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Exploring the Role of Robots in Home Organization

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ABSTRACT

Technologists have long wanted to put robots in the home, making robots truly personal and present in every aspect of our lives. It has not been clear, however, exactly what these robots should do in the home. The difficulty of tasking robots with home chores comes not only from the significant technical challenges, but also from the strong emotions and expectations people have about their home lives. In this paper, we explore one possible set of tasks a robot could perform, home organization and storage tasks. Using the technique of *need finding*, we interviewed a group of people regarding the reality of organization in their home; the successes, failures, family dynamics and practicalities surrounding organization. These interviews are abstracted into a set of frameworks and design implications for home robotics, which we contribute to the community as inspiration and hypotheses for future robot prototypes to test.

Categories and Subject Descriptors

H.5.2. [**Information Interfaces and Presentation**]: User Interfaces—*User-centered Design*

Keywords

home robots, need finding, home organization, robot design

1. INTRODUCTION

In 1945, Vannevar Bush wrote of a future machine, the Memex, which would help to enhance human memory [4]. The Memex would store and organize records, books, and communications, all converted to a digital form. In many respects, this predicted future is now the present. Most music is now digital. Communication has also become digitized through email, social and news websites and academic publications. Books are increasingly being digitized. Interestingly, however, the elimination of physical books is being slowed not only by the screen readability, but also by human emotional attachment to the physical books themselves.

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Figure 1: Storage areas seen in informants' homes. These are the dark, cluttered and variable spaces that a robot tasked with organization will face.

The computerization of the organization of our social lives, work lives, and knowledge have been well studied (e.g. [21]). But what of our home lives, specifically the physical organization of objects? Technologists dream of putting robots in the home [10], however it is not clear what tasks these robots should perform. This paper explores the issues surrounding computers, in their physical incarnations as robots, helping to organize the physical *stuff* in our homes.

"Tidy the room." "Put stuff away." "Tell me where object X is." "Retrieve object X." "Help me throw stuff away." "Figure out how to fit all of my stuff into my home." These are all requests that might be made of a home robot. *Rosie* from *The Jetsons* television show, a human-sized robot maid, would have easily completed these tasks. Previous work has shown that our opinions of what robots should do are colored by popular culture [20, 13]. And yet, organization is a sensitive topic. Rosie was a fantastic machine, an AI, a member of the family, but even human family members become annoying when they move your things without permission.

Organization is such a complex task that entire industries have grown to serve the need, such as the National Association of Professional Organizers [15]. Unlike the tasks "wash the dishes" or "vacuum the floor", the task space of home organization is nuanced and emotional. To make matters more difficult, since personal robotics is still an emerging market, there are no established methods for exploring whether or how robots should perform a task in the home before the technology itself has been specified. To help direct research into robotics for home organization, this paper presents a set of frameworks for home organization and their related de-

sign implications discovered through the technique of *need finding* [2]. Need finding is a methodological tool borrowed from the product design community which rapidly explores a design space through a series of interviews and experiences. The interviews look for *needs*, the gaps between use, usability and meaning. The findings from the need finding process are meant to be inspirational and generative, allowing researchers to develop creative solutions. We hypothesize that applying need finding to robotics research will allow it to have broader impact and usability.

In the course of this exploration, we interviewed twelve people in their homes, discussing their approaches to organization and the emotions and practicalities around having help with organization. We then toured each home to discover first-hand the organizational methods (or lack thereof) in place. The set of interviews and tours were abstracted into frameworks and design implications intended to generate ideas for the role of robots within the home. We present these abstractions as guidance for others exploring the use of robots for organization within the home. These abstractions are not intended to be prescriptive nor universal, rather they should be tested with users once solutions to specific problems are prototyped.

2. NEED FINDING

We present *need finding* as a methodological tool for quickly learning about a user space, inspiring robotics research within that space, and grounding the resulting research.

Much (although certainly not all) of robotics research today is inspired by technology push - a technologist deciding to apply a technology to a problem. User-based research often does not start until after a prototype or system specification exists. This is a valuable method as researchers have spent years building intuition for their field. For robotics research, *need finding* can provide a complementary, user-driven source of inspiration and guidance, as well as refining technology push ideas to better fit an application space.

