Product Ecologies: Understanding the Context of Use Surrounding Products

A dissertation submitted to the
School of Computer Science
in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy in
Design in Human-Computer Interaction

by
Jodi Forlizzi

Dissertation Committee:
Sara Kiesler, Chair
Pamela J. Hinds
Suguru Ishizaki
Christine Neuwirth

Pittsburgh, PA
May, 2007

Carnegie Mellon University
School of Computer Science
Dissertation

Submitted in partial fulfillment of the requirements
for the Degree of Doctor of Philosophy

Title:

Product Ecologies: Understanding the
Context of Use Surrounding Products

Author:

Jodi Forlizzi

Accepted by:

The School of Computer Science

Readers:

_____
Thesis Committee Chair   Date

_____
Department Head   Date

Approved by the Dean of SCS:

_____
Dean   Date

Acknowledgements

I would like to begin by thanking my committee chair, mentor, and primary advisor, Sara Kiesler. Sara strongly advocated that I do a dissertation; in my 8 years at Carnegie Mellon I have learned so much from watching her thought process, research process, and interactions with others.

I am also indebted to my committee members — Pam Hinds, for creating a place for me to begin my work at Stanford and for providing outstanding guidance along the way, Suguru Ishizaki, for reading every word of every draft and providing invaluable design guidance, and Chris Neuwirth, for making sure that every phase of the research and analysis was appropriately rigorous.

I also want to thank my CMU community — colleagues and students alike — for providing an invigorating environment in which to mature as a researcher, particularly Scott Hudson, Howie Choset, Robert Kraut, Jessica Hodgins, Bobbie Klatsky, Carl DiSalvo, Joonhwan Lee, Bilge Mutlu, Rachel Gockley, Ian Li, and numerous Master's students in HCI and Design.

Finally, I want to thank my family, for enduring the long haul, and providing unconditional love, support, and encouragement.

Product Ecologies: Understanding the Context of Use Surrounding Products

Table of Contents

Abstract

This dissertation is motivated by research on elders using social products in the context of the home. Social products are artifacts, services, and systems that have social meaning and implications for people's social behavior and relationships. The home is an interesting place to study these products because the home provides significant technical and interaction challenges. The home also has a history of product choices based on function, aesthetics, and symbolic meaning. The research presented here builds on an ethnography of elders and ways they use or fail to use products. The main goal of this work is to understand how elders adopt and use products, individually and with other household members. It is also to understand how products play meaningful roles as part of a social system. This work particularly emphasizes new computer-based products for the home. I also suggest methods for understanding the context of use when designing a new product.

In this work, I introduce the product ecology as a theoretical framework to understand social product use. The product ecology is informed by social ecology theory in social science, which speaks to behavior within an environment and the relationships of the people within it. The focus of the product ecology is the product. Within the ecology are various interacting factors: people who have attitudes, personalities, roles, relationships, and values; activities in which the product is involved; the built environment, and the social and cultural context, including the norms and routines of the places in which the product is used.

This dissertation includes an ethnographic study of the cleaning patterns of families that included elders and non-elders. For each household, I report the experience of cleaning in terms of each factor in the product ecology. Each family was given a lightweight vacuum: either the Hoover Flair stick vacuum or the Roomba Discovery robotic vacuum. The vacuums had the same functionally, except that the Roomba cleaned autonomously. Although the Flair did little to impact the existing product ecology, the Roomba changed the product ecology significantly: new people cleaned, and adopted new roles. Households cleaned more often and in new places, both opportunistically and in creative ways. Cleaning impacted other activities. New social interactions developed around cleaning and the use of the Roomba. Additionally, people talked about the Roomba in functional, aesthetic and symbolic terms, unlike other cleaning products, which were described merely in terms of their functionality.

In the final chapter, I show how the interconnections among the factors of the ecology can be used in the design of new technology products for use by elders and non-elders in many contexts, including the home.

1 Introduction and Motivation

1.1 Introduction

This dissertation is motivated by my interest in studies of product use by elders and non-elders in the context of the home. The home is an interesting place to study for many reasons. There are both technical and interaction challenges in the home, as well as many human needs — specialized user groups like the elderly, the mentally impaired and the disabled — that require us to be sensitive to social and cultural values of those we are trying to support. There is a long history of how people collect and use products that will fit the home functionally, aesthetically, and symbolically. Finally, my early research suggested that products played meaningful roles as part of a social system. For example, Mrs. D's daughter recommended that she get a hearing aid, to ensure her safety and quality of life in day-to-day interactions. However, Mrs. D initially refused to wear a hearing aid in the presence of others, even though she could not hear well enough to carry on a conversation. She felt it would detract from her appearance, until she saw a new, tiny model worn by a friend. Based on this experience, she consented to wearing the assistive device.

My early research also revealed that elders often described products using social rather than functional words, a phenomenon that I found intriguing. These observations led me to think about products as objects that carry social meaning. I define social products as artifacts, services or systems that have social meaning, and often, implications for people's social behavior and relationships. For example, Jane S thought of the walker her mother selected to help her get from the front door to Jane's car as primarily a functional device. By contrast, Mrs. S described the walker as something that permitted her to make her way to the community's informal social hour each day, thereby maintaining or extending her social activities. Mr. J suffered from Parkinson's disease and was losing his fine motor skills. Nonetheless, he and his wife maintained their routine of having him drive to church each Sunday, even though Mrs. J knew that it put their safety at risk, because it was an important social ritual to both of them. Other scholars have considered social aspects of products, particularly people's tendency to personalize possessions, to imbue them with a sense of self-extension or self-identity, and to feel very attached to such products [e.g., Ahuvia, 2005; Beggan, 1992; Belk, 1988]. Nass and his colleagues [Reeves and Nass, 2003; Nass and Brave, 2006] have examined people's social interaction with computers and interactive media. My research takes a broader perspective, examining many ways that products are involved in our social interactions with other people.

New products, made feasible by advances in technology, have historically changed the way that people interact with each other.

Product Ecologies:
Understanding the Context of Use Surrounding Products

These products are interesting because people often rely on social interaction to make sense of them, and to fit them into their experience of the world. Many new technology products (such as electronic friend and dating sites, multimedia messaging, intelligent products such as robots, and numerous others) use technology to allow different kinds of people to use products to create and maintain social relationships in new ways. The history of product design offers countless other examples of products that have helped people communicate, share information, and form social bonds. For example, the first automobiles were designed to hold passengers as well as a driver. The advent of inexpensive, portable still and video cameras enabled people to collaborate in a different way by creating content to document particular aspects of life that could be easily shared. Social products are diverse in form and function, some with simple technology and some with advanced technology. They bring people together in a virtual or physically bounded context of use, have great impact on society and culture, and create new knowledge and experience as the result of their use.

1.2 Developing a theoretical framework for interaction design

My approach in developing the product ecology was to conduct a series of small studies, increasingly focused on robotic products. Over nearly six years, I interviewed 75 individuals ranging in age from 9 to 94. I first started by talking with 15 elders and five caregivers living at or associated with a retirement community in central Pennsylvania. From these discussions, I created an overall picture of the experience of aging and providing care. Next, I conducted an ethnography of 17 elders and five caregivers in two large Midwestern cities. This work was focused on product use in the home specifically. I included four types of households in the study: private homes where elders had raised their children, downsized elder apartments or condominiums, elder apartments in senior residential communities, and households in which elders had moved in with their adult children or adult children had moved in with older parents. This work was instrumental in exposing the dynamic, ecological relationship among the factors in aging and product use; it also identified nearly 60 opportunities for how robotic technology might help this audience. I conducted a follow-up study with 12 elders to understand responses to types of robotic products in the home. Finally, I conducted a semi-structured study with six families focused on cleaning and robotic vacuums in the home. Three families were elder-centered; three were not. Three families received a Roomba vacuum; three received a Hoover Flair upright vacuum. This work was critical in testing the product ecology as a theoretical construct. The second and fourth study mainly contributed to the work presented in this dissertation. The analyses used are primarily qualitative, and are drawn from observations, interviews, and photographic diary studies with participants.

1.3 Relevance of this work

The simple fact that consumer products are available to increasingly more diverse populations (in terms of age, ability, and economic status) makes design difficult. This difficulty is compounded by the fact that adding intelligent technology to products makes the task of inclusive design even harder. All of the aspects of a product that help to shape its experience of use — its shape, materials, manner of expression, and product behavior — need to address the functional and aesthetic needs of a diverse number of people. Product and interaction designers have done so, but they have focused more on the individual than on the social aspects of how people interact with products.

In this dissertation I present the product ecology, a theoretical framework to understand the different social relationships and experiences surrounding the use of intelligent products. The product ecology is informed by social ecology theory in social science, which examines the social and physical environment of behavior (not focusing on products per se). The product ecology is an interaction design theory that extends social ecology theory to include people's interactions with products in their social environment. This approach enables designers not to predict behavior with products, but instead to incorporate knowledge about social environments and relationships into the design of products.

The ecology takes a product-centered view of the world of activities and meaningful relationships that people make with products. Conceptually, at the center of the ecology is the product. Surrounding it are other products within the category and system of products; people and their attitudes, disposition, roles, relationships and values; the place, comprised of the built environment, and the norms and routines of the place the product is used. The ecology provides a snapshot of the social and cultural contexts of the people who use the product.

I will argue that the product ecology can be used to both describe the experience of use of a social product, and to generate ideas for designing social products that support different kinds of people. It can be used as a tool for design research and practice for those in the disciplines of design. It can also be used by those outside the design discipline who work with designers as a way to bring together theory and research through design.

1.4 Crossing disciplinary boundaries

The product ecology exemplifies how sensitizing concepts and theories in interaction design can be used as a catalyst for doing work with other disciplines that work with technology and ideas. It allows for

research through design to unfold concurrently with research and development done by other disciplines. This approach is less established, and is usually driven by a witnessed group of phenomena in the world. The knowledge generated takes the form of products, design theories, methods, and first guiding principles of design. For example, a new research method combining qualitative and visual data gathering with more empirical investigation might be a possible outcome. We developed such a technique in order to assess people's perception of the humanlike qualities of a humanoid robot head, towards designing an assistive robot for elders [DiSalvo et. al, 2002].

Each design problem has unique properties. Theories of human behavior will offer some insight towards a solution, but the details are often best attended to by designers and others who can observe the specific problem in detail and shape human behavior around products. Therefore, the product ecology can be understood as a way to investigate the unique properties of each individual product that exists at the intersection of a group of people. The dynamic nature of the product ecology makes the nature of the design problems emergent and the nature of the design activities that lead towards a solution opportunistic. In attempting to design the best product, details come in and out of focus, while major components of the solution are sometimes reduced in importance or taken entirely for granted. It is this kind of in-situ experimentation for which the product ecology is intended, resulting in new knowledge as well as new artifacts, services, and systems.

1.5 Contribution to interaction design research and practice

In this dissertation, I will illustrate how the product ecology contributes to designers and those in the human-computer interaction and human-robot interaction communities. First, it helps designers consider the many aspects of context when doing interaction design research. Second, the product ecology describes the social experience of use of a product, as well as how adaptation might occur among the people, products, and places in the ecology. People and place affect how products are used; in turn, product use changes the user(s) and the context of use as a result. Finally, the product ecology helps those working with designers to understand the methods and levels of analysis used in doing interaction design.

The specific contributions of this work are as follows:

• The product ecology framework is presented as an interaction design theory and a framework for understanding how particular product factors affect the use of a product.

• The product ecology framework offers a product-centered view for understanding the context of use of a product, thereby complementing theories in CSCW and the ubicomp communities.

• The product ecology framework helps those designing new technology to take context and product factors into account singly and in combination.

• The product ecology framework suggests qualitative research methods for the discipline of design, to help design future technology products.

• The product ecology framework broadens the notion of what a product is. For many, a product is synonymous with an artifact or service that a designer has created, rather than part of a social system. The product ecology framework allows designers to understand all of the ways products can serve meaningful roles in people's lives.

1.6 Structure of the dissertation

The roadmap for this dissertation is as follows:

Chapter 2 presents the product ecology, a theoretical framework to explain the social use of products. The product ecology extends social ecology theory to examine the relationship between people and the functional, aesthetic, symbolic, emotional and social aspects of products.

Throughout the dissertation, the term "product ecology" is used to describe both the framework and a particular set of phenomena around a product studied in the research.

Chapter 3 presents the context of the study: elders in the home, assistive robotic products, and cleaning activities and products in the home.

Chapter 4 presents an ethnographic study focused on elders and products. Why elders want products, use products, and value products is different than the younger population. One finding is that the dynamic experience of aging and related product use is best described by an ecological relationship; this sets the context for the final ethnographic study.

Chapter 5 presents the design-focused ethnographic methods used in the final study.

Chapter 6 presents a semi-structured ethnographic study to test the product ecology as a framework, comparing the Roomba robotic

Product Ecologies:
Understanding the Context of Use Surrounding Products

vacuum to the Flair upright vacuum in families with and without elders. While the Flair did little to impact the existing product ecology, the Roomba impacted the product ecology significantly: different people within the ecology cleaned more, adopting new roles; more cleaning was undertaken, both opportunistically and in creative ways, impacting activities; and a social context was developed around cleaning and the use of the Roomba, impacting the social context of use. Additionally, people described the Roomba in functional, aesthetic and symbolic terms, unlike other cleaning products, which are described merely in terms of functionality or lack thereof.

Chapter 7 compares the product ecology to other design theories, and to human factors and contextual design as guiding methods for product design. Using an example of social products that support religious practices, I show single and multiple factors in the product ecology can be used to understand how to design new technology products for use in a variety of contexts.

2 The Product Ecology

The product ecology is a theoretical framework that describes social product use — how products can change people's relationships with products and with each other. The product ecology is informed by social ecology theory, which is broadly concerned with the dynamic relationship between an individual and the social environment. The product ecology is both a theory and a sensitizing concept that I will argue is useful for those designing and implementing new technology products.

The factors in the product ecology include the product; other products within the category and system of products; people and their attitudes, knowledge, roles, relationships and values; the place, comprised of the built environment, norms and routines of the place the product is used; and the social and cultural context of the people who use the product and for some purposes, the people who make the product. Although the product ecology is applicable in any setting, whether virtually or geographically bounded, this work is concerned with the home as a bounding area.

The concept of the product ecology originated from studies of elders and their relationships to products in the home, and the dynamic interactions among home constraints, products, and attributes of people that suggested an ecological relationship among factors. Young elders (in their 60s and 70s) have a far more expansive life style than old elders do. For old elders who remain in their homes, the home is more than just a place to eat, sleep, and occasionally entertain. The home gradually becomes the place where most everyday activities happen, becoming the sole place where people socialize, exercise, and provide care for each other. At this time, new assistive products may be needed, while other products are no longer usable. Products play an interesting role in the process of aging, highlighting aspects of the values, activities, and emotions that are important to elders and their caregivers.

In this chapter, I describe social ecology theory, and use it to extend the ecology of aging to describe the product ecology. I conclude with a basic set of assumptions about the product ecology, which helps to set the context for further study.

2.1 Social ecology theory

To further develop the concept of the ecology of aging, I reviewed the social science literature on social ecology theory. In social science, social ecology theory focuses simultaneously on the environment and the social relationships among the people within it. The underlying assumption is that human behavior can be understood as an adaptive fit to an external environment, and that the relationships between the

human and environmental factors are complex and dynamic [Netting, 1986]. Context shapes these relationships, and is understood as a complex, dynamic set of factors, including social context (social networks and support systems), historical context, cultural context, and institutional context.

Social ecology theory makes certain assumptions about the dynamics of social relationships [Social Ecology Web, 2006]. First, human experience is influenced by multiple factors in the physical environment (e.g., geography, architecture, and technology) as well as the social environment (e.g., culture, economics, and politics). Second, analyses of the ecology should address the multidimensional and complex nature of the factors in the environments. Third, just as environments can be described in terms of their relative scale and complexity, their inhabitants can be studied at various levels including individuals and small groups (micro level analyses), organizations or neighborhoods (meso level analyes), and regions or populations (macro level analyses). Multiple research methods, including questionnaires, behavioral observations, and environmental recordings should be used to assess contexts, conditions, and the experience of individuals within an ecology. Fourth, the social ecological perspective incorporates a variety of concepts derived from systems theory, including interdependence, homeostasis, and negative feedback [Stokols, 1992].

Social ecology theory is by nature multidisciplinary, offering theoretical constructs that integrate concepts from multiple disciplines. They are useful when the approach of one discipline may not offer a well-rounded perspective on a particular problem. For example, strategies for healthcare may be grounded in clinical medicine, and ignore facets of the physical environment in which patients reside. A social ecological view of such a problem might reveal interventions at the individual, organizational, and environmental level.

An excellent example of the power of social ecology theory can be found in Heise's social ecology of factors that lead to violence against women [Heise, 1998]. The framework is offered to ground some of the literature in the area, and to move the task of theory building from a narrow disciplinary bias, where individual explanations explain the causes of violence, to a widespread, etiology-based description of violence against women. This approach conceptualizes violence as a multifaceted phenomenon grounded in an interplay among personal, situational, and sociocultural factors, with embedded levels of causality.

There are four main factors in Heise's social ecology, visualized as four concentric circles: the individual, the microsystem, the exosystem, and the macrosystem (Figure 1). In the innermost circle is the individual,

and the personal history that each individual brings to his or her behavior and relationships. An individual's ontogenic factors are the features of an individual's experience or personality that shape her response to microsystem and exosystem stressors. The next circle is the microsystem, which represents the immediate context in which abuse takes place (usually the family or other intimate relationship). The microsystem refers to those interactions in which a person directly engages with others as well as to the subjective meanings assigned to those interactions. The third circle is the exosystem, encompassing the formal and informal institutions and social structures that embed the microsystem — the world of work, the neighborhood, social networks, and identity groups. These social structures influence, delimit or determine the behavior that goes on in a particular setting. The final circle, the macrosystem, represents the general views and attitudes that permeate the culture at large. For example, in the context of abuse, male supremacy as a macrolevel factor could influence decision-making authority in intimate relationships. Adherence to rigid gender roles also increases the likelihood of violence against women.
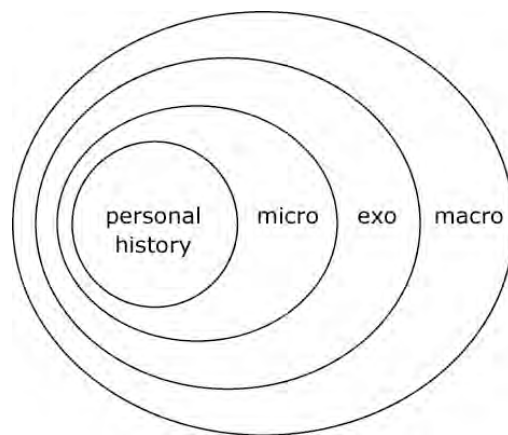
Figure 1. A social ecology of violence against women [after Heise, 1998].

These factors can be studied in combination to determine which combinations of variables best explain reasons for abuse by setting. Furthermore, the framework can be applied at the level of the individual or the level of the community to better understand how rates of abuse vary by setting.

Two key social ecology theories exist relative to the experience of aging. Birkel [1987] studied caregiving triggered by an elder's increased dependency, describing it as a series of adaptive processes designed to fit a household to its new function. Two main factors exist in Birkel's social ecology: the household, including the physical context of the home; and the family, including the number of residents, their status, and their patterns of behavior inside the home. He studied

modifications of the home and adaptations of the family in response to elders' family life course and social change, and argued that households adapted along structural, temporal, and task demand dimensions.

Lawton's social ecology of the health of older people has two factors, the person and the environment [Lawton, 1974; Lawton, 1990]. Lawton asserted that the context in which elders live is a significant determinant of how they perform. His environmental press model studies the competence of an individual and susceptibility to change of immediate behavior due to influence of the environment [Lawton, 1982]. Elders' performance levels decline more when they are coping with environments built for younger people. The design of a health-engendering environment can raise people's functional competence.

