakdowns at the different touch-points. Minimally, a bag would need to know the current time and date and the schedule of upcoming events for an activity. The bag would need to know the equipment required for each instance of the event and have some ability to sense if that equipment was in or was not in the bag. Some events have an almost class-like structure in the relationship of activity to equipment. For example, home games and away games often have different equipment and often games require different equipment than practices. The bag would need the ability to be programmed, where users create the associations between the instances and equipment and where they specify the timing for the different reminders. Finally, the bag would need a method for communicating its current state and needs at both a context level (something is missing) and at a focus level (this item is missing).



A more advanced bag could also benefit from the ability to sense its location, have knowledge of the location of the child and other family members, and have the ability to communicate with people outside of the immediate area of the bag. The bag could employ different behaviors, preset for the different touch-points, and it could select an appropriate script by leveraging knowledge of location, time, and event schedule to infer which touch-point is currently in play. With remote communication capabilities, people could program or modify a program for the bag as they receive information instead of waiting to enter this when they come in contact with the bag. Additionally, remote communication would allow the bag to reach out to people via channels such as text messages and phone calls when it infers that it has been left behind or that an item in need of removal has been left inside the bag beyond a critical time period.

The bag presents an opportunity to frame it as a mediator in the relationship between parents and the child. In framing this opportunity, consider that the bag can create an intersection between the parents' goal of teaching their child to be more responsible, so as to be more successful in life, and the child's goal to grow up and gain independence from and the trust of his or her parents. In terms of interaction, the bag has two main activities that can bring a child and parents together. First, the parents and child can program the bag together. This includes determining what items are needed at different times and when different reminders might trigger. Additionally, this can include the design of the routine flow of artifacts and responsibilities between the child, the bag, and the parents. For example, the parents and child can more explicitly design how an item, like a dirty uniform moves from the child's care to the parent's care and then back to the child's care. Parents and children can iterate the design of this flow, working with the capabilities of the bag to make the handoff and time of responsibilities more explicit. Second, the bag can connect the parent and child as it actively participates and supports this flow of item and responsibility as the parents and child enact their different parts of the routine.

In terms of personal and family identity, there are two main implications: the form of the bag and the intended outcome from repeated use of the bag in terms of reducing breakdowns and creating dependency. The fieldwork with participating families revealed a range of forms for bags and motivations for selecting bags that connect to both the child and the family's self presentation, revealing different concerns and different levels of concern within each family [9]. In designing a smart activity bag it is important to consider the many different values the child and parents bring will influence their connection to the physical form of the bag as well as the expressive form of the communication. For some there may be a desire to harmonize the form of communication with the activity, a specific fashion aesthetic, or with the specific function of not forgetting items. In general, we feel there is not one

correct design, but a broad space for many designs that allow families to choose a physical and communicative form that matches their specific identity goals.

Identity is also strongly connected to the desired outcome from repeated use of the bag, and this outcome may be different for parents and for the child. The fieldwork and the needs validation show a clear desire for both parents and children to have a bag that allows them to more gracefully and effortlessly manage the many small tasks associated with their participation in an activity. However, in designing a system there are at least two approaches to take. A bag could function similarly to spell checkers in word processing software, which reduce the risk of sharing a message or document with a spelling error. The tool reduces the effort needed to make a "good" document, but it does nothing to help people become better spellers. In casting this device as a support system for children in taking on more responsibility, the outcome desired by parents may be more like a spell checker that helps a child become a better speller, or in this case an activity bag that helps a child learn how to create effective routines that reduce the chances of forgetting something, instead of functioning as an assistive technology that through repeated use creates a dependency. This subtle yet important aspect of the behavior needs additional research, and it may end up being that different families want different outcomes, making this as personal a choice as the selection of the bag's form.

## CONCLUSION

In this paper we have advanced the research on the concept of smart bags. Through a process of fieldwork and needs validation, we investigated the experiences and desires of dual-income families, identifying many key issues and opportunities around a smart bag's behavior. While this work focuses on a bag for children who participate in enrichment activities, we see the strong reaction in our participants as preliminary evidence for many other kinds of sensing bags such as diaper bags, briefcases, school backpacks, purses, evening bags, suitcases, etc. that could help people to remember the equipment they use regularly. We suspect that in moving away from a focus on dual-income families, issues like the need for different rules at different touch-points, and our insights on why breakdowns occur will generalize to other types of bags and activities.

## Future Work

As a next step in this research we plan to build a smart bag prototype to further investigate the form of the communication and the social impact of interacting with intelligent products both in and out of the home.

## ACKNOWLEDGMENTS

We would like to thank research team: Nick Ferrara, Diana Yu, Siddartha Butalia, Jing Jin, Luther Young, Soo ho Park, Emily Vincent, Karl Nieberding; the developers of the idea of smart bags for dual-income families: Min-kyung Lee,

Scott Davidoff, and Anind Dey; and all the families that patiently participated in this work.

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