Need finding is a method that comes from the product design community [2]. The goal is to identify a set of fundamental user needs of the community a product aims to satisfy. The need finding process is summarized in Figure 2. Need finding begins with generating empathy for the user group through interviews, and sharing that empathy with other designers and researchers through conversations and media like videos. This is a concrete and analytic process. The results from the interviews are then abstracted into frameworks, often presented in graphical form such as the 2x2 charts in Figures 2 and 3. The lessons from the frameworks are then converted to design implications, which are meant to be generative, allowing many interesting solutions to evolve. This process can be iterated and interleaved as necessary. The process is expanded upon below, with a description of our own implementation for this paper.

2.1 Interviews and Observations

Need finding begins with identifying a community of potential product users. A very small team goes out to visit a sample of community members in the places where they do the activities that the product supports. Immersion in the interviewee's environment is the key to success and a distinguishing feature of need finding. This immersion inspires the participant to discuss details they might have otherwise forgotten, and allows the interviewer to quickly reconcile the interviewee's words with reality. It is important to note that

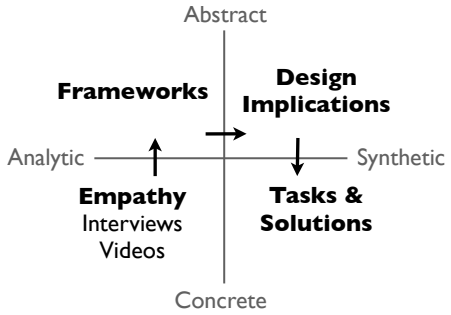

Figure 2: An overview of the *need finding* process.

relying on self-reported data alone is dangerous due to people's poor memories, as well as the social desirability bias (an inclination for respondents to say things they think will be received favorably.) There is even a standardized scale for measuring a person's inclination toward the social desirability bias [5]. These problems can be so serious that some usability experts suggest completely ignoring what users say, and instead watching what they do [16].

Along with getting a sense of the physical, cultural, and social environments, artifacts, and activities, the need finding team focuses on hearing good stories. The types of stories and observations that can be particularly interesting and fruitful for insight are contradictions (e.g., parents saying they want their children to exercise, but instead finding them in front of the television), spoken and unspoken social norms (e.g., not firing an employee via text message), and success or failure stories [7]. Interviewees' stories reflect situations in which reality did not match their mental model, thereby expressing an unfulfilled need.

The interview process also generates empathy towards the user group. This is an important step for technologists, especially those accustomed to technology push. Empathy allows technologists to be advocates for their users, designing for them more instinctively. Generating empathy is best done by meeting users and visiting their environment, however, it is not possible for each person to talk to each interviewee. Therefore, interviews should be presented to the entire team through videos, images, stories, or other media.

As compared to other types of user engagements, the sample size is relatively small; a sample size of eight to sixteen interviews is typical. Cultural Consensus Theory [18, 24] states that for a sufficiently culturally coherent group, a small number of interviews will yield responses which have a high probability of representing the entire group. So determining the group's level of cultural knowledge and agreement in turn determines how many interviews are required to obtain representative information.

Data gathered from the interviews forms the basis of the four components of the need finding process: generating empathy, creating frameworks, generating design implications and finally, creating solutions and prototypes.

2.2 Study Design

For this study, we interviewed people regarding the organization techniques, habits and difficulties within their homes. Each participant was interviewed in their own home, and the interviews were filmed. Each session began with a conversation in a comfortable room, encouraging participants to relax. Once a rapport was established, we asked to be taken

on a tour of the home, focusing on organization issues. During the tour, we were able to reconcile the interviewees' stories with the realities of their homes. The interviewees also remembered extra details and told more stories during the tour. These visits lasted between 1.5 and 3 hours. An interesting difference versus traditional ethnography is that the interviewers may direct the conversation to keep on topic and make the process time-efficient. The goal is to extract useful information, not simply compile observations.

The interviews were structured but conversational, allowing for digression and topic reordering as necessary. That said, the basic interview guide was as follows:

Signing of the study agreement form.

Introduction: "We're interested in learning about your experiences with organizing your home. What's more important is that we'd like to get to know you as a person. So we're going to ask questions about your home, organizing, daily life, hobbies, chores, and much more." Robots and technology were not mentioned.

Interviewee general introduction: questions about the participant, their family, and their history in the home.

Description of a typical day

Description of the home: among the topics in this section were a description of rooms and their uses, the interviewee's favorite and least favorite spaces, any remodeling done, and any technology in the home.