Lawton used social ecology principles to describe a change model of interventions that can be applied to the person or the environment. An additional factor is whether the individual initiates the treatment or responds to the environmental application of a treatment. For example, someone might respond to treatments that are applied individually, or respond to a change applied to the environment. Lawton's change model can be used as a way to encourage practitioners in many disciplines — health professionals, social planners, and architects and interior designers, among others — to engage in the task of producing health-engendering environments for older people.

A list of the factors commonly used in social ecological approaches to understanding human behavior is provided in Table 1. Common to all approaches is the use of people and the environment as key factors. Each can be analyzed at many different levels. An individual can play a role in a family, a social group, an institution, or a cultural group. Similarly, the environment can be analyzed at many levels (for example, a particular culture or institution, or a social setting).

2.2 The product ecology

Social ecology theory describes the dynamic relationship between people and their environment. I have extended these concepts to develop a theoretical product ecology, which combines social ecology theory and an approach centered on a product to create a framework describing the dynamic relationships between people, products, social activities, and contexts of use.

Product Ecologies:
Understanding the Context of Use Surrounding Products

	Heise	Birkel	Lawton	Others
People				
individual (behavior, gender)	X	X	X	1, 3, 5, 6
family	X	X		1, 2, 4
social group	X			1, 5, 6
socioeconomic group	X			
cultural values and beliefs				5, 6
Environments				
home	X	X		4
physical environment		X	X	4, 5, 6
social environment		X	X	1, 5, 6
work environment				1, 3
institutional environment			X	2, 3, 5
Time frames		X		

[1]Family, school and classroom ecologies were examined to find out what factors interact to increase or decrease social competence for first graders [Hoglund and Leadbeater, 2004].

[2]Examined the social ecology of families with hearing loss, and the resources available to families as they differ in urban and rural areas [Waters and Gavin, 1980].

[3]The work environment and objective and subjective features of jobs combine to form the factors of a social ecology of how jobs affect health [Ettner and Grzywacz, 2001].

[4]Factors in the physical environment of the home are examined to see how crowding affects the interaction of a family [Evans, Lepore, & Schroder, 1996].

5Offers a social ecological analysis of health promotive environments, looking at individual and collective behavior and institutional constraints in environmental settings [Stokols, 1992].

[6]The impact of environment context (social networks and neighborhood characteristics) is examined as it relates to elderly depression [LaGory and Fitzpatrick, 1992].

Table 1. Summary of factors in social ecological approaches.

2.2.1 Factors in the product ecology

In a product ecology, the product is the central unit of analysis. The functional, aesthetic, emotional, symbolic, emotional and social dimensions of a product, combined with other units of analysis in the ecology, help to describe how people make social relationships with products. These include the product; the surrounding products and other systems of products; the people who use it, and their attitudes,

disposition, roles, and relationships; the physical structure, norms and routines of the place the product is used; and the social and cultural contexts of the people who use the product and possibly even the people who make the product (Figure 2).
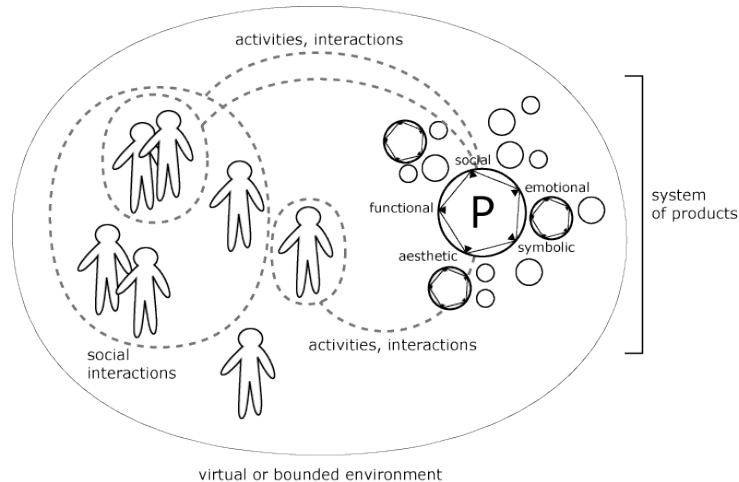

Figure 2. A schematic diagram of a product ecology, showing products, people, the built and social environment, and the social and cultural context of use surrounding a product.

2.2.2 Key ideas about the product ecology

There are several key ideas about the product ecology. First, each product has its own ecology, a set of factors that offers subjective and individual experiences with the same product when experienced by different people. This was drastically evident in the studies of elders and products. For example, an adult child of an elder might believe that a hearing aid is an essential product, in order for her parent to have the best quality of life and to remain functioning normally in society. However, the elder may find the hearing aid too stigmatizing, too uncomfortable, or too expensive. If a friend of the elder has used a hearing aid with success, the elder may be more willing to try the device. Similarly, a nurse and a bus driver may have drastically different knowledge about how to help an elder on and off of a bus, but each may be called on to do a similar task to assist the elder. Among each group of people surrounding a product, there are differences in how each person perceives the dimensions of a product, and in how each forms a relationship with the product.

Take, for example, the product ecology of a hybrid vehicle, a Honda Prius, that a family purchases. A group of people share in using this vehicle, but they have different relationships with it, depending on their circumstances and relationships with one another. The wife likes it for running daily errands but finds it too small for taking children and their friends places or for family vacations. The husband loves

tinkering with the mileage and participates in an online Prius owners group. His brother-in-law, with a truck that consumes gas, borrows it for personal trips. The family uses other products in coordination with the Prius: the minivan for long trips, home repair, and hauling, or a rental car for business trips. However, the Prius represents two values important to the family in purchase and use of the vehicle: contributing to a cleaner environment and saving money.

Second, the factors in the product ecology are interconnected in several ways. They are adaptive. For example, if a person changes in physical ability or role (someone sprains an ankle so is unable to drive), product use within the ecology will change in response (the car will remain unused, since the driver makes fewer trips, or other products and services might come into play, such as public transportation or a free van service). Additionally, new products can change the existing ecology, as activities are modified and new ones are developed (a new vacuum cleaner is purchased because the old one is heavy and stored in the basement, so spot cleaning happens more frequently and is done by more than one family member). Additionally, the flow of information and communication among components is complex, and can be transformed by perceptions and unanticipated communication patterns. For example, an elder may rely on her primary care physician for information ranging from blood pressure to how to deal with depression. The physician, in turn, may rely on the elder's family for reports on the how the elder is doing in checking blood pressure on her own with a home monitoring device. The elder, in turn, may feel unable to use the monitor on her own, and ask her family for help. Also, the components are dynamic and evolving. An elder who has broken a hip will have a myriad of product choices to assist her in the first few critical weeks, institutional care, home health care, and private and government services. Choosing any one of these can cause the particular experience of the central and surrounding figures in the ecology to change greatly. Finally, the components of the product ecology have the potential to break down. Continuing with the above example, if an elder's family imposes a move to a care institution, the outcome may be more detrimental than beneficial to the elder, resulting in reduced quality of life and well-being.

Third, factors within the product ecology can play different roles. When playing a key role, products help people in a variety of activities and experiences, supporting independence and well-being, mediating activities, and helping people to accomplish goals. Fundamental changes in product use contribute to changes in the product ecology. When a product no longer plays a key role, it is marked by events such as people changing roles, or going in and out of the ecology; owning more than one product to do exactly the same task or making modifications to a particular product; allowing products to clutter the

environment, unused and without special significance; and modifying the social relationships that exist around a product. Appropriately designed technology products have the potential to play a new key role in the product ecology, by providing better ways to manage the adaptive and dynamic qualities of the relationships between people, products, and the flow of human experience.

Fourth, the product ecology can be geographically or virtually bounded. For example, for elders, the product ecology is often the home, surrounded by a small, physically-bounded social network. The community of use for a product such as flickr, a photosharing service [flickr.com], is quite different. This environment is a group of people who may not be physically bounded, but who share the perceived values and benefits of sharing digital images. This dissertation is concerned with the home as a place for the social use of a product, and how product ecologies change for elders and non-elders when new products, both intelligent and non-intelligent, are brought into the home. The physical boundary of the home as a place provided a way to focus the study; however, the ideas are applicable to any place, whether or not it is geographically bounded.

2.2.3 Key assumptions about the product ecology

The product ecology is distinguished by four assumptions:

Assumption 1. Multiple dimensions of the product (for example, functional, aesthetic, symbolic, social and emotional) and place, the physical and social environment are integral components of the product ecology.

For example, applying assumption one to a robotic vacuum cleaner will allow researchers to examine the social and emotional aspects of product use, beyond issues of usability, such as reduced task time, that are more common to HCI investigations.

Assumption 2. The scale and complexity of the place of use of a product can be characterized in terms of a number of components, including physical and social environment (which collectively form a place), the intersubjective (actual) and subjective (perceived) qualities of that place, and scale and immediacy of the product use to individuals and groups.

The collective elements of context are complex. Assumption 2 sensitizes those designing social products to all aspects of context that might have an impact.

Assumption 3. The product ecology perspective incorporates design methodologies and multiple levels of analysis.

Assumption 3 will be elaborated in Chapter 7.

Assumption 4. The product ecology perspective incorporates concepts from system and service design [Shedroff, 2007], to take into account both the interdependencies that exist among products, and the dynamic interactions between people, products, and places.

The key idea in Assumption 4 is that multiple levels of experience of product use must be understood, from moment-to-moment interactions to emotional and symbolic states that result from years of product use.

2.3 Conclusion

This chapter presented the product ecology, a theoretical framework that is informed by social ecology theory and is intended to describe the dynamic and social factors surrounding product use. The product ecology was informed by research on elders and how they use products in the home, an extensive literature review, and social ecology theory.

I will demonstrate that the product ecology allows designers and researchers to evolve a rich notion of context around a product or system of products. The product ecology can be used to focus on small details such as individual product features, or broader issues such as the social and informational context surrounding product use. It allows for the notion of context, which originates from both social and technical perspectives, to be rectified into a unified view.

3 Cleaning in the Home as a Context for Research

The context of study for this work is elders and non-elders in the home, their caregiving and housekeeping activities, and the products they rely on to accomplish floor cleaning tasks. In this chapter, the context of the research is described in three areas: elders who live at home, a population characterized by changes that differ from changes in the young and middle aged; the context of elders and assistive robotics; and the home as a bounding environment, and the appliances and cleaning products within it.

3.1 Ethnographic studies of aging

Although little direct study of elders and products can be found in the literature, the social sciences have a rich body of literature on aging and the elderly, which I used to inform my own inquiry. The general experience of aging has been studied from physical, social, environmental, and cultural perspectives. Within sociology and anthropology, substantial ethnographies have examined the individual's experience of aging and interpreted that experience within social, cultural, and even economic frameworks [Bailey, 1996; Hazan, 1994; Golant, 1984; Silverman, 1987; Ward, LaGory, and Sherman, 1988]. There has been significantly less study on the interrelationships among these issues, activities in the home, and product use in particular.

Elders are particularly interesting because changes can be rapid and sometimes irreversible. Some have strokes or experience devasting falls. Others become confused, making driving and other everyday activities dangerous. Eventually, all lose friends and family to death, reducing the size of the social network and possibilities of social support. Old age is dynamic and rife with transitions; complex changes in physical, psychological, and social well-being characterize this period in an individual's life. In addition, an elder's environment and the environment as a living situation are often subject to adaptation and change. One of the measures of independence includes the ability to manage the household, second in importance only to the activities of daily living including eating, bathing, and using the toilet [NAIC, 1989]. All of these conditions mean that there will be varied, and changing, relationships with products.

The term "elder" has generally been used to refer to people over the age of 60. However, chronological age merely offers guidelines for the events of aging. Because people are living longer, some researchers have made distinctions within this age group. People between the ages of 60 and 75 often do not have significant issues with illness or disability, and are known as the "young-old." The "old-old" (age 76 to

84 years) and the "very old" (age 85 and above) are the fastest growing segments of the population in the United States [Hansson and Carpenter, 1994].

In our research, using pre-interview questionnaires, we identified two types of individuals: well elders who were mobile, cognitively intact, and able to maintain their households with relatively little help; and declining elders, who were experiencing either reduced mobility, cognitive impairment, or problems performing household maintenance tasks [Forlizzi et. al, 2004]. In our interviews, we heard well elders speak infrequently about the cognitive, physical, and emotional shortcomings associated with aging. Declining elders spoke frequently about how aspects of aging changed their day-to-day activities, and how products they relied on became unusable or inaccessible.

The experience of elders in decline has been broadly examined in the literature. Attempts to describe a general experience of aging have failed, however, because individuals age differently and physical, social, and economic context play a role in shaping the experience. Researchers have yet to understand the details and the interrelationships among elements of change. Relationships with family, caregivers, and peers are lost, created, and modified. All of these issues are embedded within traditions of social, economic, and political institutions, which can result in elders being stigmatized socially and culturally, treated as stereotypes rather than individuals, and at the extreme, even abused. For elders and their families and caregivers, continuous adaptation and coping strategies must be discovered and put into place.

Studies of the general experience of aging and how aspects of the culture of aging are shaped from both internal and external forces can be found in the literature as early as the 1940s. These initial efforts attempted to propose criteria by which aging could be examined cross culturally [Simmons, 1945]. While it is hard to generalize more than the broadest issues, early findings highlight the internal and external aspects of culture on this group. For example, one set of findings indicated the importance of maintaining value in mainstream culture by retaining skills and knowledge through old age, while defining post-retirement primarily as a time for leisure [Kleemeier, 1961].

More recent studies reveal the "realities" of old age by highlighting the interdependence of social, cultural, and economic issues. These studies span linguistic usage, symbolic codes that reflect the culture of aging, social control, and the structure of meaning in life and death [Hazan, 1994]. Some researchers assert that these aspects of culture, more so than the biological or physical aspects of aging, are critical factors in the experience of aging [Bailey, 1986]. For example, Social Security and Medicare can be thought of as symbols that encourage the

concept of elders as members of society that are too weak to work and need assistance [p. 29]. Nevertheless, many elders shun the stigma of becoming older, and retain many of the social activities of their younger lives. The values of remaining autonomous, sustaining personal growth, helping others, maintaining social ties, and experiencing pleasure have been identified as important for this population [Dorfman, 1994].

Environmental issues also play a critical role in the experience of aging, both in terms of ability to adapt to the environment, change and reduction in environment, reduced mobility leading to the home gradually subsuming all activities, and ultimately, the inability to care for the home. Throughout the last 50 years, the environment has witnessed increased focus as a research topic, starting with the work of Lawton in the 1970s and 1980s. His Environmental Press model of aging, based on the social ecology theory described in Chapter 2, identifies both physical and cognitive decline (personal competence), as well as social and environmental factors (environmental press), as playing significant roles in the aging experience [Lawton, 1982; Lawton, 1990]. Other environmental factors play a role, as elders often move to smaller homes and need desirable surroundings as they transition to new and smaller spaces [Ward, LaGory, and Sherman, 1988].

Lawton defined environmental docility as a narrow range of adaptability to the environment caused by reduced physical health, psychological competence, and social competence [Lawton, 1990]. For example, elders may feel more distressed when housing or neighborhood conditions become less supportive or secure. Dissatisfaction with the environment is associated with elders of higher income, and can result in anxiety, fear, and stress [Golant, 1984]. Ultimately, the need for physical assistance or modifications to the home, or the high cost of maintaining a larger home, may make it unfeasible to stay in the same place any longer. In response, elders may move to smaller homes, institutions, or to the homes of their adult children, forcing a reduction of possessions.

The 'Caisser-Maison' ritual, whereby one deconstructs the household and divests possessions to other family members, explores the relationship between mobility, aging, and death [Marcoux, 2001]. The process of downsizing the home and redistributing material possession to others in preparation for moving to a care facility serves as a reconstruction of the self. Products are retained that functionally support the elder's abilities, but that also symbolically signify former lifestyles.

3.2 Assistive robotics for the elderly

Many technological advances are currently being developed with elders in mind. These products emphasize independence as a primary goal. They provide support for a range of basic activities, including eating, bathing, dressing, and toileting [RAID, 2002; RAIL, 2002; MOVAID, 2002]; supporting mobility in the form of ambulation assistance [Morris et. al, 2002; GuideCane, 2002; Haptica, 2002; NavChair, 2002; Wheelesley, 2002]; and providing household monitoring of residents' activities and context [Mynatt, Essa, and Rogers, 2000]. In my research I found that many of these products have been designed with little consideration of the social, aesthetic and emotional relationships that elders will form with the product [Hirsch et. al, 2000]. Future assistive products will need to move beyond task-based interactions, and be attractive, affordable, and non-stigmatizing. Accessibility, ease of use, reliability, and the ability to facilitate social and emotional relationships with and through the product will also be particularly important.

For example, current mobility aids provide an interesting case study of the many factors that influence whether or not a product is used. Walkers, rollators, and canes assist in mobility for all who use them. For the elder population, these products mediate the activities of daily living, provide opportunities for partaking in social activities, and reduce the risk of falls. Unfortunately, studies of elders have shown that nearly one third of these devices are abandoned within the first three months [Guralnik et. al, 1993]; the disuse rate is as high as 54% [Scherer and Galvin, 1994]. The appearance of these products inhibits many from using them in normal social situations [Pirkl, 1994]. Some elders prioritize autonomy, using a walker no matter how poorly it is designed; for these people, aesthetic considerations are secondary [Mann et. al, 1995].

An examination of the growing field of rehabilitative robotics reveals many opportunities for improving the design of such products that will be used in the home. Many debilitating accidents happen to the elderly and infirm while unattended at home [Living at Home, 2002]. As robotic products emerge to address these safety problems, design research can support their broader usefulness and desirability to elders in home environments.

3.3 The home as a place for product use

The home is an interesting place to study. Technical and interaction challenges exist in the home, along with specialized human needs — user groups including the old and the young, the mentally impaired and the disabled — that require designers to be sensitive to the social and cultural values of those we are trying to support. Additionally, there is a long history of how people collect and use products that functionally, aesthetically, and symbolically fit the home.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Within the HCI community, the home is an interesting area as a place for new technology. Historically, early research on the home centered on workplace activities in the home [Kraut et. al, 1996; Junestrand and Tollmar, 1998; O'Brien et. al, 1996; Hindus et. al, 2001]; later, ethnography as a means of describing the experience of the home became popular [Salvador, 1999; Mateas et. al, 1996]. Recently, research labs at numerous academic institutions in the US and abroad have built real or simulated homes to conduct extensive research "in the wild" [Kidd et. al, 1999; Intille et. al, 2005; Mihailidis et. al, 2004; Morris et. al, 2003; Luscombe, 2003]. While early efforts augment existing technology in the home, later efforts assume that technological interventions will be extreme. The reality is that today's homes don't seem to be keeping up with a networked vision of the future — landline telephones, home alarm systems, and broadband services are the most cutting edge communication and information technologies that are commonly seen in homes in the US. Fundamental changes in the structure and infrastructure of the home will need to take place to support the ubiquitous computing and autonomous service robots of the near future.

3.4 The history of appliances in the home

To understand how people and technology products situate in the home, one must first understand the history of industrialization and the social, economic, and technological factors surrounding the design and development of products and services for the home. While factories were undergoing change during the industrial revolution, a separate industrial revolution was taking place in the home, in the form of new products that were meant to save labor and to help housekeepers do a more efficient job. How new products were actually adopted is a complex process, involving gender issues, social factors, and economic factors.

Industrialization has been broadly defined by design historians as the separation of creation and fabrication processes, and the birth of the discipline of industrial design. The original form of creating artifacts, with a single pair of hands responsible for both design and fabrication, is embodied in the ideal of the individual craftsman. A craft is any process that attempts to create a functional artifact without separating design from manufacture [Lucie-Smith, 1981]. In early European, Asian, and American history, craftsmen were responsible for creating a variety of artifacts, ranging from china to fabric, from hand tools to kitchen tools, and from slippers to horse-drawn carriages. Craftsmen controlled the production of the artifact from ideation through production and even distribution.

During the Medieval period, large workshops sprang up to develop products that catered to the tastes of courts, churches, and rich

merchants. Items created by a skilled practitioner were copied and duplicated by workers who were not trained or as skilled in the craft. As these workshops grew, so did competitive pressures to differentiate approaches to customer needs. Products that further divorced the designer from the making of the product developed in response [Heskett, 1980].

While in Europe, craft techniques were adapted to new production mechanisms that produced large quantities of goods that still reflected the design of products from pre-industrialized traditions, designers in the United States instead embraced the machine aesthetic. Rather than mimicking the old, in the US new production mechanisms influenced the development of interchangeable parts, and how goods were produced, organized, and marketed. Newly mechanized processes impacted many industries, resulting in a number of new products — tableware, clocks and watches, railroad cars, and electric appliances — that impacted the pre-industrial life of a family.

At first, these new timesaving appliances were only affordable by the very wealthy, and were used by housekeepers and maids rather than the lady of the home. A combination of new production techniques and revolutionary materials such as plastic and steel in the late 19th and early 20th centuries enabled less expensive mass production of many new material goods in the US and Europe. At this time, more people began to have access to more products — including people from the lower and middle classes. At the same time, the world of advertising played an important role in creating narratives about who would use these products and how they would benefit from them.

The First World War greatly increased productive capability in the US, and consumer product development continued to grow rapidly. Technological innovations resulted in elegant and useful designs for products including the steam engine, the electric motor, the telephone, and the transistor radio. With each design, significant changes in the social strata followed.

For example, Raymond Loewy's design for the 1935 Coldspot Refrigerator demonstrates how a radically different design, made feasible by an advance in technology, could also foster a social and cultural sea change within the home. A technological development, in the form of pressed steel casing, enabled Loewy to change the design of earlier varnished wood cabinet cooling systems. The Coldspot was encased in smooth white chrome, and Loewy added a compartmentalized interior to facilitate food storage, ice cube trays, and a semi-automatic defrosting unit. Where other refrigerator designs had been dark, angular and cumbersome, the Coldspot, with its pressed steel casing and seamless white aesthetic, embodied both designer's and consumer's ideal value of hygienic cleanliness. As a

result of Loewy's design, Coldspot sales jumped from 15,000 to 275,000 in five years [Forty, 1986], changing the appearance and function of the modern kitchen.

3.5 Industrialization in the home changes roles within the family

Technological innovations such as the Coldspot Refrigerator clearly had a huge impact on cleaning and homemaking. Manufactured products brought into the home transformed family life, changing and differentiating the role of each individual. However, in many instances, these new products failed to save time and provide convenience as manufacturers believed and advertisers promised [Cowan, 1983].

Before industrialization, the family was the basic social unit. A family produced, processed, repaired, and maintained almost everything needed for its own support; surplus was traded in the marketplace. The lives of both pre-industrial women and men were subsumed by household tasks. Women cooked, laundered, cleaned, sewed, and nursed children. Men prepared food for cooking, maintained buildings and fields, sewed heavy goods such as leather, and managed livestock and carriages. Prior to the industrial revolution, the word "housekeeper" applied to both genders, since almost all men and women worked in the grounds of their own home or someone else's [Cowan, 1983].

After the industrial revolution, separate work routines evolved for both men and women. Households had to adapt to new schedules for industrial workers. The notion of "home" began to be associated with women, and "work" outside of the home to be associated with men. As new products and services, including gas, electricity, running water, ready-made foods, furniture, and utensils became available to families, an economic transformation took place that waged changes as great as the industrial revolution [Strasser, 1982]. The historian Ruth Cowan examined technological development through household products as a means of charting the development of separate work routines for men and women [Cowan, 1983]. The products women used post industrialization — early cast-iron cooking stoves, automatic flour mills, and factory-produced food and clothing — galvanized the process of women taking on all of the housework in the household.

Cowan studied the transformative effects of lamp light, electricity, cooking gas, appliances such as stoves, washers, and irons, and bathroom fixtures. Clearly, the changes provoked by these modernizations were profound. As a result, structural changes occurred in the way work was done. The household labor force experienced the disappearance of paid and unpaid servants (unmarried daughters, sisters, and grandmothers) as household workers, and the imposition of all of the housework on the woman of the household herself [Cowan, 1985]. Statistically, the number of persons in the US

employed in domestic service dropped from 1.8 million in 1910 to 1.4 million in 1920, while the number of households rose from 20 to 24 million [Kaplan and Casey, 1958]. Additionally, as the number of household servants declined, the number of tasks increased; women had to engage in childcare duties that were previously undertaken by servants, and learn new tasks associated with the consumption of many new goods. For example, Cowan describes how modern plumbing eradicated the need to procure fresh water, but at the same time created the need to "produce" sanitary sinks, tubs and toilets in the bathroom on a regular basis. Cowan describes time studies that showed that housewives with conveniences were spending just as much time on household duties and housewives as without them [Cowan, 1985]. Clearly housework expanded to fill the time available, and was taken on wholly by women.

According to Cowan, as industries industrialize, general changes in the work force occur: more differentiation in structure, more specialization among workers, an increase in managerial function, and a disappearance in the emotional content of the work [Cowan, 1985]. On all four counts, industrialization in the home had an inverse effect. Work in the home became less differentiated as domestic servants left and women took on more responsibility, women became less specialized as they took on more tasks, the roles of manager and worker were combined in the role of the housewife, and the emotional relationship to the work increased.

For the homemaker, a sense of self-worth seemed to be linked to success at managing products and tools designed to maintain the household. This theme has been explored historically, for example through studies of attitudes towards housework, and studies that explore the balancing of pleasure and emotional satisfaction while managing the care of a home [Oakley, 1994; Moss, 1997]. This theme was also borne out in my research, where I observed homemakers and career women alike attempting to balance keeping house, caring for others, and managing the myriad of other tasks they were expected and required to do [Forlizzi, 2007].

4.6 From soapboxes to autonomous robots

The vacuum cleaner has a rich history, inspired by advances in technology and design, and inspiring change in how households were maintained. The lineage of the vacuum offers a variety of designs that are increasingly advanced in technology. In 1907, James Spangler, a janitor in a department store in Ohio, designed the first portable electric vacuum cleaner in response to allergies aggravated from sweeping dusty carpets [Blellis, 2005]. The components of the design included a soapbox attached to a broom handle, a pillowcase for a dust collector, and an old fan motor to operate the mechanism. In 1908, Spangler patented the device and formed the Electric Suction Sweeper

Company. Spangler's cousin was William Hoover, who improved on his design and formed, with Spangler, the Hoover Company. The Hoover Company built the first electric vacuum cleaner that used a cloth cleaning bag and cleaning attachments (Figure 3). The company offered a free, 10-day home trial, allowing early vacuum cleaners to slowly begin to penetrate the home market.

Figure 3. Hoover Model O, 1907.

At the time the Hoover Model O cost $75, one quarter of the price of a Model T Ford, which cost $300. Therefore, the Hoover was a luxury item, found only in the homes of the wealthy. Illustrations in early instruction booklets and advertisements pictured domestic servants rather than housewives using the Hoover, reinforcing the message that this was a product to assist the servants of the wealthy rather than a middle class homemaker.

Between 1912 and 1930, other models and competitors proliferated, penetrating the market with machines with improved function and lower cost: the Eureka in 1912, Sears' models in the 1920s, and the Electrolux in 1925 (the first canister vacuum on the market). This change in form ushered in a decade focusing exceedingly on the machine aesthetic; the design of household vacuums changed in the next two decades to conceal the bulky, unsightly motors and mechanical apparatus in each vacuum under aesthetic metal casings. For example, the Kirby 505 vacuum from 1945 was a vacuum with high aesthetic considerations and high function — a polished aluminum housing with black and red trim, with a powerful motor inside. To accent its functionality, it included many innovative accessories, as well as the capability to convert from an upright machine to a hand-carried portable (Figure 4).

Product Ecologies:
Understanding the Context of Use Surrounding Products

Figure 4. Kirby 505 vacuum, a study in high aesthetics and functionality.

By World War II, vacuums had become ubiquitous in middle class homes [Wikipedia, 2005]. Two general configurations emerged: upright, which had the pump mounted directly above the suction outlet, with a bag attached to a waist-height handle; and canister, which had the motor and canister on a wheeled unit, attached by a long flexible tube to the vacuum head. A few cleaners were designed to be worn on the back using a shoulder strap; another design popular in the 1970s was a central vacuum system, to which a hose was attached at a local baseboard outlet.

By the 1940's, advertising campaigns no longer showed hired help interacting with the vacuums. Instead, the woman of the home was shown using her affordable, easy-to-use vacuum cleaner. She was nearly always depicted in a formal dress, jewelry, and heels, asserting the message that the technology was as easy to use as pushing a button [Blellis, 2005].

The basic design and technology of the home vacuum cleaner did not change for several decades. In the 1990s, James Dyson, a British inventor, created a cyclone vacuum cleaner for use in the home. A cyclone cleaner uses forced air to move the dirt and dust particles to the outside of a bagless canister using centrifugal force. Since Dyson's invention, other companies have adopted cyclone models.

A logical merging of vacuum technology and intelligent technology has resulted in the development of the robotic vacuum. More than 15 years ago, large companies in Asia, Europe, and North America began to develop mobile robotic vacuum cleaners [Prassler et al, 2000]. These machines move themselves autonomously across the floor, brushing or vacuuming dirt and dust into a bagless dustbin. Home cleaning robots mimicked earlier industrial models, but were smaller, lighter, less functional, and less costly.

Product Ecologies:
Understanding the Context of Use Surrounding Products

The sensor systems in home cleaning robots are not sophisticated. Inexpensive contact sensors or infrared sensors are most frequently used, along with simple heuristics to follow random motion patterns. Armed with additional features, basic models are capable of navigating around furniture and returning to a charging station.

Current companies offering consumer models include the Electrolux Trilobite [http://trilobite.electrolux.se/], the iRobot Roomba series [http://www.irobot.com/consumer/], the Kärcher 300 Robo-cleaner [http://www.robocleaner.de/english/work1.html], and the Zucchetti Orazio robotic floor cleaner [http://www.zucchetti.com/portal/jsp/prodotto.jsp?prod_id=203], among others. The functionality in these models ranges from brush sweeping to vacuuming, simple motion patters to generation of 3D maps, fitting under furniture, autonomously finding the charging station, autocharging, and even cleaning wet or dry floors (Figure 5).

Figure 5. Current consumer robotic vacuums: Electrolux Trilobite, iRobot Roomba Discovery, Kärcher Robocleaner, and Zucchetti Orazio.

To observe the differences between traditional and robotic vacuums, I compared the Flair S2200 bagless upright stick vacuum to the Roomba Discovery robotic vacuum during my study. Families were given one of these two models because their vacuuming functionality and their ability to be used by someone with mobility problems is similar. The Flair vacuum is a bagless upright vacuum with an electrical cord (Figure 6). It has a one-speed motor that is suitable for use on carpeting or wood floors. The body is formed plastic with a small, flexible suction head. The vacuum does not stand up, which means it can easily be used under furniture.

The Roomba robotic vacuum is simple and easy to use. There are four large buttons on the top of the vacuum: Power, Spot, Clean, and Max. For standard operation, one simply powers on the unit and pushes the "Clean" button. Max mode will enable the Roomba to clean multiple rooms in one cleaning cycle, or intensely clean one room for up to two hours. Spot mode will provide repeated cleaning in a three-foot area. Suction power, along with three counter-rotating brushes that pick up dirt, dust, and hair, combine to perform cleaning. The Roomba uses a simple path planning algorithm to clean the whole floor, adjusting automatically to carpet, tile, and linoleum. The Roomba has sensors to

depict when it is stuck and uses pre-programmed routines to free itself. Virtual walls, or invisible beams of light, can be set up to confine to Roomba to a designated area. The Roomba can also return itself to the charging base when it has finished traversing an area. When the Roomba's dirt container is full, it can be accessed easily and removed without tools so that it can be emptied. The Discovery model contains a fast charging base so the unit, once parked in its dock, can be re-charged in under three hours. The base must be near an electrical outlet, which often means that the Roomba often cannot be stored in a closet.

Figure 6. Hoover Flair Upright bagless vacuum.

The Flair is a lightweight handheld vacuum with two settings, one for bare floors and one for carpets. It has an extremely slim form, and a flexible head, which means that the vacuum can be easily steered with the wrist, rather than requiring pushing as with a traditional upright vacuum. The Flair plugs into an electrical outlet and has a 20 foot long cord to facilitate the vacuuming process. It features a dirt container that is easily accessed without the use of tools. The vacuum does not stand up on its own and must be leaned against a wall when not in use. The vacuum also has a hook so that it can be hung on a wall for storage.

3.7 Conclusion

This chapter examined elders and the experience of aging, elders and assistive robotic products, and cleaning products in the home as a context for research. Investigating the context of the research reveals several compelling research questions. I conclude with the concept that robotic technology might have a great impact in the home.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Autonomous technology, might, in fact, drastically change cleaning practices for women, the traditional caregivers in the family, and elders, who often begin to have trouble managing cleaning activities. In the next chapter, I present the method for the study, and present the four hypotheses that were investigated.

4 Study 1: Why Elders Want, Need, and Create Relationships with Products[1]

As an interaction designer interested in how people interact with products, I have long been interested in examining how products engender different kinds of social experiences. Take, for example, cameras as a general product category. The invention of the first camera in the 19th century allowed a few select photographers to begin to describe the world in visual terms, and to indicate that the data they collected in the form of images were believable as fact. Over time, cameras became readily accessible to larger numbers of people. With the advent of small and affordable video cameras, the interconnectivity of the web and weblogs, and ready access to digital imaging tools such as disposable digital cameras and camera phones, new relationships between people and how they use images have developed. Today, ubiquitous images are shared at weddings and class reunions; the American consumer is bombarded with reality TV; internet users follow photo weblogs of unknown people documenting their experience; and law suits have developed around the illicit use of camera phones. Technology continues to enable new levels of social experience. Product experiences can change social experiences, but social experiences can also change product experiences.

To understand this complex set of issues, we first need to understand what a product is. First, products are the result of design activity. Nearly everything that we interact with in the built environment, whether tangible or intangible, is a product that resulted from a design process. Second, we need to understand products as things that offer ways for people to accomplish activities, evoke experience, and to potentially change human behavior. Many designers and design researchers have asserted the importance of understanding the nature of human experience through understanding how people will use products. This relationship that designers and users create through products has been examined from inspirational, functional, aesthetic, social, and even organizational and political stances [Margolin, 1997; Rafalei & Vilnai-Yavetz, 2004; Sanders, 2002; Battarbee, 2003; Battarbee, 2004; Battarbee & Koskinen, 2005].

Third, products should be thought of as more than just physical commodities. Victor Margolin, a design historian, uses the term 'product milieu' to represent the system of objects, activities, services, and environments that can be defined as products in our world [Margolin, 1995]. The design community is responding to this proposition, as the Industrial Designers Society of America [IDSA] and the International Council of Societies of Industrial Design [ICSID] have

---

[1]A version of this chapter was originally published in [Forlizzi et al, 2004].

expanded the categories of industrial design practice to include intangible products such as software. Richard Buchanan also defines products broadly, as artifacts, environments, systems, and services that offer arguments, or the potential for human interaction, that suggest how we might live our lives [Buchanan, 2001].

Finally, a special subset of products can be described as social products. These are the artifacts, environments, services, and systems that we create social relationships with or through. Most obvious in this group are intelligent or computer-supported products that allow groups of people to create, share, or access content together — products like photo sharing services, web logs, and instant messaging services. However, in my research, I discovered that people create and maintain social relationships using other kinds of products. Mrs. S's walker was valued and described as a tool to help her socialize rather than be mobile. Although they worked on projects separately, Mrs. M and Mrs. H socialized by knitting together, visiting the yarn shop, and comparing knitting projects.

I have long had an interest in conducting research on how products might help, hinder, and facilitate social relationships for the aging population. In an earlier study, my research group found that assistive products can feel threatening as well as helpful to elders. One woman refused to install bathroom grab bars even though her husband had fallen several times in the bathroom; the bars would have ruined the décor of the house [Hirsch, Forlizzi, Hyder, Goetz, Stroback, & Kurtz, 2000]. In a related study on health and fitness practices, we asked men and women to describe their reactions to a sleek, stylish, arm-worn medical monitoring device [McCormack & Forlizzi, 2000]. Despite the fashionable product form, over half of the participants said they would not feel comfortable wearing it, particularly in public, and described the device as being similar to a lie detector or a blood sugar monitor, despite the high design of the product form. These preliminary studies show that much more needs to be understood about the functional and aesthetic aspects of assistive and social products.

4.1 Ethnographic study 1

To extend and test my initial ideas about how elders interact with products, my research group conducted a two-year ethnographic study focusing on elders and the products they use. In this study, we examined elders' activities and interactions with products, an area comparatively uncharted in the literature. We conducted qualitative semi-structured interviews and observations with seventeen elders aged 62 to 90 living in fifteen private residences (Table 2: primary home, downsized condominium, elder community, or with adult children) in the Pittsburgh and Chicago metropolitan areas. We investigated typical daily experiences for these participants, and

focused on how products support or hinder activities for this population. To give more context to our findings, we talked with five experienced visiting nurses and social workers in a home healthcare program sponsored by a Pittsburgh hospital.

	Live in family home	Live in a condominium	Live in an elder-specific community	Live with adult children
Well elders	N = 2	N = 2	N = 1	
Declining elders	N = 4	N = 2	N = 5	N = 1

Table 2. Distribution of participants in Study 1, aged 65-92.

Analysis of the data focused on creating participant profiles, and reviewing and summarizing relationships between participants, products, and the activities that specific products enabled or prevented. Products were coded using the Industrial Design Society of America standards for product categories [IDSA, 2002]. Activities were coded using the National Aging Information Center's Activities of Daily Living and Independent Activities of Daily Living [NAIC, 1989], and the Extended Activities of Daily Living characterized by other research in the area of elder support [Mynatt, Essa, and Rogers, 2000] (Table 3).

4.2 Findings

Our analysis of interviews with elders revealed the dynamic, interconnected nature of their aging experience. For well elders, product use plays a critical role in keeping activities, interactions with others, and the experience of wellness all in balance.

4.3 Elders and products

How elders interact with products — whether they take the form of artifacts, services, or environments — plays a key role in defining the experience of aging. We learned that as elders begin to decline, why they want products, how they use products, and what they value about products changes. Elders are unique in their relationships with products for several reasons. First, elders generally have fewer reasons to make relationships with new products as they age. Reduction in income and social interaction limit opportunities for defining relationships with new products. Reduced or limited mobility also creates fewer opportunities for elders to interact with new products. Second, elders may adopt or ignore products based on how they reinforce personal identity and values, particularly during the transition to smaller homes and new communities. For example, housewares, art objects, furniture, clothes, and jewelry provide a clear message to the community about who an elder is and even the status enjoyed in adult life. Third, sometimes products designed specifically

for elders (particularly assistive products) are stigmatizing and demeaning. These products are often not used at all, or are modified to serve marginal uses. Product breakdowns like these create a gap between elder and environment, sometimes resulting in danger, isolation, and eventually, institutionalization.