Help in the home: topics included the amount of paid help, frequency of visits, assigned tasks, and the informant's feelings about having help in their home.

Organization: including whether the space was too big or small, storage solutions, approaches to organization, and family dynamics surrounding organization.

Home tour: a tour of the entire home, including areas such as closets.

Wrap-up: our interest in robots in the home.

The home tour was a vital component, allowing us to verify the interviewees' self-reported information with the reality of their homes. Examining private parts of a home, such as a bedroom closet, also accelerated the rapport-building process, allowing us to probe more deeply into previous comments. Entering interviewees' homes in this manner distinguishes this study from those conducted in a lab.

For this paper, 12 people were interviewed in 8 separate interviews. This group consisted of four married couples interviewed together, three married people interviewed without their spouses, and one single person. All of the interviewees were the principle figures in the home, organizing and directing activity. Ten of the twelve informants were found by a professional recruiting service, while the two professional organizers were found through professional contacts. All of the interviews centered around the topic of organization.

To increase the cultural coherence and competence of the informants, all of the interviewees lived in the San Francisco Bay Area, spoke English fluently, were not retired adults (ages 27-60) and were upper-middle class. Tightly specifying the user group should provide more reliable results given the group size [18, 24]. We hypothesize that this group is likely to be among early adopters of new technology and thus particularly relevant. The results described herein, however, may not generalize to other user groups.

Given the small number of interviews, it was important to extract useful information quickly and efficiently. One technique for doing so is to interview *extreme users*. Extreme users push the boundaries of a technique, technology or situation. They also communicate needs quickly because they feel them acutely. For example, someone with an average sized home may have some complaints about closet space, but those complaints are minimal. Because they do not encounter space constraints on a daily basis, it will take a long time for them to complain about closets in an interview. For someone with a very small space, however, the lack of storage is felt in daily attempts to dress, put groceries away, etc., so they will complain about the issue quickly and loudly.

The interviews presented herein include three types of extreme users. 1) People living in small spaces (under 600 square feet): spouses Sam and Mary, and single interviewee Tony. The small space constraint makes it difficult to store objects. 2) People living in large homes (above 4500 square feet), allowing them to accumulate possessions if desired: spouses Jeff and Beth, spouses Kate and Dave, and spouses Ann and Bob, and Jill (interviewed without her spouse). 3) Professional organizers, who help others organize their homes: Eva and Emma (interviewed without their spouses).

To develop the technologists' empathy for users, a key goal of this exercise, the interviews were conducted by a mixed team of need finding experts and technologists.

2.3 Frameworks, Implications and Solutions

Stories are the unit of analysis for need finding. Frameworks are extracted from the stories told by the informants relating "contradictions, spoken and unspoken norms, success and failure" [2]. The stories are used to identify the important dimensions (e.g. cognitive load or clutter level) of analysis and generate structured concepts such as timelines, hierarchies of needs, 2x2 diagrams (e.g. Figure 3), or any format that expresses an idea heard in multiple interviews. The frameworks are populated with specific examples from the interviews and are used to identify trends and gaps, which are then expressed as design implications.

Design implications are guidelines for a system design which will satisfy users. Even at this stage, it is preferable not to presuppose solutions. Consider the use-case example of an astronaut recording notes in space. A design implication might be that the astronaut must be able to record information while floating; another implication might be a need to recall the information within two seconds; finally an astronaut must always feel in control. None of these design implications presupposes that the astronaut will write the information, leaving open solutions such as voice recording.

With empathy for the user group, frameworks representing their needs and viewpoints, and design implications making these needs concrete, the process of generating solutions and prototypes is informed and responsive to the pull of user needs. The prototypes generated are hypotheses of what users want. Promising prototypes can be subjected to the traditional exercise of user testing to obtain more concrete feedback. Although this method seems linear, it is usually not. Most teams bounce back and forth between articulating stories, framework, insights, and solutions.

2.4 Related Approaches

Need finding is inspired by ethnographic research in cultural anthropology, conducting interviews and making observations. The methods differ beneath this superficial similarity, however. Ethnographic research aims to create a detailed, "thick description" of a culture [11]. Need finding, on the other hand, is concerned with rapidly extracting

user needs and empathy for the culture being studied. The process also includes abstraction into frameworks describing these user needs, and the extraction of design implications to inspire new technologies. Finally, actual solutions to the needs are created, prototyped, and taken back to users.

A method similar to need finding is needs assessment [12]. The two methods have similar goals, both methods separate user needs from actual technological solutions. They differ, however, in that needs assessment aims to identify gaps between results and consequences, whereas need finding aims to identify gaps between use, usability, and meaning. The scope of needs assessment work is typically very broad, working at many levels of an organization (mega, macro, and micro). In contrast, the need finding work presented here is oriented toward driving research and development that will ultimately have impact for end-users.

3. FRAMEWORKS AND IMPLICATIONS

In this section, we present the findings from our need finding exercise. Each subsection describes a framework, the observations which lead to the framework abstraction, and the design implications of the framework.

The frameworks and design implications contained herein are hypotheses. As previously mentioned, need finding is an iterative process. To further validate these hypotheses, it will be necessary to design solutions inspired by the frameworks and encapsulating the design implications, and take those solutions back out to users for feedback and more traditional user studies.

3.1 Roles within the Home

Framework

Family members take on different roles within the home, taking responsibility for some tasks while delegating others.

In 5 of the 8 households we spoke to, one person was the *Organizer*. The Organizer determined storage methods and usually physically put objects away. More importantly, the Organizer kept the list of what-goes-where in their head. Family members would ask them when anything was needed. This hands-on approach was very important to the Organizers. They believed that they were more organized than their family, so it was necessary to keep control. In fact, even the suggestion of delegating the task made them nervous.

In homes with a dominant Organizer, the other family members were hands-off about organizing. They generally did not know where items were stored, except for the few things they used on a daily basis. They also did not care to expend more energy on organizing. It is interesting to note that none of the homes with an Organizer used lists of any sort to remember the locations of items or communicate those locations between family members. The Organizers reported being happy with the existing arrangement in which they were asked for items.

The Organizer versus family member dynamic was nuanced. In 4 of the 5 households with Organizers, the Organizer dominated the other family members (with respect to organizing), and felt like they ran the household. This was a source of tension within the family. Two of the Organizers' spouses teased the Organizers, rolling their eyes and using condescending language to describe their organizational tendencies. All of the Organizers called themselves "anal," "OCD," or other derogatory terms. The fifth home had a different dynamic, with the Organizer's spouse acting like a CEO (which he once was.) Jeff delegated the organization to his wife as a CEO would delegate to an assistant, retaining the feeling of control while remaining hands-off.

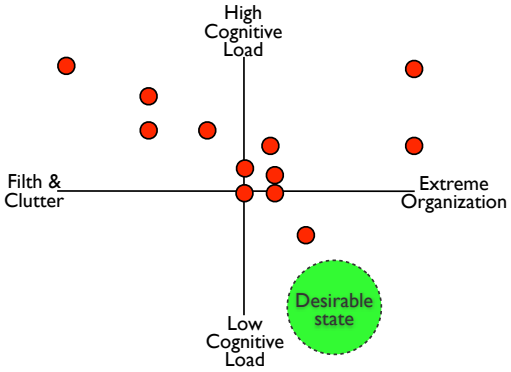

Figure 3: Framework: the informants' tradeoffs between cognitive load and organization in their homes. Each red dot represents a single informant. The green circle is a hypothesized desirable tradeoff.

In two of the other households, the organizational duties were spread more evenly among the family members. One person assumed a more managerial role, making sure tasks were completed, but overall the workload was shared. The final household was a single-member household.

Design implications

The family dynamics surrounding organization suggest multiple design implications. First and foremost, a robot must be designed for the entire family. Although it will often be 'owned' by one person, it will interact with everyone. The robot should allow people who are Organizers to feel like they have control over and are participating in the organizational process. Organizers want to save time, but they also need to know where everything is. An automation system which takes away this knowledge actually increases the Organizer's cognitive load as they are constantly wondering where things are. An organizing robot should take advantage of the stress-reducing power of human participation.

In contrast, the other family members should be able to interact with the robot in a hands-off manner, not exerting more effort than if a human were organizing. The other family members do not need to know where an object is in storage, but do need to access objects quickly.

A technology for organization should also not create tension between users by making them appear overly involved, or conversely overly lazy, to each other.

Finally, a robotic storage solution must avoid becoming a dependency. On a daily basis, the hands-off users can treat the technology as they currently treat the Organizer, allowing the robot to remember item whereabouts. But given that all technology fails eventually, there must be a non-automatic mode which allows users to find and retrieve their belongings. The worst case scenario was described in a paper about home automation in which the home automator passed away and no one else in the family could control the home [3]. If a robot fails, it must not leave a family unable to find their possessions; the robot cannot fail catastrophically.