Products		Activities	
P1	Assistive products (hearing aids, walkers)	A1	Activities of daily living (bathing, dressing, eating, ambulation)
P2	Appliances and housewares		
P3	Diagnostic equipment (blood sugar monitor)	A2	Instrumental activities of daily living (meal preparation, household management, medicine management)
P4	Entertainment products (stereo, television)		
P5	Medical equipment (medicine management)		
P6	Personal products and meaningful items		
P7	Services (cleaning, medicine management)	A3	Extended activities of daily living (entertainment activities, social work, volunteer work)
P8	Technical products (computers, cell phones)		
P9	Transportation products (shuttle service, automobiles)	A4	Communication activities

Table 3. Product and activity codes used to analyze data.

4.3.1 Why do elders want products?

We found that elders generally want products that match their aesthetic desires, that they use products that support their functional needs and abandon products that don't, and that the most important products are the ones that support elders' values of personal identity, dignity, and independence. Products are traditionally used to define one's identity (possibly, in defeat of ageism), or to re-establish or maintain one's identity after relocating to a new home. After many decades of interacting with products, many participants had adopted discriminating tastes. In our interviews, elders spoke at length about aesthetic qualities and personal meaning of cherished products.

For example, Mrs. A, an active artist at the age of 82, recently moved from her home in another state to live with one of her grown sons. The move forced Mrs. A to reduce her possessions to those that were most important to her (her paintings and painting supplies) to fit in a home filled with her son's family's possessions. When comparing her current home to her previous home, Mrs. A stated:

"The transition here has been very hard. Breezy was my home. Here, I live here. I used to cook a great deal. I did my own laundry. Now, everything is different. It's hard. Although my days are active, I

stopped driving when I came here. That takes your everything, your independence away. It's, well, as I say, hard."

When asked to provide a tour of her home, Mrs. A focused only on her paintings in each room, rather than any of the general family photos and possessions. In the dining room, where the family ate together every night, she talked only about her artwork. When she arrived at a shelf full of family photos and art objects, she chose only to describe an art award that she had won. Through the objects that she chose to discuss during the interview, it seemed that Mrs. A was asserting her identity within her son's home.

Similarly, Mrs. T, an 81-year-old, lived in an elder high rise for seven years. In the last two years, she had begun to decline rapidly, causing her son, who lived at a distance, to become more concerned and to increase the amount of support and interaction he provided. During her interview, Mrs. T spoke at length about an air conditioning unit purchased by her son:

"My son came in from Arizona, and he said 'Mother, how could you live in here? It's so hot!' and he went to Home Depot and he bought it and he put it in himself. I don't like the looks of the window, you know, [referencing the connection to the window done in a crude manner with a large plastic hose] but... it is pretty [referencing the unit]. He paid over six hundred dollars for it... and then he needed another part, so he went out, back to Home Depot and bought another part. And you take it out in the wintertime. The janitor and the maintenance man will take it out in the wintertime when it gets cold. I'll have them put it back in and maybe they will do it right. But my son wanted to make sure that he got it for me."

Rather than highlighting its function, Mrs. T chose to discuss the fine quality of the air conditioner, even describing it as pretty. I interpreted this exchange as being indicative of her pleasure in having her son contribute to a comfortable living environment.

4.3.2 How do elders use products?

Elders use products because the functional aspects of products meet their current needs. Products are instrumental in completing a variety of daily activities. This most likely differs from the product use of the young population, who often uses products because of stylistic considerations irregardless of functionality. For example, think of a teenage girl wearing dangerously high platform shoes, placing style before function in choosing such a shoe. The elders in our interviews told many stories of how household appliances, transportation products, and communication products such as telephones, cell phones and computers enabled them to help themselves, provide for family

members and friends, and stay in touch with people in their social network.

Mrs. N, an 80-year-old actively engaged in her community, expressed pride in being able to help an acquaintance in need, despite her own recent recovery from a bout of pneumonia:

"Even though I am on hiatus [from many of her usual activities, due to pneumonia], once a week, I take P shopping. She is a person in the building. That's my helping work. Every Friday we go have our hair done, then we have lunch, then we do the shopping."

Whereas well elders mentioned product successes more frequently than product failures, declining elders talked at length about how the functional aspects of products and environments no longer served them. Eight of the twelve declining elders that we interviewed discussed how they could no longer easily make use of bathroom tubs, toilets and fixtures, kitchen appliances, tables and counters, telephones, clock radios, grocery carts, automobiles, and public transportation to support their basic needs.

For example, Mrs. L is a 79-year-old who suffers from depression, insomnia, neural degeneration, gastric reflux, and balance problems. She lived in a high-rise condominium for elders, but the design of her bathroom made it so inaccessible that she had great difficulty using it. This was especially evident as she described the bathtub, shower, and hot and cold water faucets relative to the shortcomings of her own body (Figure 7a). In describing the process of taking a shower, Mrs. L commented:

"This apartment was made for old people, and they knew it when they made it. Yet why would they put that up so high? [referencing the height of the shower rod] I can just barely hang anything over there… it really is much too high. And another thing, I'm not so smart my dear, this faucet, I mean, you have to be a rocket scientist to use this faucet! I think it's very hard to use. Until I get it running right, I am ready to give up on it."
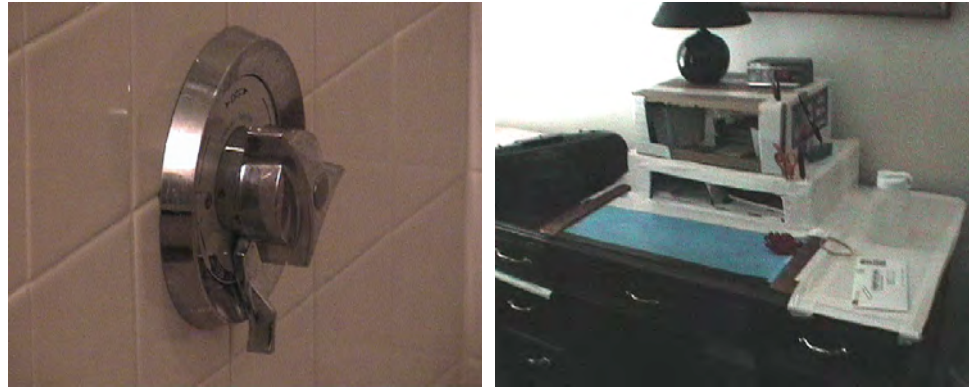
Figure 7. (a) Mrs. L's water control in her shower was hard to understand and use and resulted in her bathing less frequently. (b) Mr. G took great satisfaction in modifying his desk.

Unfortunately, functional shortcomings with products such as the ones Mrs. L described in the bathroom are enough to force elders to stop using them — in this case, compromising personal hygiene.

An alternative to discontinuing the use of products that can no longer help is to make a modification to products at hand to retain their usefulness. Six of our participants showed and described modifications they had made to communications products and housewares, to increase accessibility. Modification results in a personalized product that is satisfying to use, as a conversation with Mr. G about his personalized desk illustrates (Figure 7b):

"Yes, yes, I fixed that thing [the desk] up for myself. I did that for myself. It holds my envelopes, papers, pencils… everything is in there. I work on it periodically. If I see a box that looks better, I might take one down and put a new one up there instead."

As elders' bodies continue to decline, problems with products continue to be magnified, are less likely to be corrected, and ultimately result in messy, unsafe environments with more than one product to serve the same function. For example, Mrs. V, an 81-year-old struggling with basic activities of daily living, kept two clock radios on her bedside table (Figure 8a):

"You know what, [pointing to digital clock] I never used that as an alarm. I don't know how to set it. I use this one — [pointing to analog clock], but it is not any good... I have to get a new one. I use this one [pointing to digital clock] to look at the time."

The use of kitchen products and environments can highlight functional breakdowns, and make normal meal preparation difficult and even dangerous for elders. Mrs. G kept busy baking a quiche and preparing fruit salad during her interview. At one point, she needed to retrieve a container from a cupboard over the stove that was out of her reach. To do so, she took a broom and repeatedly jabbed it into the open cabinet until the item that she wanted fell out and on the floor. During this process, several other items fell out of the cabinet and landed on the stove, presenting a fire hazard. Mrs. G also had trouble reaching items in back of the refrigerator, which was filled with containers of food in precarious locations and in various stages of deterioration.

Mrs R, a 90-year-old, was no longer able to maintain her home of 43 years. Her kitchen was also in a dangerous state of disarray, which she repeatedly blamed on her laziness (Figure 8b):

"My kitchen isn't fit to be seen..." [Mrs. R starts cleaning passively, and interviewer tells her it is unnecessary.] "Well, I'll get around to it. It's not bad looking when you take all the stuff away. I'm just too lazy to do stuff...It's not bad when you can see all these plates, if I take time to clean. But I'm just maybe lazy or... (she trails off)." [Interviewer asks if Mrs. R uses the cupboards at all for storage any more.] "Oh yeah, I've got my dishes." [Opens cupboard to reveal dishes and glassware wrapped in newsprint and plastic bags.] "And I use all this stuff in here. Well, if you look in here it's a mess. My son is after me, he says, 'Do you want all that stuff on the floor? Put it in the basement or carry it up.'"

Figure 8 (a). A clock radio no longer serves someone with vision and muscular limitations, resulting in use of more than one product. (b). Bending and stretching to reach storage areas becomes difficult, resulting in using the counter for storage and disarray in the kitchen.

Product Ecologies:
Understanding the Context of Use Surrounding Products

If elders can understand how assistive products can help them remain independent, they are likely to consider and adopt products such as hearing aids, dentures, canes, walkers, and wheelchairs. Without this understanding, there is resistance in acquiring and using assistive devices. Elders harbor many misconceptions about what assistive products can be helpful, and how they might be acquired. Out of the twelve declining elders that we interviewed, almost three quarters were not able to recognize the need for assistive products, and nearly half had severe misconceptions about their purchase and use.

For example, through a conversation with Mrs. G we interpreted that she was in denial about her failing health and ambulatory abilities. Although her doctor recommended surgery, she hoped to avoid it for as long as possible:

"I said, 'Well I'm not doing it!' [referencing her doctor's request that she have knee surgery]. I'm going to fight it — I'm going to work it out. I do it myself, I found out that if I use the topical medications… I can do it with exercising. I'm doing fine. Anyway, the doctor said I have to have it done [the surgery] so I said that I'm up in years now, would it make any difference when I have it done? I'm going to be eighty, so therefore is it bad? He says it doesn't make any difference. Now I'm really actually not going to have it done unless I have to. I'm going to wait until I can't walk, if I can pull it off, and I don't know if I can pull it off. That's the unknown."

Mrs. V had accepted her decline, but seemed wary of assistive devices and unwilling to think about making changes to her home. An 80-year-old declining elder, she had suffered cancer and serious complications related to surgery a few years ago, and had used a walker during her long convalescence. When asked about using her walker, she commented:

"Well, I must have used it that whole month. I couldn't walk [while recovering at home from cancer], and I did not want a wheelchair. The reason I did not want a wheelchair – I would become an invalid! It's so easy to become an invalid. See you don't realize it when you are young…."

This exchange suggests that while Mrs. V was aware of her current need for assistance, she feared that by responding to it she would only decline more quickly. During her interview Mrs. V struggled with many of the products and environments within her home. She had ceased using many products altogether. Although simple modifications could have been made to drastically improve her quality of life (for example, by asking her children or a cleaning service to help remove clutter and unused products), she seemed to be unaware of the benefits. When asked what changes she expected to make in her home in the next five years, she responded that if her husband would let her, she would

like to build a patio off of the kitchen. Her inability to perceive the need for change not only presented an immediate physical hazard, but also increased the likelihood that Mrs. V would need to leave her home for a professional care community.

From the interviews, it seemed that elders who had accepted physical and cognitive decline seemed to be more willing to explore the use of assistive products. However, they often lack appropriate information to make decisions about what products will be the right ones. Mr. and Mrs. H were aware of the shortcomings of old age and had begun to modify their living space by having custom cabinets built, placing an amplifier on the phone, and using specialized tools, such as electric can openers, in the kitchen. However, they told an interesting story about grab bars installed by the previous resident of their apartment:

"When we moved into this place, these rails, well she [Mrs. H] said, 'they have got to go.' It wasn't too long before we realized they are really useful, particularly for getting up from the john and the tub. [Interviewer asks why they wanted to remove the grab bars.] Well, we didn't think we needed them. We were a young couple ten years ago! We were only in our 70s. Who needed them? The old lady who used to live here, her doctor son had them installed. It wasn't very long before we realized, it was a blessing to have them. Well [Mrs. H] is pretty husky, and it is difficult, and she has trouble breathing. She has to use all her energy for breathing."

Despite the fact that Mr. and Mrs. H had made many modifications to their home, it was only through direct experience of the grab bars that they realized their utility.

As elders continue to decline, they must begin to rely on family, friends, neighbors, or acquaintances to perform basic household tasks. Our interviews showed that direct experiences with assistive products, such as the one described above, were useful in illustrating the utility of assistive products and services. Other subjects described fear and trepidation when deciding to try a new product or service, partly because of the fear of the unknown and partly because accepting these products and services is often seen as stigmatizing or as a sign of admitting defeat.

Elders choose products that please them aesthetically, that will support them functionally, and that are indicative of personal identity. Additionally, products support values that are important to their users, and this takes on particular meaning for elders.

4.3.3 How do products support values for the elder population?
Our explorations of elder experiences showed that independence and dignity were unanimously important to this population [see also

Dorfman, 1994]. These values have behavioral and emotional aspects. Behavioral values are acted out in interactions with products and self-held standards for conduct and appearance — for example, being nicely dressed when interviewers arrived and offering home cooked food as if interviewers were guests. Emotional values are surrounded by intense feelings, and are often acted out in defensive arguments about particular behavior. Independence and dignity were evident in elders' stories about both products and activities. For example, Mrs. L insisted on driving to do errands, even though it was unsafe, rather than relying on her daughter, with whom she had a distant relationship. This behavior could be interpreted as her way of asserting her independence from her daughter.

Independence, the state of being competent and self-supporting, is a common value for many adults, regardless of age or lifestage. For example, consider the independence cherished by a 16-year-old who has just learned how to drive and is experiencing the first of many interactions with a vehicle. For elders, a shifting of capabilities causes a particular reprioritization of products and activities that helps them assert their independence. For example, many of our participants used cell phones to maintain social connections even as they had to rely on others to drive them to social functions. Independence was manifested behaviorally through product choices like these, and in actions like choosing to continue to drive or to stay in a large home. Independence was manifested emotionally in the stories we elicited about how elders envisioned their future lives. A common response often began with, "My children have offered to help, but my hope is not to burden them."

Dignity, the state of being worthy of respect, is a particularly important value for elders. In our interviews, dignity was behaviorally manifested in an elder's desire to maintain a particular personal standard within the home or the community. For example, nine of our participants had hired cleaning services to assist with household management. At least three of these elders had forged close friendships with the women who cleaned their homes. These friendships may be evidence of the fact that elders have accepted the need for help at home with dignity.

For example, Mrs. K had a Hemlock Society publication hidden among her pile of magazines. Explicitly removing it from the stack and revealing it to us, she explained:

"I belong to this [The Hemlock Society]. Instead of being left to die in agony, I would rather go when I am still… able. I did not tell my family. My son would have a fit if he knew."

Rather than relying on her family to decide what to do when she experienced significant decline, Mrs. K instead preferred freedom in

making choices about the end of her life. We interpreted this as her way of asserting both her independence and her dignity over making final choices.

The exploration of values and how they are manifested through interactions with products reveals how our participants prioritized products and activities that supported independence and dignity. This is in keeping with research that shows how what elders value can change dynamically, even day to day, as elders experience decline [Dorfman, 1994].

4.4 Elders and environments

Environmental reduction is a critical component of the experience of aging. The home becomes especially important as time spent in travel, work settings, and other spaces declines. As elders move to smaller homes, they seek desirable surroundings in new and smaller spaces [Ward, La Gory, & Sherman, 1988]. We observed elders living in three basic types of home environments. The first type was a participant's original home, inhabited for more than 15 or 20 years and occupied when the participant was younger and not subject to the shortcomings of old age. These were often expansive homes, filled with a collection of products and artifacts, showing few signs of change or modification. Often several rooms within these homes were no longer used, or were used for the storage of random items. The second type was a small home, condominium, or apartment not specifically in an elder high rise. These spaces often showed signs of contraction, and were inhabited as the result of a significant life event, such as divorce or the death of a spouse or child. The third type was an apartment or condominium in an elder community. These spaces were generally designed to support physical decline. Many of them had been further modified by our participants. Elder communities often had public laundry facilities and service staff such as superintendents to help residents. They also had community spaces where formal and informal social gatherings took place.

Many of the environments we saw in our interviews (even those designed and constructed specifically with elders in mind) did not fully accommodate elders' needs. Bathrooms and kitchens had particular shortcomings that impeded activities of daily living, as water controls are notoriously poorly designed [Norman, 1990]. The problem was exacerbated for our population, as witnessed in our interview with Mrs. L. Her solution was to take fewer showers.

Kitchen environments often fail ergonomically. As elders decline, they may have limited physical mobility, which makes reaching kitchen surfaces, storage areas, and products situated within the kitchen quite difficult. In several kitchens (such as Mrs. R's, discussed earlier), we

found collections of food, appliances, and other kitchen products in disarray on the kitchen counters.

Storage in general was a problem for most of our participants. Many could not see, let alone reach, upper and lower shelves of kitchen cabinets and storage closets. Only three participants had been proactive in reconciling this problem. One couple had custom cabinets built, and another participant had her cupboards re-hung eight inches lower so she could reach the shelves. Mrs. L's son built new shelves in her hall closet, creating an accessible space that she could use for customizable storage of toiletries and medications.

Usability and accessibility of the kitchen can make the act of preparing and eating food unsafe, tedious, and no longer enjoyable. We witnessed Mrs. L making lunch in her kitchen. Her degenerative muscle disease made it very difficult for her to stand at the counter and use a paring knife to make a sandwich. Mrs. L also had trouble getting in and out of a chair, so she had to continue to stand uncomfortably at the counter to eat lunch.

Participants' comments about environmental shortcomings in bathrooms and kitchens were used to prompt a discussion of their perceived need for changes to home environments in the next five years. Not surprisingly, our participants were hesitant to describe changes in the foreseeable future. The majority of those we interviewed were clearly unable to articulate the needs that would result from various stages of decline. Most reported little need to make changes, and instead described changes to the home in terms of aesthetic remodeling.

4.5 Elders, activities and experiences

We found that product use for elders facilitated activities, mediated social interactions, and evoked experiences that contributed to a sense of self. Properly designed products and assistive products played a key role in helping elders undertake activities. Activities that promoted social interaction were extremely important for this group. They played a critical role in helping elders to remain healthy, happy, and independent. Our participants cited a large range of activities that helped them stay engaged socially. The inability to participate in these activities resulted in contraction of their social space.

Elders undertook a variety of activities, including family outings, visits to friends' homes, meals, volunteer activities, and religious and community events. Many activities mentioned were not explicitly described as social, but were implicitly social in nature. These included lifelong learning classes, exercise classes, doctor visits, and assistance to neighbors in the community.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Particular living arrangements appear to support frequent social interactions with both family members and the community. Mrs. G said she "maintained" two households — one with her estranged husband, and another with her daughter and granddaughter. Mrs. G spent most of her time at her daughter's house, providing "assistance" in buying food and preparing meals. We observed her working in her kitchen during our visit. The kitchen cupboards and the refrigerator were in a state of general disarray. Several times while cooking, Mrs. G neglected to clean the utensils before placing them back in the drawers. These observations suggest that the relationship was more a social than a practical necessity for Mrs. G's daughter and granddaughter.

Volunteering and helping others are activities that strongly define an elder's sense of self-identity. For example, Mrs. C participated in four different volunteer activities. She was a founding member of a cooperatively managed used bookstore, a church trustee, a trustee at a credit foundation, and a board member for a local school organization. In addition to participating in these activities, she helped others to participate by driving them to and from events.