3.2 Clutter and Cognitive Load

An interesting view of our interviewees emerges from considering the cognitive load they reported with respect to or-

ganizing, versus the actual order we saw in their homes. In this case, cognitive load was subjectively measured by how often the informants thought about organizing, regardless of whether that thought turned into action.

At one extreme, informant Tony did little to clean his small apartment and it was in a very disordered state. Tony did, however, report constantly think about cleaning, feeling guilty that he could not motivate himself into action.

Informant Ann also regularly thought about organizing, and did occasionally organize sections of her home. The large size of her home and her inability to throw things out, however, left some areas very disorganized even after cleaning. Clutter moved from one area to another, but never actually left the house. Ann repeatedly stated that the clutter in her home was very bothersome, and even suggested that her home was messy enough to be on a televised reality show. Although the reality we saw was not nearly drastic enough to be on television, there were certainly rooms that had accumulated a large amount of clutter over decades.

At the other end of the spectrum was Emma. Emma is a professional organizer and every item in her home was in its proper place, despite the disruptive presence of a baby. Much of her day, both professionally and at home, was spent organizing. Along with organizing communal objects and her personal possessions, Emma reported helping her husband organize his possessions, and returning objects to their "correct" locations after the housecleaning service finished.

Jill had also committed a large amount of time to organization, but focused instead on storage space. Having built her own home, she was able to include an impressive amount of storage cabinets, closets, etc. She had so much storage, in fact, that many of her cabinets were empty. Jill also came up with creative storage solutions, such as using large trash bins as table bottoms (hidden by a table skirt) to store infrequently used items such as Christmas decorations, as seen in the bottom-right of Figure 1. The result was an extremely organized home. Jill also reported being the only one in her household who knew where things were; when she was away, her husband would call her to ask about object whereabouts.

The examples above suggest that both too little and too much organization can be associated with high cognitive load. Is there an optimal tradeoff, a level of organization that can be achieved with less effort, but does not generate feelings of uneasiness for the homeowner? Informants Mary and Sam gave evidence of having a reasonable cognitive load versus organization tradeoff. Living in a very small apartment, Mary and Sam told of their organization challenges. By refraining from buying extraneous items for lack of storage, they kept their cognitive load as low as possible. However, they still had to play games like "Tetris" or "Jenga" when dealing with the objects in their closets. While they were managing day-to-day and reported satisfaction with their organization level, the possibility of being pushed into organizational chaos still weighed on their minds.

Kate, Dave and their seven children kept their cognitive load relatively low by distributing home organization among the family. Each person's load was low and the home was usually tidy. The possibility of chores being forgotten resulting in organizational chaos, however, was ever present.

Jeff had the lowest cognitive load among the informants. He had delegated all of the organization to his wife who was fastidious about cleanliness. However, Jeff had reserved for himself the task of organizing the items he needed on a daily basis, retaining control over his habits. Even this arrangement was not optimal, however, as Jeff was subjected to his wife's complaints about the need for more order and her cleaning efforts, thereby increasing his own cognitive load.

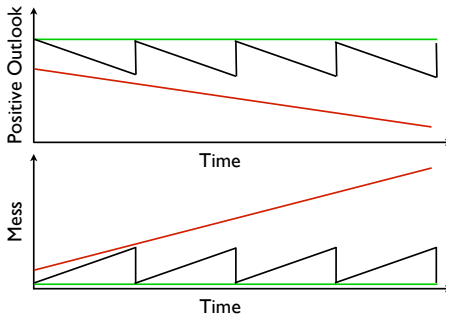

Figure 4: Framework: the correlation between a homeowner's positive outlook and home tidiness over time. Green: the desired but unachievable state of perpetual organization. Red: the degenerate case of unceasing increasing messiness and decreasing happiness. Black: the usual reality is a sawtooth pattern, worsening over time and then recovering in bursts of organization.

Framework

The tradeoffs between organization and cognitive load made by our informants are illustrated in Figure 3. We hypothesize that lowering the cognitive load requirement would be a more satisfying situation (the green circle in the diagram). In order to keep the cognitive load low, the resulting level of organization cannot be extreme (such as in Emma's house), but should be well beyond the tipping point into disorganization. This buffer of extra organization prevents concern that things could go wrong at any moment. Lower cognitive load can also be achieved by delegating organization, but there is a corresponding loss of control.

Note that none of the informants were in the lower-left quadrant of the diagram with both low organization and low cognitive load. This reflects the selection bias in our sample as we specifically recruited informants who self-reported organization challenges. This omission is not a hindrance for robot design, however. A problem which people do not care to solve is not a suitable task domain for which to invent new technology, there simply would not be a market.

Design implications

This framework implies that the current minimum for stress and cognitive load comes at below-maximum organization. Can robots push the amount of organization that can be achieved without increasing cognitive load? If not, robots should instead attempt to lower the cognitive load for creating the current buffer zone between organization and chaos. Increasing the cognitive load, even for a return of increased organization, is not valuable.

3.3 Organization Levels Fluctuate

"I get a bee in my bonnet," said interviewee Ann about organizing. Jill said, "You know, you just get into a mood to throw things out!" Kate and Dave said, "Sometimes we invite guests over to make us clean." In fact, all but one of our informants spoke about organizing and purging objects as discrete events, punctuating longer periods of declining

orderliness. The level and length of decline varied, but the need to organize and purge came in strongly felt waves.

Purging events were explained in two ways. One was the impending arrival of guests. The second motivation was unknown, the informants simply said they felt compelled to tidy. The exact tipping point was unclear, but the feeling acute. Discomfort with the state of their home built up with the disorder, until finally something had to be done. All of the informants reported feeling happier and more satisfied with their homes after a bout of organization.

A counter-example to the cycle was Tony, who reported suffering from depression and was unemployed. He reported wanting to organize but being unable to find the energy for a cleaning binge. As a result, his apartment grew messier and Tony grew more upset over time.

Note that none of the informants maintained a constant state of order in their homes, the supposed ideal situation.

Framework

The organizing patterns and corresponding mental states of our informants are summarized in Figure 4. The ideal state of constant low messiness and highly positive outlook, which none of the informants attained, is given by the green line. The dismal reality of Tony's state is that the messiness continues over time while his outlook becomes increasingly more negative, as represented by the red line.

For most people, organization levels and mood are represented by the black sawtooth line. The mess in their homes increases, matched by a decrease in their satisfaction level. Then, guests visit or the urge to organize overtakes them, and order and happiness are restored. The cycle repeats.

Design implications

Robots as organizational aids have the potential to be tireless, organizing continuously. Working autonomously, robots could potentially minimize the overall mess in a home and prolong the positive outlook of the home's inhabitants.

It is likely, however, that robots will need human participation in the organizing process. Humans will facilitate the robot's actions, perhaps moving things from the robot's path as is done for a Roomba [8, 23]. Humans will certainly need to decide where to place items or when to discard them (as discussed in Section 3.5). In either case, robot algorithm design cannot expect humans to be consistently diligent about tending to the organizing task at all times. A robot should not continuously nag its owner.

A more successful strategy might be for a robot to work within the organizing patterns of its owner, grouping questions or tasks for when the human "has a bee in their bonnet" about organizing, all the while performing autonomous tasks in the background. The length of human-in-the-loop interventions will change with the owner, but it is clear that the person will tire of the organization task. The goal, however, does not need to be a spotless home, but instead to return the homeowner to a state of happiness with their home.

3.4 The Journey of Stuff

A commonly cited myth of organization is O.H.I.O, or Only Handle It Once. This mantra is often applied to mail or paperwork, and translates into the recipient completely dealing with the item (reading, addressing any requests, shredding or filing, etc.) at one time. Applied to objects within the home, O.H.I.O is interpreted as putting objects in their correct location as soon as they arrive, and immediately after each use. While this superficially seems like a good idea, the reality is quite different.

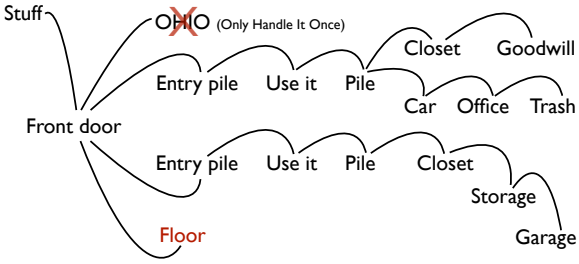

Figure 5: Framework: the journey of stuff over time. With time flowing from left to right, this figure shows examples of paths that objects take throughout their lifetime in the homes of our informants.