Decline, mediated by breakdowns in product use, drastically reduced elders' activities. At that point, many activities not ostensibly intended for social interaction in middle age became valued points of engagement in old age. These included activities such as doing laundry in a communal facility, receiving a visit from a home nurse, or participating in exercise and physical therapy classes. Nine of the seventeen elders that we interviewed participated in at least one such activity every week, if not every day. These activities were described in social rather than functional terms. They often provided an opportunity to leave the house, meet peers, and make light of aches and pains. Many physical therapy and exercise classes took place at senior community centers rather than hospitals, further emphasizing their social nature. Often, exercise made our participants feel young and desirable. Mr. H, who exercised nine times a week, proudly professed, "I'm a jock, and I get to spend lots of time with widows!"

Gradual yet substantial decline in abilities can have especially damaging effects on social interaction, because elders can simply give up. Figure 9 compares the number of times activities of daily living, instrumental activities of daily living, extended activities of daily living, and communication activities were mentioned during interviews. Declining elders mentioned basic and instrumental daily activities more frequently, consistently describing disappointment in no longer being able to successfully undertake a given activity.

Product Ecologies:
Understanding the Context of Use Surrounding Products
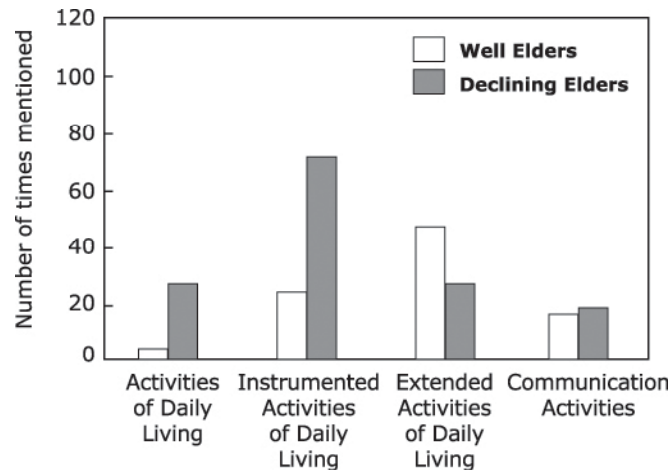

Figure 9. Frequency that well and declining elders mentioned different activities.

Mrs. L was a poignant example of this disappointment. Her physical decline was recent, but rapid and extensive. At the beginning of the interview, Mrs. L commented:

"Everything has changed. I mean, my life is completely different [since the onset of multiple conditions]. But I still try to go and do. My neighbor has asked me to go to lunch. I see her, and she says, 'When are we going?' I hate to have to tell her that it is just too hard."

Mrs. L's situation is interesting to interpret. Over the course of the interview, we began to understand how difficult social interaction had become for her. She occasionally drove to the grocery store and the beauty salon, went on outings with her family, and maintained relationships with a few women in her building. Yet she spent most of her day watching TV, despite the fact that her friends made repeated efforts to engage her socially. Near the end of the interview she commented that socializing was becoming too much of an effort. We felt this indicated that Mrs. L still desired social interaction, but that the changes in her life were making social engagements harder and harder for her to undertake. These kinds of situations can lead to isolation or even danger. Mrs. L could eventually entirely give up attempting social engagements, although they may be quite feasible with proper assistance.

Although assistive products are often described as facilitating the activities of daily living by making those activities accessible to people with physical or cognitive disabilities [Fernie, 1991], our interviews showed that assistive products also could play a powerful role in helping elders to create socially engaging experiences. Mrs. T, an 82-year-old woman suffering from degenerative muscular disease,

provided a clear example of how an assistive product can serve social needs. Mrs. T could barely swallow, walk, or get in and out of a chair, and fell several times a day. In spite of all this, she insisted on taking part in the informal social gathering each afternoon in the courtyard of her building. In the past year, it was only after acquiring a walker that she could even attempt this activity. Even though she relied on others for almost all aspects of personal and household management, she enjoyed having the agency to partake in this social activity. We believed that her walker was valued not in terms of facilitating her mobility, but instead in terms of creating opportunities for her to socially engage with the world.

Analysis of the data led to the concept of the ecology of aging as a way to describe the interconnected products, activities, and experiences of aging [Forlizzi et al, 2004]. To understand the ecology of aging, it is first important to understand how the term ecology is fitting to describe this dynamic relationship.

4.6 What is an ecology?

An ecology, derived from the Greek oikos, meaning habitation, can be generally thought of as a set of interdependent parts that have particular relationships within a system. Ecology began as a form of science describing the relationships of living organisms to the external world, but the meaning has broadened to include many kinds of dynamic and interdependent relationships. Whether one is studying migration patterns in Liberia or the use of cleaning products in California homes, an ecological structure can be useful for examining dynamic relationships among people and their environment.

Ecological approaches have long had major influences in the fields of anthropology, cultural ecology, organizational studies, and social and economic systems analysis, among other fields. The unifying theme is the relationship between people and their environment. In the late 1800s, anthropologists first used the term ecology to define the relationship that living beings have with organic and inorganic environments, as "the study of the household, the economy, of animal organisms" [Netting, 1986].

The study of ecological anthropology evolved to focus on how people create adaptive relationships with their environment. These relationships subsequently shape the population's social, economic, and political life. Ecological anthropology attempts to provide a materialist explanation of human society and culture as products of adaptation to given environmental conditions. For example, some research examined how populations in Africa naturally outstrip their food supply, leading to disease, hunger, and a limit in the growth of the African population.

Product Ecologies:
Understanding the Context of Use Surrounding Products

The related study of cultural ecology describes the study of the symbiotic relationship between people of a given culture and the social environment [Harris, 1979; Netting, 1986]. For example, the cultural ecology of male supremacy in Amazonia has been studied to understand how it impacts labor, population management, and the stability of the culture.

The related anthropological study of material culture is relevant for the discipline of design. Material evidence in the form of products people use such as clothing, consumer and household goods, art, home design, and landscape design provide unique insights into cultural groups and social behavior. Material objects can serve as an important source of evidence about the adaptation between people and their environment. The consumption of material goods can also be considered as a social or cultural ritual [Douglas & Isherwood, 2001]. Anthropological methods for study of material culture have been inspired by disciplines as diverse as archaeology, art history, and folklore. For example, the study of Amish barn signs (Hex signs) reveals their symbolic meaning and value placed on prosperity and faith as a population.

Bell [1999] has recently used the term ecology even more broadly, to include all the aspects of a specific experience in context. According to Bell, researching an ecology helps to "convey an experience, a sense, a glimpse, or a window into another world… a way of talking about deep cultural patterns that implicate everything we do. Knowing these stories, interests, and patterns makes it possible to design and develop products and services that fit (intuitively) into people's lives." [Bell, 2001]. Bell's approach seems relevant for product design, because it offers a mechanism for examining multifaceted aspects of the environment, including the products we interact with.

Other researchers in HCI have studied the adoption and use of technology using an ecological approach. Nardi and O'Day [1999] used the term information ecology to describe an interrelated system of people, practices, values, and technologies within a local environment. Pirolli and Card [1995] used the term information foraging to explore how information-seeking activities unfold in an ecological relationship of people and technology. Interdependency is a characteristic of an ecological relationship. The interconnections are dynamic and interesting to study, as the environment serves as a catalyst for adaptation and change.

4.7 Ecology of aging

We described the complex interrelationships between elders, the products they use, and the activities and experiences that result as an ecology of aging. These interactions take place in a local environment bounded roughly by the home and the elder community. The

components of the ecology of aging can be systems or networks themselves. For example, the elder's community is also a social network. Components may or may not reflect the roles and functionality they have in the rest of society. The nurse's approach to providing care is drastically different from that of the superintendent in an apartment building, but both may be called upon to assist with a caregiving task.

Products play a role in a balanced ecology of aging, supporting well elders in a variety of activities and experiences. For example, Mrs. G disseminated information about social events at her community center, and made sure newcomers felt welcome by telling jokes and giving small gifts. Mrs. C befriended her cleaning lady, preparing a home cooked meal to share on housecleaning days. Figure 10a depicts an elder within a healthy ecology of family and social connections interacting with products and undertaking activities, connected and vital within a local environment.

Products also play a role in an unbalanced ecology of aging. Changes in physical and cognitive abilities contribute to fundamental changes in product interactions. Some products become unusable as the elder is less able to undertake activities, begins to relinquish independence, and to rely on assistance. For example, Mrs. R was clearly struggling to manage her household, and was hurt and upset that her son had begun to "help" by removing items such as her prized Victorola. Mrs. L relied on a local meal delivery service, but did not like the way the food was prepared and had begun to lose substantial weight. Figure 10b depicts the ecology of a declining elder who can no longer use all the products she formerly relied on. As a result, a gap is created between the elder and her environment, and a contraction of physical and social lifespace occurs.

Unfortunately, restoring balance to the ecology is often not an easy proposition. For example, an elder could experience rapid decline as the result of illness or an accident. A physician might believe that a safe solution is to place the elder in an assisted living facility. However, the elder might not want to move there, the family might not have the financial means to do so, or no space may be available in an appropriate facility. Alternative measures are often put in place — and a more suitable solution may never be realized.
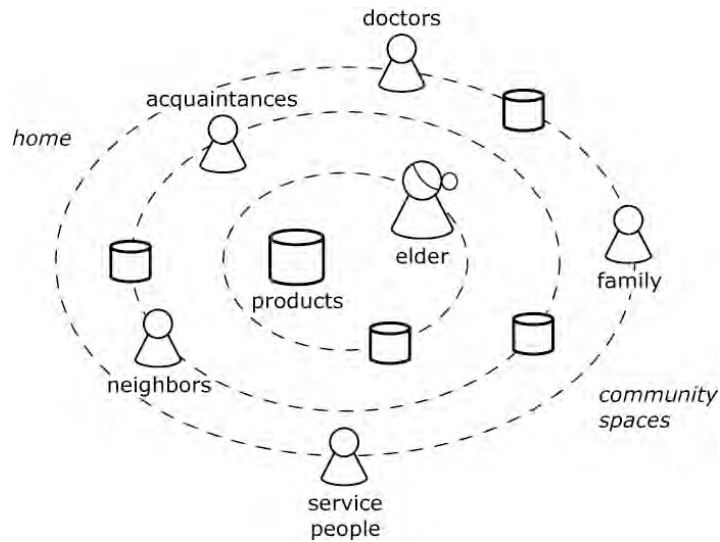
Figure 10a. A balanced elder ecology. Elders interact independently with products and people in their network of social connections.
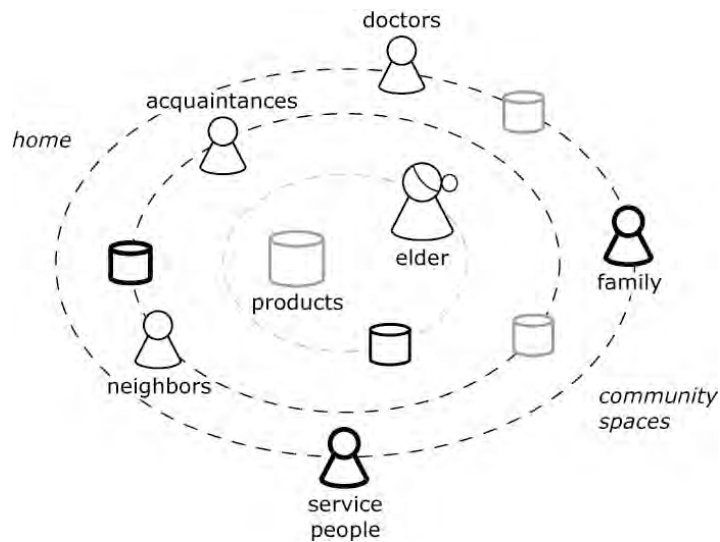

Figure 10b. An imbalanced elder ecology. Shifts in the ecology may be caused by the inability to independently and successfully use products, resulting in a gap between elder and environment. Elders need to rely on others for assistance (shown in bold) and begin to contract services for household help.
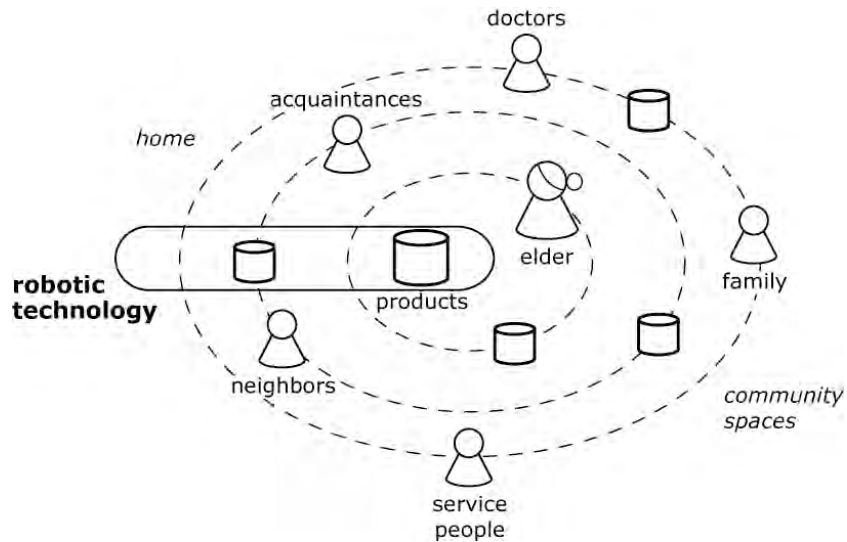
Figure 10c. An elder ecology sustained by future robotic products. Robotic products support multifaceted product interactions and activities. The elder has the same sphere of influence and quality of life as others in the ecology.

We propose that assistive robotic products can help to slow or reverse the inevitable change and instability of the ecology of aging, and provide balance while allowing the elder to retain independence and dignity. Figure 10c shows how future robotic products might reinstate the balance within the ecology of aging, by mediating among components that are helping elders to support what they value or undertake daily activities.

4.8 Conclusion

This chapter presented an initial study of well and declining elders and the products that they use. I found that why elders want products, how they use products, and what they value about products is often reprioritized as physical and cognitive decline begins to take place. These phenomena can be described by an ecological relationship, which I call the ecology of aging.

The ecology of aging was used as a basis for forming the product ecology. By shifting to a product centered view, I reasoned that one could understand all of the elements of context that factor in to how a person or a group of people use products. In the next chapter, I present the method for a subsequent study testing the product ecology framework.

5 Methods of Study 2

This chapter presents an overview of the qualitative, inductive ethnographic methods that were used for this study. Ethnographic methods are useful for studying phenomena that are new, emergent, or poorly understood, and for beginning to develop nascent theory [Strauss and Corbin, 1998; Edmonson and MacManus, 2007]. Traditional ethnographies yield a description of experience and the discovery of the unanticipated. Design-focused descriptions additionally focus on phenomena arising from a group of conditions or situations rather than phenomena arising from one particular situation [Nelson and Stoltermann, 2003]; have a special focus on the elicitation of ideas that not only describe current experience, but can be used to generate models and theories; and often have a specific goal of developing new products as an outcome — prototypes and artifacts that serve as descriptions of what might be.

A growing number of design researchers have begun to engage in ethnographic field research — studying people in the contexts of where they work and live — to advance theory in design [For example, see Bell, 1999; Battarbee, 2004; Mateas et. al, 1996]. Theory in many fields can be placed along a continuum from nascent to mature. Mature theory presents well-developed frameworks and constructs that have been studied over time with increasing precision by a variety of researchers, resulting in a body of work in a field that is largely in agreement and represents the cumulative knowledge of the field. Intermediate theory, on the continuum between nascent and mature, presents provisional explanations of phenomena, often introducing a new construct and proposing relationships between it and established constructs. Nascent theory, on the other hand, proposes tentative questions to questions of how and why [Edmondson and MacManus, 2005]. Most theories in design are nascent, posing tentative answers from questions arising from phenomena observed in the world. Often, nascent design theories suggest a stance or lens with which to understand the groups of factors that produce the observed phenomena.

Both Study 1, described in Chapter 4 and Study 2, described in Chapter 5 and 6, can be characterized as research that contributes to nascent theory. In both cases, open-ended inquiry was conducted to understand phenomena arising from groups of factors. Initially, open-ended qualitative data was collected and interpreted to derive initial meaning. To analyze the data, few formal measures were used; instead, patterns in behavior and new constructs were sought through thematic content analysis coding. The outcome of Study 1 — the complex interrelationship of factors related to aging — provided a place to discover issues for further investigation. The outcome of

Product Ecologies:
Understanding the Context of Use Surrounding Products

Study 2 is a suggestive theory, which will hopefully invite further research in the area.

While more structured than Study 1, Study 2 also takes the form of research supporting the development of nascent theory, addressing questions and formalizing concepts that arose from the earlier ethnographic study. Groups of three to four family members containing both elders and non-elders were selected for the study. After understanding each family's experience, a new product was introduced into each family. Different relationships to products could be ascertained by studying each individual's relationship to particular products. Obtaining the perspectives of different family members was critical to understanding how different motivations, interests, activities and roles affected interactions around the new product, and the functional, emotional, aesthetic and symbolic relationships that resulted. The product ecology serves as a sensitizing concept and a point of comparison for the interrelationships between these factors around the introduction of a new product.

5.1 Goals of the research

The overall goal of Study 2 was to strengthen the conceptual and empirical foundations of the product ecology, using a semi-structured approach. By integrating a new product into the home as a bounding environment, I would be able to understand how the product, (and particular functional, aesthetic, symbolic, and social aspects of it; the people who use it, and their attitudes, disposition, roles, and relationships; the physical structure, norms and routines of the place the product is used; and the interactions between the different people who use the product, the people who make or modify the product, and other products used would affect the existing product ecology.

I conducted semi-structured qualitative interviews and home tours with six groups of family members. Three of these groups had elders at the center of the product ecology and three featured non-elders (Table 4). Overall, the range in age of all subjects was 10-90, with the age of the female head of the household ranging in age from 40-81. In general, female heads of the household were in charge of housekeeping, except in the case of older retirees experiencing decline, when duties were renegotiated and shared. Each family lived in a private residence that they had owned between five and 50 years.

	Elders in family	Non-elders in family
Roomba Discovery vacuum	N = 2 (8)	N = 1 (3)
Hoover Flair Upright bagless vacuum	N = 1 (2)	N = 2 (8)

Table 4. Structure for the ethnographic interviews. N is number of families in each condition; total individuals is in parentheses.

5.2 Research site, data sources, and sample

The ethnography was conducted in central and western Pennsylvania, with four interviews taking place Pittsburgh, PA and two in Harrisburg, PA. Pittsburgh is a city of about 350,000 people on the western border of Pennsylvania [PA Census, 2000]. By national standards, Pittsburgh can be considered an aging community. A boom in steel production many decades ago led to growth in the number of residents; many of those people remain in the city and surrounding suburbs as senior citizens. The percentage of citizens aged 65 and over is about 17%; in the last decade, the segment of the population aged 85 and older grew by 9%, while all other segments except for those aged 45-55 decreased in size. Per capita income for Allegheny county is below the national average. In Harrisburg, the percentage of citizens aged 65 and over is about 10.8% [US Census, 2000]. Per capita income for Dauphin County is also below the national average.

Participants were recruited by using word of mouth, locally posted flyers, and newspapers. Participants were pre-screened to understand their affinity to technology and to ensure that they were not currently using one of the vacuums in the study. In one instance, participants recommended neighbors; the neighborhood community, in addition to the home, was understood as an additional perspective into housekeeping and caregiving.