All of the informants save one told of the journey stuff takes through their homes and lives. Specifically, they all spoke about the occurrence of "piles". Mary and Sam, who live in a very small apartment, described an acceptable journey for their stuff as: it enters the home and is deposited in a pile near the entryway. They may use the object, and often deposit it back into the entry pile. At some point, the existence of the pile becomes a nuisance and the objects are put in their proper storage place, such as the closet. Closets are occasionally purged to make way for new things, depositing the old objects in the trash or giving them to a charity. Sam guiltily admitted that sometimes he is unable to organize his things and they end up stored in his car trunk, and then his office. Eventually these items are also stored or discarded.

Anther couple, Ann and Bob, were extremely upset about the seemingly unending journey of objects in their large home. They told of the entryway pile, but also of piles in other places. Piles of random objects in closets created minutes before guests arrived, then moved to the storage room when they had been selected for disposal, and eventually to the garage where they remained. Despite being marked as garbage, the objects were never disposed of; the piles formed temporary storage for transient objects.

Emma, a professional organizer with a meticulously organized home, admitted to the existence of temporary piles of mail and other small items on her kitchen counter. She fought the visual clutter by organizing the piles into attractive storage bins, but they were piles nonetheless.

Among our informants, only Tony actually only handled objects once. The result by Tony's own admission was a disorganized, messy, unsatisfying apartment. Tony would deposit objects wherever he used them, on the floor, on a chair, on his bed. Garbage and useful items alike were everywhere. Tony acutely felt failure about the disorder, but could not rectify the situation.

Framework

The framework that arises from this data is that stuff has a journey. Figure 5 illustrates some of the journeys discovered in our interviews. Objects move within a home between temporary storage, use, permanent storage, or disposal. Malone [14] wrote of a similar path for items on desktops, whose location on the desk and in piles aids human memory and productivity. A Steelcase Inc. office study discovered that piling patterns change with job responsibilities [22]. This journey of stuff can be satisfying or disap-

pointing, but it is a reality. Only in degenerate cases is stuff only touched once.

Design implications

We hypothesize that O.H.I.O is an unattainable ideal that robots should not attempt to make a reality. Instead, robots should help to move stuff along its journey so that it does not stall. Piles of objects in a home are problematic when it seems like they will never dissipate. Acknowledged temporary piles, however, are necessary and acceptable. Robots should allow for the physical journey of objects and the accompanying mental journey of the home's occupants.

3.5 Organizing is Decision Making

When asked whether she would allow her housecleaning service to throw out unused items, Ann responded categorically, "No." All of the other interviewees had the same response, it was simply unacceptable for any other person, including their spouse, to decide what was garbage. Even Tony, incapable of summoning the strength to organize on his own, insisted on supervising his sister when she came to help; he would make the decisions.

Framework

Organizing is decision making, and decision making is hard. There is literature describing both phenomena, a full recital of which is beyond the scope of this paper. For example, Frost [9] links the inability to make decisions to hoarding. Baumeister et al. [1] and Danzigera et al. [6] describe decision fatigue, the declining ability to make decisions over time, necessitating rest between decision-making sessions. Schwartz [19] discusses how too many choices exhaust us and leave us unable to choose at all.

Interviewee Ann described the process of sorting through an overflowing closet as exhausting. She described beginning the process with good intentions, putting items in *keep* or *discard* piles. However, her willpower quickly drained, and the remaining unsorted items were simply deposited back into the closet. Even worse, having exhausted her stores of decision making energy, she was unable to actually throw out the items in the *discard* pile and instead deposited them in a storage room or the basement.

In addition to the difficulty of decision making, much of the inability to organize and discard now-useless items actually stems from the meaning of those items. Informant Eva, a professional organizer, categorized the stuff that clutters people's homes into two categorizes. The first category represents unfulfilled dreams, a past or potential reality the owner had to give up. The second category includes items kept just in case they might be needed one day.

We did in fact see many examples of the first category in our informants' homes. Eva herself kept scrubs from her previous career as a doctor. Ann kept baby items from her days as a young mother. Bob kept old technology, such as ten year old modems, from his days as an engineer. Tony kept his college textbooks in the hopes of a career which was slow to evolve. These items all reflected our informants' personalities. Keeping such items was not a decision based on utility, but rather on sentimentality mixed with denial.