5.3 Procedure

There were four parts to the research activity. In Part I, conversational interviews were conducted with each of the members in the ecology. A set of guiding questions can be found in Appendix 1. The goal was to get to know the participants, whether and how the activities of daily living are managed, what cleaning events take place, and what people, products, processes, and breakdowns occur within. For example, each family member was asked, "What are three things you do to keep the household running smoothly?" For each, they were asked to report on the frequency of the event, how long it took, what products and services they used, and the emotional responses to undertaking such a task. They were also asked how things changed in the last five or ten years, and how they envisioned things would change in the next five or ten years. This elicited ideas ranging from the change of seasons to holiday preparations, and from children getting older to cleaning staff getting fired.

In Part II, the person who did the majority of cleaning in the household filled out 12 images of a visual story diary (photographs augmented by written descriptions in a logbook). An example entry is shown in Figure 11, and sample questions can be found in Appendix 2. They were asked to document events that make the floor dirty (for example, meals, parties, animals, and accidents), along with floor cleaning events (planned and opportunistic, in response to events).

Product Ecologies:
Understanding the Context of Use Surrounding Products

They were also asked to document the products and services used to clean floors, ranging from rags to brooms and mops, to vacuums and dustbusters, to cleaning services. For each entry, they also noted their mood at the time the photo was taken, and how long they had been in that mood.

The family was then given either a Roomba vacuum or a Hoover Flair upright bagless vacuum. These products offer essentially the same cleaning functionality (medium suction power and the ability to navigate under pieces of furniture), except that the Roomba is autonomous and the Flair is not. Participants received no assistance in setting up and using the new products.
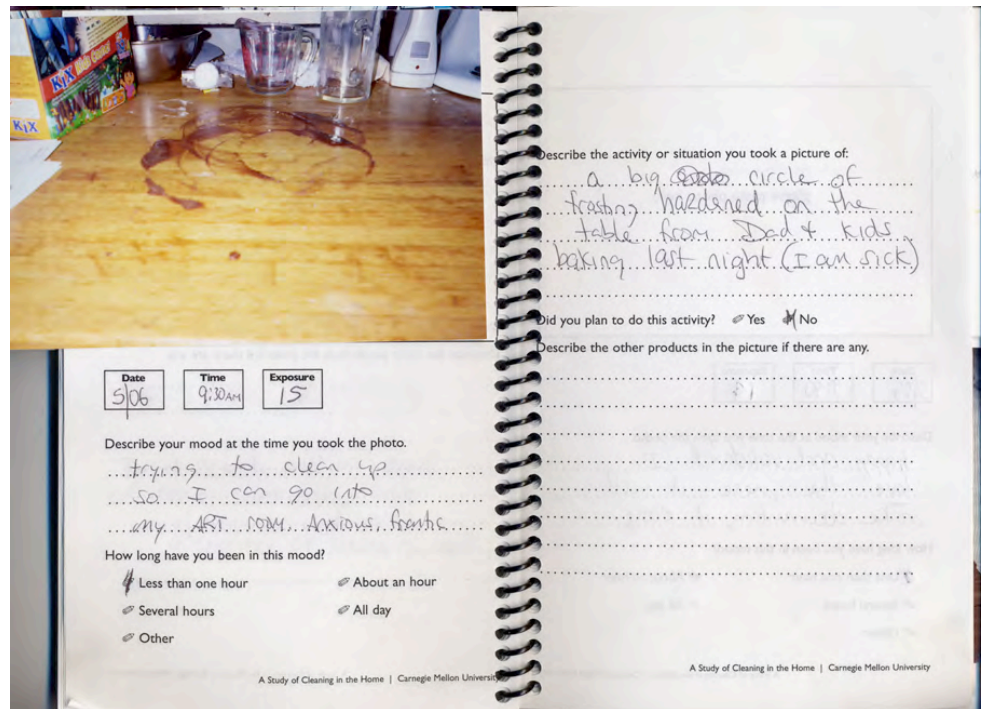

Figure 11. An entry from a visual story diary.

In Part III, the central person in the ecology filled out 12 images of a visual story diary. They were asked to document and describe whether and how the vacuum they were given assisted with or changed particular cleaning tasks, and whether it fit into the group of cleaning products they already own, both functionally and symbolically.

In Part IV, follow-up interviews were conducted with members of the ecology. The goal was to understand whether the new product had an influence on the ecology, from the perspective of each member. This was assessed through interviews and follow-up questions about the diary entries, and capturing perceptions based on their ideas about

vacuum cleaners. For example, they were asked whether or not they used the new vacuum they had been given, to describe the last time they used it (if they did), to list three likes and three dislikes about the product, and whether they felt the new product was effective, easy to use, and able to change the way they cleaned. Participants were asked to report whether they felt their new vacuum cleaned better, worse, or the same as well known brands of vacuums, a dust mop, or broom. Followup interviews were conducted at three, six, nine, and 12 months after receiving the vacuum.

Part I was videotaped; still photos were taken to augment the video recordings. Parts II and III were documented through still images and written entries in the diaries. Part IV was audiotaped. In all, between 20 and 24 hours of conversation were recorded in a total of six different settings, and over 150 images were recorded and annotated in six different settings.

5.4 Analysis

The interviews were transcribed, and the interviews, field notes, and visual story diaries were coded and analyzed, using methods modeled after Strauss and Corbin (1998). These methods involve identifying key themes in the data, for example, instances of people talking about planned vs. opportunistic cleaning. The NVIVO software program was used to code the entire set of field notes and transcriptions.

The visual story diaries were coded for the main categories in each entry: date and time of day, current mood and length of time in current mood, current activity, products pictured, and products in use. In addition, the products that were mentioned were coded for the presence or absence of five dimensions: function, aesthetics, symbolism, emotion, and social interaction. Comments from the interviews and entries in the cleaning diaries were also examined to focus specifically on these product dimensions. This work is based on product research in organizational literature, where research from product design, marketing, and organizational psychology were drawn on to articulate functional, aesthetic, and emotional product factors [Rafaeli and Vilnai-Yavetz, 2004]. I added the factors of symbolic and social behavior based on issues found in my early research. Symbolic behavior was coded through mentions of "who would use the product" and "who the product was designed for." Social behavior was coded through more than one description of the same experience, mention of sharing and moving a particular product, and mention of using a product together. Excerpts describing cleaning products, vacuums, and the Flair and Roomba vacuums were excerpted and coded by two separate coders to ensure reliability. Coder reliability was high (Kappa = .92); disagreements were settled by a third coder.

Product Ecologies:
Understanding the Context of Use Surrounding Products

To assess the validity of ethnographic data, one looks for how specific phenomena contribute to the factors under study. Strauss and Corbin suggest that a qualitative study should fit the substantive area without forcing; be comprehensible to readers and the people who were subjects, and be applicable to a variety of contexts related to the phenomena [Strauss and Corbin, 1998]. These criteria guided the development of concepts from coded constructs.

6 Study 2: How Technology Inspires New Cleaning Activities

The routine work of a functioning household includes an assortment of cleaning and household maintenance tasks, performed on a regular, if not scheduled, basis: laundry, dusting, vacuuming, picking up, cleaning up spills and messes, washing dishes and keeping kitchens and bathrooms sanitary. Historically, as shown in Chapter 4, women have traditionally performed this work. A few household skills — most notably yard work and maintaining the exterior of the home — traditionally have been performed by men.

My research findings were consistent with these traditional patterns. In the families defined by two people in a heterosexual partnership, most often with children, the roles of housekeeping and caregiving were well formed. In all cases, the woman in the partnership did nearly all of the housekeeping and caregiving tasks, and was the solitary user of the one or two vacuum cleaners. Infrequently, her husband or children provided minor assistance with some cleaning tasks.

Most young women in the study balanced a career outside the home and the needs of their families. This arrangement caused great stress in finding time to manage routine household tasks. For example, Mrs. Smith became angry when her husband remarked that his wife cleaned differently than his mother had cleaned. She was quick to point out that her career as a music teacher meant that she had far less time to clean than Mr. Smith's mother, who was a homemaker. Younger women juggling careers and families cleaned opportunistically, when things "looked dirty" or when free time became available during the week. On the other hand, elder women were comfortable, even proud, of their roles as homemaker and caregiver. They upheld a strict schedule of planned cleaning activities each week, and conducted planned housecleaning activities several times a year.

Cohort as well as age differences should be considered influential in the product ecology of cleaning. Because this study was conducted during one period of time (2005-6), it is not possible to distinguish age differences versus the fact that the older women in the study had been raised in a markedly different political and social climate for women than were the younger women. Perhaps when the young women in this study grow old, they will continue to clean opportunistically, or perhaps they will become more formal about their cleaning routines as they age.

Two families in the study were undergoing change. One couple had just fired their cleaning woman. Their cleaning tasks were under negotiation — who would do what, how often, and whether or not

Product Ecologies:
Understanding the Context of Use Surrounding Products

Household (E=elders)	Product	People	Pets	Architecture of home	Number/ brand of vacuums	Affinity for tech	Cleaning service
003 Drake family	Flair	Donna, F, 40; David M, 40; Sam, M, 13; Janet, F, 12; Ed, M, 9	Draka, a parakeet	First home of 6 years; two story with large combined living room and dining room, no renovation, <2500 sqft	Hoover upright, stored on 2nd floor	Low to average	No
004 Powell family	Flair	Pat Smith, F, 52; Wanda Powell, F, 61; Chris Powell, M, 13 year old birth son of PS (adopted by WP)	Nikki, a dog	Second home of 6 years; three story with rental apartment on top floor; extensive renovation, >2500 sqft	Rainbow upright, stored in basement; Hoover upright, stored on second floor	Average to high	Yes
005 Harris family (E)	Flair	Rita Sana, F, 75; Ed Harris, M, 78		Rita's home of 50 years; two stories, showing signs of wear, no modification; <2500 sqft	Eureka upright, stored on second floor; Hoover handheld, stored in upstairs hall closet	Low to average	No
001 Smith family	Roomba	Janet, F; 46; Ken, M, 50; Eva, F, 13	Sinka, a cat	First home of 6 years, three stories, extensive renovation, >2500 sqft	Sears canister, left out in second floor hallway	High	No
002 Long family (E)	Roomba	Carla, F, 81; Don, M, 82; Pat, M, 43; Nate, M, 11	Kiski, a dog, Spot, a dog	Second home of 44 years, no modification, <2500 sqft	Shark push vacuum in family room (basement); Shark upright on first floor, Shark upright on second floor	Average	No
006 Jones family (E)	Roomba	Jane, F, 57; Meg, F, 53; Margaret, F, 90; Alex, M, 14	Ruby, a dog; Magic, a cat	Jane's home of 13 years, left to her after divorce, some renovation and modification, >2500 sqft	Eureka portable (wearable) stored in first floor hall closet	Average	No, but a visiting nurse

Table 5. Overview of families who participated in the study.

All of the families in the study alluded to how the normal course of life events changed the nature of housekeeping and caregiving roles. Children get older and need less assistance, adults get older and retire, increasing the amount of unscheduled time and creating the

ability to be more flexible about when cleaning gets done. As adults age and begin to decline, the amount that they can do decreases, and they need to rely on others for assistance. Most of the families discussed how change was constant, and inevitable. Even the change of a season, such as the arrival of summer or the Christmas holidays, could significantly impact cleaning routines.

In the next section, I will describe each family as I encountered them in my early interviews. The impact of the vacuum on each family and the product ecology of existing vacuums in the home will also be discussed. An overview of each family is provided in Table 5.

6.1 Product ecologies of families receiving Flair vacuums
6.1.1 The Drake family (non-elders)

Mr. and Mrs. Drake were two 40-year olds with three children, Sam, age 13, Janet, age 12, and Ed, age 9. Mr. Drake worked at a non-profit agency, and Mrs. Drake was an artist working in glass and mosaic. All of the children were in school; one suffered from asthma. They had a parakeet that was a prized member of the family. The family seemed to be a solidly lower middle class Caucasian family. Both husband and wife were born and raised in Pittsburgh, and possessed a strong work ethic. Many of their possessions were well used, and had come from thrift stores or donations from other members of their family.

Environment. The couple purchased their two-story home six years ago. This was the first home that they were able to afford. It was a ramshackle house on a well-maintained street. The house was old and in need of renovation, and was comfortably cluttered with shoes, books, papers, and toys. The floors were hardwood with area rugs, with some wall-to-wall carpeting on the second floor.

The family most commonly entered the house through the back door, which opened into the kitchen. The most commonly used public space was the large dining room, which had oversize couches and the TV/video system. They spent four to five hours together there every day, eating, playing, and watching TV. The bird was also there, in front of the window. The living room was used for guests and visitors. Children also played in a playroom in the basement.

The Drake family had an average affinity for technology. (Affinity was defined by how current a home computer system was, if one was present, and number of mentions of technology use during interviews). A computer running Windows was in the living room, and was shared by the family. The Internet was accessed using dial-up services.

Cleaning activities. Mrs. Drake did all of the cleaning in the house, and in her journal, expressed strong emotions about managing it all in a

timely fashion. Her idiosyncrasies included cleaning in isolation so her family would not see her, setting a timer for 10 minutes and cleaning as much as she could, and becoming argumentative when she had to clean before company came over. She expressed tension between her role as a "caregiver who is available 24/7" and as an artist. She also acknowledged that her role would change as her children got older and become more independent, allowing her more free time to work at her career.

She once attempted to get her children involved in cleaning tasks by designing a "summer boot camp," which failed. She was also concerned that she did not have good cleaning skills, and had culled tips and timetables for cleaning from neighbors and other sources and kept them in a recipe card file in the kitchen. This anxiety stemmed from a childhood experience — when she grew up, her mother was known in their neighborhood for not being able to clean well, and their house was known as "the musty house." My feeling was that she did know how to clean, and spent a good deal of time doing it, as well as managing the household to keep it nice for her family. For example, she neatened up the main family dining and social area every day before her husband got home. She budgeted time to work on her artwork late at night or in the early afternoon just before her family got home, rather than take time away from her family.

Most of Mrs. Drake's cleaning activities appeared to be opportunistic cleaning (i.e., setting the timer for 10 or 20 minutes and doing as much as she could in a room). Additionally, if people were coming over or houseguests would be staying, cleaning was done. Cleaning was more organizing and spot cleaning than thorough cleaning. Lists were made of each room, although humorously Mrs. Drake admitted that this was "a failure." Because her son had asthma, his room was cleaned thoroughly once a week. Some areas never got cleaned — her studio and her husband's "refrigerator room." Floors were cleaned by walking on soapy rags, but this was not done very frequently. The kitchen floor was spot cleaned using Windex. Garbage was stored in the freezer until garbage day so it did not stink up the house. Clorox cleanup was sprayed in the bathroom everyday. I estimated that she spent about three hours a week cleaning and five hours a week straightening the house.

Cleaning products. Mrs. Drake owned an old Hoover upright vacuum that was stored on the second floor. The dustpan and brush seemed to be used more frequently than the vacuum. Cleaning supplies including Windex, orange almond oil, bleach, and Murphy's oil soap were stored with hard liquor in a high cabinet in the kitchen. Cloth rags were used, and seemed to be very important. Bleach and vinegar were also used. She had a concern about toxins and poisons because of the bird and her asthmatic son.

6.1.2 After the new vacuum

The Drake family received a Flair vacuum, which did not significantly impact the product ecology. The vacuum was the sole possession of Mrs. Drake. She appreciated the swivel head and portability of the vacuum, although the product did not motivate her to clean more. She once referred to the Flair as "her darling" (Figure 12), but she did not give it a name. The product does not appear to have served any social function in the family other than the possessive "my darling" reference.

Figure 12. An image created by Mrs. Drake to which she added the caption, "My new darling in a faceoff with its enemies."

Mrs. Drake appreciated the Flair for its functional benefit. She liked the portability of the vacuum and the swivel head, using it to opportunistically clean the house. She liked it for cleanups under the birdcage. She did not like the fact that the vacuum did not stand up.

Mrs. Drake felt the vacuum would not be appropriate for her "unless she changed to become a better person." If she were a better person, she would clean more often and would need to use a vacuum like this. (I interpreted this to mean that she felt the Flair vacuum was useful for opportunistic cleaning.) She felt it was designed for someone like her mom, who lived in a condo and can "just zip through." She did mention that the size and weight of the vacuum would be suitable for someone who had mobility problems.

6.1.3 The Smith and Powell family (non-elders)

Mrs. Powell and Mrs. Smith were a 52-year and 61-year old lesbian couple who had been in a relationship for over 20 years. Mrs. Powell, a native of upstate New York, had one birth son, Chris, aged 13, who Mrs. Smith, of Italian descent and a native of Pittsburgh, had also adopted. Mrs. Powell was a retired nurse, and Mrs. Smith worked at a local university and planned to retire in the fall. They had a dog. Chris was a 7th grader at a local junior high. Although solidly middle class, the family had extended itself financially by purchasing a home on a nicer street in a better school district. With Mrs. Smith's impending retirement, the philosophy of cutting back and living more simply

Product Ecologies:
Understanding the Context of Use Surrounding Products

figured greatly in their approach to obtaining and using items in the home.

Environment. The family had lived in their three-story home for six years. They knew of the home a long time before it went up for sale. They thought the location was ideal, because the area was safe and the schools were good. They bought the house "as is" without a home inspection — the foundation was cracked and the house needed extensive repair. However, they had a great deal of pride in their home.

Since moving in they had renovated and repaired the kitchen and the entire first floor, and the second floor was underway. Much of the house had been in turmoil, and rooms were appropriated for storage and living areas while other rooms were under construction. This year they hoped to renovate the third floor into a small apartment that they could rent out.

The house was fairly cluttered with paperwork, toys, and projects underway. The floors were hardwood, with some area rugs, and were nearly half covered with piles of toys, household objects, and material for art projects. The kitchen and breakfast nook were used frequently, as the area had just been remodeled. They were very happy with the result; Mrs. Powell had managed the project. The den, next to the kitchen, was also the place where they convened to watch TV and snack together. Each of the family members had an office or space for personal work and use: one had a craft room on the third floor, one had appropriated a guest room for her clothing and craftwork, and their son had a loft in his bedroom.

The family had an average affinity for technology. An old PC was on the third floor, but had been replaced with a newer PC running Windows that was placed in the foyer for Mrs. Powell to use. Mrs. Smith also had a computer in her office that she used to work from home one day a week. The family accessed the Internet using a cable modem.

Cleaning activities. The cleaning activities were in negotiation in this household, due to the fact that they had recently fired their cleaning woman. Unlike other families, Mrs. Smith and Mrs. Powell discussed and negotiated most of the household management, and frequently mentioned working on "plans and approaches" to solving problems and getting things done. While Mrs. Powell was responsible for managing household renovations, Mrs. Smith did the laundry and most of the cooking. They had recently terminated their cleaning woman because they felt it was costly and that they were not getting their money's worth. They felt in the past few weeks that she had made serious

mistakes, such as using too much water on the hard wood floors and leaving greasy furniture polish on the furniture.

Mrs. Powell planned to take over the cleaning, scheduling planned cleanings modeled after the activities done by the cleaning woman and culled from guidelines in women's magazines. Mrs. Smith felt that "other activities would become more important" than cleaning for Mrs. Powell, and that her planned cleaning schedule would fall by the wayside. During the final interview, it was revealed to be the case. Mrs. Smith was planning to retire in September, and was going to take over the housecleaning. No tasks were delegated to their son. They were clearly moving to a new phase with regard to cleaning the house. New routines would have to be developed, and their differing ideas of "the standard" created a point of tension in the relationship. Both remarked, "I don't want to get a divorce over this."

To augment the cleaning woman, Mrs. Smith had been doing opportunistic cleaning. She did touchups in the bathroom every day using Bon Ami and Clorox Clean Up. She sprayed an environmental product on the shower walls after each shower. The couple kept the new kitchen spotless with environmental products. They used water to keep the new white cabinets clean. They also straightened up before the cleaning woman came so she would be able to dust more surfaces.