Design implications

The task of home organization implicitly involves decision making. A robot will either have to make the decisions itself, or encourage people to decide. Our research suggests that there is only a small subset of items in the home for which a robot will be allowed to make decisions such as when to discard them, or even where to store them. For most objects, the robot will need to elicit human decisions.

To encourage decision making, the number of choices requested at one time should be minimal. Also, the robot should allow for temporary storage (such as piles) when decisions are simply too difficult. As previously discussed, allowing stuff to have a journey can mitigate the emotional turmoil associated with organizing. In the extreme, there should be allowances in robot behavior for objects with emotional significance which the robot may not touch at all.

3.6 My Way, Now

Framework

At work, there are compromises and inefficiencies, but we cope with them because we are paid to do so. This is not the case at home. At home, we expect things to go our way and be efficient, even the intrusion of family members on our intended path is frustrating.

Sam noted that when his small apartment became cluttered, every task took an unacceptable "five extra steps." Despite generally delegating organization to his wife, Jeff retained control over objects on his "critical path" through the day, allowing him to execute tasks efficiently and without compromise. Jill creatively organized her entire home, but did not touch her husband's work tools, which he needed on a daily basis. When organization implied extra work at task execution time for critical tasks (such as searching for keys on the way out the door), the informants withdrew the required items from the normal home organization scheme.

Design implications

A robot assisting with home organization should not make it more complicated for people to execute common tasks which they do efficiently in the absence of the robot. The robot should not complicate tasks in time, number of steps, or in the mental load required. Objects should never be placed where their owners cannot find them.

3.7 Peers, Parents, and the Work Ethic

Framework

Interestingly, despite our informants' abilities to pay for household help, they all had minimal to no hired help. The highest level of assistance was a housecleaning service which came once every two weeks. Nonetheless, many of the informants complained about the high cognitive load of keeping their homes organized. When asked why they did not hire help, the response was unanimously that they felt like organizing their home was a task they should do themselves. There was a bias toward a strong work ethic and personal responsibility with respect to the home.

This view of the home as the owner's responsibility also colored how the informants perceived family members' efforts to help with organization tasks. Tony recounted that his sister had come to help him organize his apartment. Her approach was to nag him into cleaning and she would make decisions without Tony's permission. Tony perceived his sister as parental and condescending, and it upset him.

During the interviews, when Ann and Beth recounted nagging their husbands to help organize, their respective husbands rolled their eyes. Both husbands viewed the nagging as a reminder that they were not completing a task they should be capable of executing.

On the other hand, conversations about organization could be conducted in a non-confrontational manner and without guilt if approached in a peer-to-peer manner. Tony told of a

time when his brothers helped him clean. Instead of nagging him, they offered to help so that "I (Tony) could bring girls home." This offer of assistance was acceptable for Tony and did not hurt his pride. Both Mary and Sam and Kate and Dave worked as teams, sharing the organization load. This ownership over the task satisfied both partners.

Design implications

A robot which nags its owners into making decisions, implies failure or guilt in any way, or attempts to make important decisions for its owners, will read as a parent and should be avoided. Instead, a robot should help a person make decisions as a peer with shared goals. A robot should allow its owners to feel pride over accomplishing a task.

4. CONCLUSIONS

The study presented herein explored the needs and attitudes that people have with respect to organization in their homes. As a task for robots, home organization is difficult but potentially high impact. This study has discovered the deep needs, uncertainty, and family tensions which arise around organization. By relating these frameworks to design implications for robots, this paper aims to inspire and help direct future explorations into robot technologies.

In fact, the robotics community is already beginning to attempt basic organizational tasks such as putting away groceries [17]. Existing needs in the home like the ones discovered in this study, can inspire this research and direct it toward higher impact tasks and approaches. The design implications should also serve as hypotheses for user testing with new prototypes.

We have also presented the methodological tool of *need finding* for inspiring and grounding robotics research. This tool can be applied to any task domain, and is complementary to both other user-driven (needs-pull) and technology-push approaches to motivating research.

An interesting question for future studies on the topic of home organization revolves around generational issues. All of our interviewees were adults (ages 27 to 60), however, future generations may be different. Given the enormous amount and constant availability of information online, younger generations are learning to search for knowledge instead of memorizing. Will this search-based approach to knowledge extend to their homes? Will future homeowners be comfortable forgetting the whereabouts of objects and using technology to search for these objects as needed? The changes in how people relate to objects in their homes could prove to be fascinating.

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