Mrs. Smith admitted that they were not good cleaners:

"We are not great cleaners. I kind of clean in spurts when I have the energy, but I see dirt and dust and finger prints all the time. I think it's my… genetically I just see what needs to be cleaned. So I keep running lists for myself, of projects and things that need to be done in the house. So just to keep me kind of sane."

However, she was obsessed with eliminating dust and dirt from the house. This was instilled in her by her Italian mother:

"I have this memory from childhood of coming into the home from school every Friday to my mother's very clean house. So when Roberta [the cleaning woman] was here like on Thursdays and I would come in after work, just the smell of the house, and just knowing that it was clean, brought back that same feeling. So probably you know I breathed in this experience once every two weeks. I feel like ah, it's clean."

Cleaning products. Few cleaning products were in evidence in the home. The cleaning woman would bring her own. They had a Rainbow upright vacuum (a high end vacuum employing a water bath to clean carpets) with two handle attachments that was stored in the basement. They admitted it was a steep investment, and complicated

to set up, but bought and used it because of the never-ending dog hair. The cleaning woman also liked and used this vacuum. They also had a Hoover upright that they carried up and down the stairs for opportunistic vacuuming tasks, along with a large and a small Shop Vac.

Environmentally-friendly products were used in the kitchen and on the shower walls. They were trying a new Clorox cleaner with Teflon, because a colleague at work told Mrs. Powell that it was good. Other cleaning supplies included Bon Ami, Barkeeper's Friend, and 409 Cleanser. Cloth rags were used rather than commercial wipes. There was no evidence of mops or Swiffers.

6.1.4 After the new vacuum

Mrs. Smith and Mrs. Powell received a Flair vacuum, which had a short term impact on the family. Mrs. Smith became more enthusiastic about cleaning for a period of time, and Mrs. Powell also did more opportunistic cleaning. Because cleaning activities in the home were in flux, more changes were bound to take place. At the 12-month interview, no cleaning was getting done in the house whatsoever. There were no attributions made to the Flair, nor any social uses of the product.

The Flair was appreciated for its functional benefit. Mrs. Powell loved the vacuum and actually stored it in the front hallway where she accessed it for opportunistic cleaning (Figure 13). Mrs. Smith liked the fact that the flexible head could go under things. She felt that the suction was much weaker than a normal vacuum. They used it to augment their Rainbow vacuum, which was stored in the basement, not as readily accessible, and harder to set up.

They felt the Flair vacuum was designed for them because they don't clean and it helps with dog hair and dust balls. "Cleaning 101, helps us get organized." They would buy the vacuum as a smaller product to augment the Rainbow vacuum they already owned: "It is designed for the busy homemaker, who cleans up quickly when company is coming, and designed for the working person."

Figure 13. The Flair vacuum was stored in the first floor hallway where it was readily accessible for opportunistic cleaning.

6.1.5 Mrs. Sana and Mr. Harris (elders)

Mrs. Sana and Mr. Harris were age 75 and 78, and were married. This was a second marriage of 15 years. Mrs. Sana was retired as a secretary from a nearby university. Mr. Harris was a retired clerk from a local department store, and was active in volunteer work. Both people were born and raised in Pittsburgh, and were active members of the local Jewish community. Each had children and grandchildren, making up a large extended family, but none of them lived in Pittsburgh. They were a lower middle class couple, making do on their pensions, and describing themselves as "frugal."

Environment. The two-story house they lived in was the house that Mrs. Sana had lived in for 50 years. It was the house that she had lived in with her first husband, raised her children in, and lived as a widow for 10 years. She appeared to be still dealing with Mr. Harris's possessions, describing the change:

"And in those 10 years I had a separate job, so while working I had certain cleaning tasks which I did on a routine orderly basis. Once I got married and I had retired, things were a little more disorderly. First, my husband came with a lot of baggage, a lot of things from his house that he didn't want to give up. So space here was very limited, so things were not as orderly as they should be. And of course, although I shouldn't complain about him, but I am picking up after him a lot."

The house was showing signs of wear. Nothing had been renovated recently, although there were some signs of replastering on the second floor. There was well-worn wall-to-wall carpeting throughout — even on the porch. They most frequently sat in the kitchen, in the dining room, and on the porch when the weather was warm. Each had a room upstairs that they spent time in — his was a TV room, and hers was an office. They used the living room rarely, except when guests

came over. Little sense of pride in owning the house was evident. When prompted at the end of the interview, Mrs. Sana said the only reason she was still living there is that she "can't get rid of all the stuff."

The house was generally clean, but some of the rooms looked dirty from signs of wear. Kitchen counters and table surfaces were cluttered. The house smelled of cigar smoke, even though Mr. Harris was banished to the basement to smoke cigars.

The family had an average affinity for technology. Mrs. Sana had a desktop PC in the room that served as her office, and used it to keep in touch with her children and grandchildren using email.

Cleaning activities. Mrs. Sana did nearly all of the cleaning in the house. She was beginning to experience some decline, so her husband had begun to help with some tasks such as emptying the dishwasher and carrying laundry up and down the stairs for her. However, her role of caregiver was clearly defined, and he was reluctant to admit to helping her, as witnessed in a conversation about the dishwasher during their interview:

Mrs. Sana: "If I have to reach for something, or [other times] he will help. I would say, 'Ed, come here.' My cabinets are high. Or he will bring something from the basement if I need it. After I do the laundry, he carries the clothes on the hangers or the laundry basket upstairs so that I can put it away. He also empties the dishwasher for me. But I don't think he knows how to run it."

Mr. Harris: "Oh, of course I know how to run the dishwasher. What are you talking about? But why would I do it? That's your work."

When Mrs. Sana was working, she was much more regimented about planned cleaning, but since retiring, felt less stress about "fitting it all in." It "gets done eventually." She described clutter removal as being "constant." Papers and extra items were moved every day. Laundry was done every Monday. Once a week items were dusted and the floor was vacuumed. The kitchen was cleaned once a week. The floor was mopped with a rag mop (before she had trouble bending, she scrubbed it on her hands and knees once a week). The bathroom was spot cleaned daily with Clorox Cleanup, and cleaned, including washing the walls, once a week. Housecleaning was done once a year, when the windows were washed and curtains and sheers were taken down and washed.

Cleaning products. Most of the cleaning products I saw were old, nearly empty bottles. Many old containers of Windex, Dust Magic, Renew, and bargain cleansers stored under the kitchen sink. Rags

were the tool of choice and were stored inside the cupboard door under the kitchen sink. A second stash of cleaning products was in the upstairs hall closet. These included Windex, Comet, and bargain bSana bleach cleanser. The cleanser was kept on the floor by the toilet in the bathroom for everyday cleanup. Mrs. Sana mentioned that today's cleaning products seem more diverse and make cleaning more efficient.

Two vacuum cleaners were in the house. One was a Eureka upright. It was kept in Mrs. Sana's office under a dust cover that looked like a maid. She ordered it from a catalog because there was no closet space to store the vacuum. The Eureka replaced a heavier Hoover that "died." There was also a small Hoover hand-held vacuum that was kept in the upstairs hall closet. This was a gift, and was found to be very good for vacuuming the steps. She would never have purchased this vacuum for herself, but it turned out to be one of her favorite cleaning tools (Figure 14).

Figure 14. One of Mrs. Sana's favorite cleaning tools, a Hoover hand-held vacuum used for vacuuming the steps.

6.1.6 After the new vacuum

Mrs. Sana and Mr. Harris received a Flair vacuum. Mrs. Sana was the only one to use the vacuum. Since she did not like the vacuum, it is doubtful that it made her clean more. It did not change Mr. Harris's behavior or cleaning patterns, so it is doubtful that this product impacted the existing product ecology. There were no attributions made to the product and no social uses of the product.

Mrs. Sana expressed general dislike for the vacuum, and used it mostly for opportunistic cleaning and to pick up spills. However, one feature she did like was the ability to go under furniture. Although the Flair was praised for some of its functionality (portability, maneuverability, and lightweight), it was clear that the vacuum would not replace the upright and handheld vacuums in the house. Other features were seen as too poorly designed to make the vacuum usable, most notably the small cup that she described as being hard to empty, and the weak suction which she found to be insufficient on her rugs.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Mrs. Sana felt the vacuum was designed for "Young people who have apartments with little space or where places don't get too messed up." For those with lesser cleaning demands, she felt it could be "a fair substitute for a regular vacuum."

6.2 Product ecologies of families receiving Roomba vacuums
6.2.1 The Smith family (non-elders)

Mr. and Mrs. Smith were a 50 and 46-year old couple with a 13-year old daughter and a cat. Mr. Smith worked in a family plumbing business, and Mrs. Smith was a part-time music teacher, conducting lessons both in the home and outside the home. Their daughter, Eva, was a typically active 7th grader. Both Mr. and Mrs. Smith had been born and raised among German families in Central Pennsylvania. They appeared to be enjoying a substantially better quality of life than their parents before them — their home was opulent and all three of them had the latest technology products.

Environment. They had purchased their historic three-story Colonial home together in 1988, and took a lot of pride in the work they had done. They had renovated extensively, scavenging for period woodwork and filling the house with antiques. The house had hardwood floors, with fringed area rugs and floor-length curtains. The home was an important symbol of their values. They felt the neighborhood recognized them as the people who lived in the historic house. They enjoyed having guests drop by frequently to assess the renovation or to enjoy the large-screen TV on the third floor. The house was very clean, with some evidence of dust in the less-frequently used rooms and the bedrooms.

The most commonly used public space was near the large screen TV on the third floor. The family convened there daily to watch TV and movies, and guests were entertained there. Another commonly used public space was the dining room, where the piano was located. Students came here to take their piano lessons. The family ate in the kitchen at a small table. The breakfast room was used for paperwork and spillover at dinner if Eva's friends were over.

The family had a high affinity for technology, owning several cell phones, computers, and servers dedicated to music and digital videos. They also identified with others thinking of them as the "tech-savvy" family, and believed that owning a Roomba fit in with this image.

Cleaning activities. Mrs. Smith did nearly all of the cleaning in the house, save for cleaning of hairballs and spills occasionally by her husband and daughter. Mrs. Smith worked part time outside of the home and bristled at the mention of planned cleaning. She did spend a good deal of time during one day cleaning, but this time was found on an as-needed basis. Some tension existed between she and Mr. Smith

— his parents had done weekly scheduled cleaning, and he thought that way was better:

Q: "How do you feel about planned cleaning versus just doing it as needed? Do you have any ideas about that?"

Mr. Smith: "What my mom did, that's the way of doing it, when I was growing up, we had a spring cleaning and a fall cleaning and just followed a routine."

Mrs. Smith: "And it takes a lot of time. See, she doesn't work outside the home. So she has that much more time. But for me to do that, I don't know how I could do that."

Cleaning products. To do the cleaning, a canister vacuum was moved from room to room, and kept in the hallway on the second floor. This was a point of contention between Mrs. Smith and her husband: she asked him to build a storage space for the vacuum, and he had not done so. Because the vacuum was on the second floor, spills on the first floor were usually cleaned up with a floor Swiffer or a dustpan and brush. Several Swiffers were used, including a dust mop and flat head mop; these were praised for containing both a cleaning product and a tool in one. Two cleaning tools, inherited from her grandmother, were Mrs. Smith's favorites: a square-headed stair sweeper and a tool that looked a bit like a rake and was used to order fringes on the edges of floor rugs (Figure 15). These were used for spot cleaning in lieu of the vacuum.

6.2.2 After the new vacuum

The Smith family received a Roomba vacuum. Mr. Smith opened the Roomba and set it up. Mrs. Smith cleaned more using the Roomba, if only due to the fact that she could do something else while the Roomba was running. However, she seemed to feel that it was not worth having the vacuum, citing too much clutter and too many area rugs in their home. Although she said she would stop using the Roomba at the end of the study, she in fact continued to use it, and would call or email me to tell me about the new uses she had created. Ultimately, one year later, the Roomba became the possession of Eva. It was stored in her room and used solely by Eva for regular cleanings of her room.

Figure 15. Antique fringe rake given to Mrs. Smith by her grandmother. She said, "This is a very quick fix for these rugs — if I don't take time to vacuum, straightening the fringes helps the appearance in a big way. The fringe near the piano bench gets tangled because it is a high traffic area."

The family appreciated the Roomba for its functional and symbolic merit. It was praised for its autonomy, but "the problem was our house" (area rugs with fringes and long curtains that they believed were too much for the Roomba to deal with). Functionally, Mrs. Smith used the Roomba most in her daughter's room, since it had wall-to-wall carpet. She also devised creative ways to use the Roomba to increase the kind of cleaning she did (for example, vacuuming twice or cleaning under beds). However, she did not set up the barriers or use the remote control. For example, she used the Roomba to sweep under the beds, and to automatically clean a room after she had "pre-cleaned" (preparing surfaces and cleaning edges enough to employ the Roomba in what she felt was a useful way).

Symbolically, the product was a novelty in the household. The Smith family felt that they were known for having the latest gadgets, so it seemed fitting that they would be one of the first in the neighborhood to own a Roomba. Eva and her friend played with it, and her friend took it home to her parents to try for a few days. The Smith family made social attributions to the Roomba, naming it Manuel (male gender). They watched it and talked to it as it worked.

Mrs. Smith did not think the Roomba was designed for the owners of a historic home. Rather, she felt it was designed for people who lived in a modern household with wide open spaces: "Someone with a nice new modern house with a lot of wall to wall carpeting and someone who doesn't have a lot of furniture, a streamlined place with open expanses of carpet."

Product Ecologies:
Understanding the Context of Use Surrounding Products

When asked about having a robot in the home, she said, "it's a sign of things to come… the design obviously isn't perfect, but it's a sign of the future." Perhaps due to their affinity for technology, they had some understanding of how the Roomba worked, and had suggestions about how to improve the Roomba's path planning to maximize its efficiency in covering a space.

6.2.3 The Long family (elders)

Mr. and Mrs. Long were an 82 and 81-year old couple with a 43-year old son, Pat, and a 10-year old grandson, Nate, who lived nearby and also participated in the study. Nate suffered from mild Touret's syndrome. Both Mr. and Mrs. Long and their son each owned a dog. Mr. and Mrs. Long were both born and raised in small coal mining towns in Central Pennsylvania. Mr. Long was retired from the Muzak business, and Pat worked as a technical support person for a large Internet provider. Nate had a healthy and active life as a fifth grader. Mrs. Long was a housewife, and had never worked outside the home. Mr. and Mrs. Long were generally in good health, although Mr. Long suffered from arthritis and used a cane. They were a middle class family, making do on Mr. Long's retirement.

Environment. Mr. and Mrs. Long had lived in their home for 44 years. This was the house where they raised their children, and one grandchild that they treated as their own child. The house was a split-level ranch home with wall-to-wall carpeting. There were no visible modifications to account for issues related to aging. Some small renovation projects were taking place: new tile in the foyer and new paint in the living room. These were done by Mr. Long with help from his son. Three vacuums were stored in three places in the house, making access to a vacuum easy from anywhere.

The family room, on the ground floor, was the public area where the family and extended family most commonly spent time together. The family had installed a wood stove just off of this room almost 30 years ago, and still used it on cold days. The front door, the main entry of the house, opened into this room, so people and items tended to convene there. Five stairs led to the kitchen and dining room, another area where the family convened for meals. The living room was only used on holidays.

The house was spotless, and the rooms were neat and free of clutter. There was some dirt and mildew showing from the wear and tear of a large family on a middle-aged house.

Mr. and Mrs. Long had a medium to low affinity for technology. They did not have cell phones, and had purchased an older desktop computer from an estate sale a few years ago. They had one large television in their rec room, and a small one in their bedroom. Pat and

Nate used email, instant messenger, and computers in their own home much more frequently. Both Pat and Nate had cell phones.

Cleaning activities. Mrs. Long had spent all of her married life as a housewife. She was proud of that legacy, and at age 80, still took pride in providing for her husband, children and grandchildren. She did the majority of cleaning in the house on two planned cleaning days each week. Total planned cleaning time was about 5 hours a week, and unlike the younger women in the study, she had a clear idea of exactly how long it took her to clean each week. Mrs. Long also did major housecleaning two times a year:

Mrs. Long: "In the spring and fall, I do the same thing. Take the drapes down, take windows down, wash… every week I do the upstairs on Wednesdays. I have a schedule. That's me. I would say cleaning the bathroom about an hour to an hour and a half. That's Wednesdays. Then on Thursdays I usually make sure I clean down here and the living room and bedrooms. I do the kitchen floor on Thursdays, and if I don't have time on Thursdays, I do it Friday afternoon."

A few tasks — cleaning the bay windows, and cleaning ceiling fans in the bedrooms — had been delegated to her son, due to the fact that she was less mobile than she used to be. However, by and large, cleaning and keeping house was her domain.

Pat was divorced and lived alone in a home that he owned. His son stayed with him part time. He acknowledged that he cleaned less than he should — it was simply not a priority for him. He was available to help his parents on an as-needed basis, noting that they seldom asked for things and that he understood what needed to be done by making frequent social visits to the house.

Cleaning products. Mrs. Long used the Swiffer wet cloth and the Swiffer wet jet to clean her kitchen floor. Scrubbing Bubbles were used to clean the bathroom. Other surfaces were cleaned with Liquid Gold and Lysol all-purpose cleaner.

Several vacuums were used to clean the house. Three Shark and Euro Pro stick and canister vacuums were stored on the ground, first and second floors of the house. Mrs. Long had owned many bSanas of vacuums and the family had named each vacuum, starting with a Hoover named Big Bertha nearly 20 years ago. Mrs. Long expressed dislike for canister vacuums: "I don't like dragging stuff, I would rather push." Mr. Long was responsible for cleaning the wood stove and surrounding area with one of the Shark vacuums. This was viewed as a vigilant task, because the wood stove created a lot of dirt and soot.

Product Ecologies:
Understanding the Context of Use Surrounding Products

6.2.4 After the new vacuum

The Long family received a Roomba vacuum. The Roomba impacted the family greatly. The Roomba was shared between the two households and used by all three generations of the family. Probably due to his predilection for gadgets stemming from his engineering background, Mr. Long set up the Roomba and taught his wife how to use it. Mr. Long also assumed more of the vacuuming in the household. Because of its autonomy, the vacuum was recognized as being beneficial for helping people who are less mobile than they used to be. It helped Pat clean more, and Nate used it on his own accord, becoming expert with the remote control. Mr. and Mrs. Long eventually purchased another Roomba, which remained on the second floor of their house.

The Roomba vacuum was appreciated for its functional benefit. Functionally, it served Mr. and Mrs. Long, who are losing mobility. Their son liked it for the autonomy, and their gSanason liked it for the "cool" factor. Mr. Long set up the vacuum and ran it for his wife, impacting their cleaning routines by increasing cleaning time and the number of people who did the cleaning. Pat and his son read the manual, and used the remote control and barriers to set up specific cleaning areas.

Symbolically, the Roomba represented the future. Each generation had its own view of "robotic technology." Mr. Long liked the assistive nature, Pat liked the autonomy, and Nate liked learning how to control the Roomba.

The Long family made attributions to the Roomba, naming it Robbie the Robot. They had also named their other vacuums, and passed them from parents to son routinely. The Roomba was shared among three generations. They came up with ideas for improving the sound feedback together. Pat believed that the vacuum was designed for "Anyone who will believe it and who will know that it will work."

6.2.5 The Jones family (elders)

Jane Jones and Meg Jones were two sisters, aged 57 and 53, who lived with their mother, Margaret, 90, and Meg's son, Alex, age 14. This family had come together in this situation to care for their mother, who had suffered a stroke and lost the use of the right side of her body, requiring extensive care. A dog and a cat rounded out the household. Meg Jones was not working, having assumed the primary care of her mother, and Jane Jones worked as a project manager in a non-profit organization. They were two of six children.

Environment. The family had been living together in that context for 7 months. The home was owned by Jane Jones, who had originally lived

there with her husband. They divorced 5 years ago, and after her mother had a stroke, it seemed natural to move her there.

The home was in very good shape and was one of the nicer homes on a pleasant street in the city. The house was very clean. There were hardwood floors throughout with no area rugs. There was a small kitchen and a large garden in the back of the house. The third floor attic was under renovation and was the primary living space for Jane and Alex. The family shared one bathroom on the second floor. It contained a bath chair and a porta-potty for Margaret. There was another porta-potty in Margaret's room. There was little clutter on the floors, and no area rugs, affording a large area for the Roomba to operate.

The family did not convene as a group in the house, nor did they entertain very frequently. Often one family member would eat with their mother. Jane and Alex tended to stay on the third floor. Meg described how the family used to eat and watch TV together much more frequently, revealing that tensions in the family had affected communal use of public spaces in the house.

Meg Jones's schedule was entirely consumed by her mother. She stated, "My job is to be here 24/7 for care and nourishment." Meg was on task to feed, medicate, bathe, and toilet her mother. Leaving the house to run erSanas was stressful, and attempting to take her mother out of the house was nearly impossible. Because her mother was incontinent, a great deal of laundry needed to be done regularly. Meg recently hired a visiting nurse for five hours a week to give herself a break and wanted to extend it to ten.

Cleaning activities. The sisters shared the cleaning chores. Mostly this took the form of negotiating who would do what, especially their mother's laundry, and repeating cleaning tasks that the other had done. Meg remarked that Jane would frequently re-clean the house after Meg had cleaned it. Jane appeared to be very concerned about dust, allergens, and bacteria, and used biodegradable products to keep the house clean. They used a system of bleach and water and vinegar and water solutions kept in spray bottles to clean the entire house. Meg did not clean the third floor, remarking that it was her sister's domain.

Cleaning products. There were surprisingly few cleaning products. A set of bleach-water and vinegar-water solutions, kept in spray bottles, were kept in the bathroom and one in the stairwell between the basement and the kitchen. To clean the floors, they were first dust mopped and then cleaned with vinegar and water solution. There was one portable vacuum that Meg loved. It was worn over the shoulder on a strap with a long hose attachment. However, she used the vacuum

infrequently, mostly to vacuum furniture and curtains. She believed that the dust mop worked better than the vacuum, and if there were a "wireless" (cordless) vacuum she would be even happier with vacuuming.

6.2.6 After the new vacuum

The Jones family received a Roomba vacuum. It impacted the family greatly. The cleaning routines were changed, both in terms of how often they were done (they were using the Roomba more than once a week, whereas planned floor cleaning happened only once a week before the vacuum). Also, the division of labor changed: Jane cleaned more and Alex cleaned the third floor. They found the Roomba to be as good or better than their current vacuum, and therefore, essentially replaced that vacuum with the Roomba.

The family appreciated the Roomba for its functional and aesthetic benefit. They used it weekly to vacuum the whole house. Meg, Jane, and even her son Alex used the vacuum to clean. It "migrated" from floor to floor of the house. Margaret was also very interested in the vacuum, describing it as "the epitome of laziness." They liked the idea of a "high-tech object" roaming the house although Meg did not like the "clackety-clack" noise that the Roomba made.

Because they carried the robot from floor to floor and shared the cleaning tasks, the Roomba enabled social behavior. Although they did not name the vacuum, Jane said "excuse me" to the vacuum when she bumped into it. Also, the robot galvanized the family around cleaning activities — each member of the family cleaned more and appeared to argue less about what needed to be done.

Meg Jones thought that the Roomba was designed for a busy professional or someone who needs assistance; really anyone who needs help cleaning the home. She also thought that having a robot in the home simply meant less labor in the home.

6.3 Follow-up interviews at nine and twelve months later

After a year had passed, all of the families receiving Roomba vacuums were still using them, and one family receiving the Flair vacuum was still using it, the Smith and Powell household. Mr. and Mrs. Long had purchased a second Roomba so that one could be placed on each floor of the house. In the Smith household, the Roomba was eventually stored in Eva's room, and she because the sole user of the vacuum. This transition motivated her to be solely responsible for the regular cleaning of her room. In the Smith and Powell household, the Flair (now "beat up" as Mrs. Smith described) was used for opportunistic cleaning while the family awaited the retirement and ownership of cleaning activity by Mrs. Smith.

Product Ecologies:
Understanding the Context of Use Surrounding Products

In summary, families received one of two vacuums with the same suctioning power: the Roomba or the Flair. The Roomba was mobile and autonomous, and the Flair was a small, mobile handheld upright.

Participants praised the Flair for being lightweight, and easy to use, carry, and store. People liked that the head of the vacuum was very flexible, and combined with the form of the body, was easy to use under furniture. Also valued was the fact that the vacuum was easy to push, and as one participant claimed, "almost steered itself." Several participants found the dirt cup to be too small and hard to empty. Using the vacuum was sometimes described as awkward, because the Flair did not stand up on its own.

Participants praised the Roomba for being mobile, autonomous, and easy to use. They liked its ability to clean under furniture. The Roomba was criticized for having a small dirt cup. In addition, participants disliked the fact that floors needed to be clear of clutter to allow the Roomba to work efficiently. Storage and charge were an issue, because the docking station needs to be placed near to an electrical outlet. Finally, people complained that the Roomba was loud when it worked.

6.4 Discussion

The overall goal of the study was to strengthen the conceptual and empirical foundations of the product ecology, using a semi-structured qualitative approach. In this section, I will describe the factors in the product ecology relative to the Flair and the Roomba vacuums in the following order: activities (how cleaning was done); products (changes in use or disuse of other cleaning products); people (the roles assumed in housecleaning); interactions (how people interacted with each other relative to using the new vacuum, and how people jointly made sense of the vacuum); and responses to features of the vacuums themselves (functional, aesthetic, symbolic, emotional, and social).

6.4.1 Activities

The Roomba vacuum changed how cleaning activities were done in three significant ways:

• It enabled multitasking. The autonomy of the Roomba allowed for something else to be done while the floor was being vacuumed.

• It increased the frequency and type of cleaning activities. Cleaning could be done with minimal physical effort, so families used the Roomba to clean on an as-needed basis, rather than planning to clean or running the vacuum when there was free time. Children could use it to clean their rooms. Signs of increased frequency and type of cleaning were seen across all roles in the family.

• Families devised creative ways of using the Roomba. Families discovered ways to make it better support the way they cleaned. This phenomenon is in keeping with the experimentation period that people generally have with new technology and their propensity to adapt products to their needs.

Technology has promised to reduce labor numerous times in history, as described in Chapter 4. The Roomba did reduce the direct labor of cleaning, and allowed people to do something else while it cleaned:

Pat Long: "There again, I had the convenience of being able to go for a walk and back here, it is vacuuming."

Meg Jones: "It's cutting my time in half in terms of cleaning the floors. And I can do something else when that's happening. So, it's really great."

The Roomba also changed the frequency and type of cleaning activities. Most families engaged in primarily opportunistic cleaning, cleaning when time in their weekly schedule permitted. Many set a deadline for the weekend, noting that as long as cleaning tasks got done by Friday, it did not matter precisely when they were done. A few others planned cleaning activities at specific times during the week. The Roomba proved to change both types of cleaning. It shortened planned cleaning time, because other activities on the list could be undertaken while vacuuming was taking place. It was also easy to simply run the Roomba to clean up a spill or an unanticipated mess, requiring less labor during planned cleaning times. Therefore, it affected both planned and opportunistic cleaning activities. One family even noted that they could undertake more opportunistic cleaning, and keep the basic standard of cleanliness at a higher level:

Meg Jones: "Well, there is really no reason for us not to just turn it on. It takes no effort. So we might just as well have it going, you know, like every other day or something, instead of using it just once a week."

Finally, people devised creative ways to use the Roomba, as is common in the experimentation period with new technology. For example, the Roomba requires that floors are relatively clutter-free, which caused some participants to create and undertake pre-cleaning activities. Mrs. Smith found that the tradeoff of moving items off the floor was worth the benefit of having the Roomba be able to go under furniture, which she rarely did when using her Eureka vacuum:

Mrs. Smith: "Yes, I find I have to put more stuff up. If I'm just vacuuming with a regular vacuum, I will sort of go under and around, and you know move stuff a little bit to get around the furniture legs,

but then I will put it back. Whereas if I'm using the Roomba, well I take everything up and put it on the bed, so it can do its job better."

Other creative approaches for using the Roomba to support each family's cleaning needs were documented. For example, although Mrs. Smith reported that she did not like the Roomba enough to continue using it, she continued to devise and email new ways of using the vacuum several months after the study finished:

Mrs. Smith: "Another thing I like about the Roomba: if it is NOT dirt you vacuumed up, you can search it again... we lost E's earring back and it was easy to find... unlike a regular vac when you have to rip open the big bag full of nasty dust and dirt and dig through it." (Figure 16)

Mrs. Smith: I "pre-cleaned by doing the baseboards and sweeping all the dirt away from the wall. I took the extra stuff off the floor and then the Roomba could do the cleaning unattended."

Figure 16. Looking for an earring back that was vacuumed up by the Roomba. Dirt was emptied from the canister, searched, and then re-vacuumed using the Roomba.

The Flair vacuum had far less impact on cleaning activities:

• It was used for cleaning up spills. Due to its small size and mobility, it was the vacuum cleaner that was grabbed in response to dry spills in the household.

• It was used when cleaning needed to be done in a hurry. The Flair was used when cleaning needed to be done quickly, and even though it has the same suction power as the Roomba, a connotation was

made that it was not "strong" or "useful" enough to be used for planned housecleaning.

While the Flair also inspired opportunistic cleaning, the job that it did was not apparently not deemed suitable enough to significantly change the cleaning activities in the home.

6.4.2 Products

The Roomba had a large effect on the use of other floor-cleaning products within the product category.

• Two of the three families entirely replaced their floor-cleaning systems of products (vacuums, dust mops, and brooms) with the Roomba.

• One of these families purchased a second Roomba.

Interestingly, both of these families contained elderly family members.

In the Jones family, the Roomba entirely replaced the dust mop and vacuum system that W Jones had been using for weekly housecleaning:

Meg Jones: "I used to dust mop, then use vinegar and water to wash the floors. I dust mopped after I used the Roomba for the first time, and the mop was so clean that I realized I didn't need to dust and mop anymore."

Mrs. Smith, the homemaker in the third family, claimed that the Roomba did not do a good enough job to replace the current vacuums and hand cleaning tools in place in the house. She believed that the layout and materials in her home made the Roomba difficult to use. However, she continued to communicate by email new uses of the Roomba by email long after the study was finished.

The Flair instead augmented other vacuum cleaners and cleaning products used in the home.

• It was used for quick cleanups. The Flair made the activity of extracting and carrying a larger vacuum unnecessary.

• It was used as an interim replacement for cleaning staff. The Flair was used after a cleaning woman was fired.

Two of the three families who received the Flair vacuum said that the product did not change they way that they cleaned. The third household, that of Mrs. Smith and Mrs. Powell, found the product to be

somewhat novel. One of them used it to clean because it was new, and convenient:

Mrs. Powell: "Number one is that she likes new gadgets. So there is like this honeymoon period…"

However, this was the family that had fired their cleaning woman, and they also reported that the Flair was a good interim solution until a more routine cleaning plan was put into place.

6.4.3 People

Unlike the Flair or other vacuums already in use within a family, the Roomba made cleaning a concern for everyone in the home:

• Cleaning was performed by people other than the female head of the household.

• Men and children were eager to engage with the Roomba.

The Roomba also appealed to men, children, and elders. Although some of this effect is due to the novelty and autonomy of the product, it could also be due to the fact that robotic technology is accessible, and when well designed, easy to use. Many people talked about being able to vacuum "at the push of a button," and children created messes on the carpet to see how well the Roomba would do. Two of the families realized that the Roomba provided an opportunity for children to learn directly about robotic technology while engaged in cleaning activities:

Pat Long: "Nate was very interested in the Roomba. I had to keep him from driving it around the house. He was learning how to use the remote control."

Meg Jones: "I would say that my sister and my nephew were maybe a little more inclined to clean the floors than they would have been before. So it doesn't end up being my job quite as much."

In the Smith family, the Roomba served as a catalyst that helped Eva Smith to become entirely responsible for the regular cleaning of her room.

Mrs. Smith: "Yeah, for Eva's room, yeah I like it for her room. I am always surprised, I mean you know, like another week comes by, and she says, 'let's do it again.' I put it on and it's like, oh it's good and then I will put it on again, you know for the same room and I am like okay let's do it for round two. And sure enough, it got more dirt and her room is clean and I am like, 'wow, that's so nice.'"

At the 12 month interview, Mrs. Smith told me that the Roomba was kept permanently in her daughter's room and that she was quite happy with her daughter's new motivation in keeping her room clean.

Others realized that the Roomba's autonomy and ease of use made it more accessible for elders and those experiencing mobility problems:

Pat Long: "But for my parents, who run it sitting down, it allowed them to get the floor cleaned without even getting out of the chair. So for them, you know, from an elderly point of view, it definitely changed that part of cleaning."

Meg Jones: "And for people like my mom who are elderly, it's one thing where they have to struggle to figure out how they are going to vacuum, instead they could just a press a button."

Men and children were eager to engage with the Roomba. This is a deviation from the traditional role of female homemaker as described in Chapter 2. In all three families, males (two fathers and one son) were the ones to bring the technology to the family, by taking the Roomba out of its box, charging it, reading the manual, and in one case, even learning how to use the barriers and the remote control:

Meg Jones: "Well, my nephew got it out of the box. He is very interested in robotics. He got it out of the box, and he set it up, and then we used it, I think on the dining room floor. And I was very skeptical as I said in my notes. But then when I went to wet mop the floor, which I usually do after I dry mop, I noticed that I was not getting nearly as much dirt on the sponge mop that I usually did, even after I have done the other cleaning first, and so we just think it is terrific."

Pat Long: "Oh, my dad (age 81) opened it, read the instructions, and set it up, and my mom used it a great deal. At first, she was believing that it's going to get stuck under the chair, or it's going to get stuck somewhere, but it did not get stuck anywhere."

Another interesting effect could be seen in the roles in the household. The Roomba had different effects on the ways that younger and older generations cleaned. Families with elderly women at the head of the household traditionally did planned cleaning. Because the Roomba could be run at any time without disrupting other activities, it had a great effect on when and how elderly women cleaned their floors, allowing them to clean the floor opportunistically instead of at a regular time.

Younger women were not as organized about planned cleanings. In addition, many expressed feelings of guilt at not cleaning in the same

fashion that their mothers did. Since the Roomba could clean autonomously, it had an effect on this emotional construct, by lessening some of the guilt about cleaning whenever it could be done. For example, in the household of Jane and Meg Jones, their mother Margaret, would constantly comment on her cleaning practices. JJ teased her daughter that the Roomba was "the epitome of laziness," but also acknowledged that it was infinitely useful for helping the family to get the cleaning done.

The Flair had no similar effect on men, children, and the roles of planned and opportunistic cleaners. If anything, it appeared to be associated with someone who performed fast, and perhaps inadequate, cleaning.

6.4.4 Interactions

In addition to causing more people in the household to clean, in certain instances the Roomba caused people to clean together. At these times, cleaning became a social activity. For example, Pat Long came and assisted Mrs. Long with some heavier cleaning tasks while she ran the Roomba and did the dusting. In another instance, Meg Jones ran the Roomba while her sister cleaned their mother's room. None of these joint cleaning activities were reported by families who received the Flair vacuum.

6.4.5 The important features of cleaning products

While the process of cleaning and the generational issues associated with it can be highly emotional, cleaning products are rarely discussed in any other than functional terms. The majority of cleaning products are accepted for their functionality, or rejected or modified to compensate for a lack of functionality, without mention of aesthetics or symbolic value. In fact, with most cleaning products, aesthetics, symbols of who the product is designed for, emotions associated with the product, and social outcomes of using the product are rarely discussed. Interestingly, participants in the study described the Roomba in functional, aesthetic, symbolic, emotional and social terms, while the Flair was described in functional and symbolic terms only.

Product function. People discussed the form factor of the vacuums, how easy they were to move and store, and how well they cleaned under furniture. Participants praised the Flair for being lightweight, and easy to use, carry, and store. People liked that the head of the vacuum was very flexible, and combined with the form of the body, was easy to use under furniture. Participants criticized the Flair for having only medium suction power. Several participants found the dirt cup to be too small and hard to empty, and the inability for the vacuum to stand up frustrating.

Participants praised the Roomba for being mobile, autonomous, and easy to use. They liked its ability to clean under furniture. The Roomba was also criticized for having a small dirt cup. Storage and charging were an issue, because the docking station needs to be placed near to an electrical outlet. Finally, people complained that the Roomba was loud when it worked, and that the preparation time of clearing floors to have it work effectively was somewhat frustrating.

Product aesthetics. Not surprisingly, only the Roomba was described in aesthetic terms. All three families that received a Roomba offered positive and negative comments about its aesthetics. Mrs. Smith disliked the way the Roomba bumped the furniture; Meg Jones disliked the "clackety-clack" noise the Roomba made as it worked. Nate and Pat Long liked the feedback sounds, and brainstormed a list of sounds they would like to add to the Roomba.

Symbolism: Who products are designed for, and why. Both the Roomba and the Flair evoked ideas of "who it was designed for" from the participants in the study.

The Roomba inspired different reactions based on age, role, and gender. Children and teenagers treated the Roomba as a game or an educational opportunity. The girls in the study used the Roomba to play games. The boys in the study attacked the Roomba as if it were a science project, reading the product manual, learning how to use the remote control, and streamlining the operation of the vacuum for the family. Women viewed the Roomba effective, but somewhat of a gadget. While women were initially skeptical about the functionality of the product, each was very pleased with the job done. Men viewed the Roomba as the latest technology and a valuable timesaver. They were proud to set up and install the Roomba, and to tell others in the neighborhood that their home had the latest in cleaning technology.

Meg and Jane Jones liked having a high-tech object in the home. Although the Smith family felt the vacuum was not suitable for a family who lived in a historic house, they also felt that because they had the latest computing technology, it was fitting that they were the first family to own a Roomba in their neighborhood. They showed it to neighbors and even loaned it to friends for a few days:

"We showed it to most of Eva's friends. All her friends had come over, and they got a little introduction. So it's being up on technology, like it's okay. That goes on well with Ken, because he is always up on technology, so it's just another gadget."

The symbolic associations about the Flair were very different. They included statements that the vacuum was for "older people," "people who don't make a lot of dirt," and "people who don't clean." Mrs.

Drake said it was for someone who lived in a condo, like her mother, and who wanted to "just zip through." These associations describe a general belief that the Flair vacuum is designed for people who cannot or do not care to do thorough or planned cleaning.

Emotional responses. Only two cleaning products inspired emotional responses from participants in the study, and these were Swiffer dusters and the Roomba vacuum. Participants described these products with happiness and excitement. They were valued for two reasons: first, they had a clear and obvious impact on the dirt, and second, they reduced the time to get dusting and vacuuming finished. The Flair did not inspire any emotional responses.

Social responses. The Roomba changed the social relationships between people within the product ecology in several ways:
 • People relied on each other to make sense of the Roomba, constructing its functional, aesthetic, and symbolic meanings.

• People made social attributions to the Roomba, by giving it names and making attributions about its behavior.

Researchers have theorized that exposure to unfamiliar products is a social and emotional event that triggers a process of sensemaking, through which cognitive and emotional processes are triggered to use the familiar to describe the unfamiliar [Rafaeli and Vilnai-Yavetz, 2004; Weick, 1993]. Research on three disparate bodies of literature — human factors [Howell 1994], industrial design [Heskett 2002], and marketing and semiotics [Aaker and Myers, 1987] — have been combined to describe three dimensions of artifacts that figure in the sensemaking process. These jointly constructed meanings include functionality, aesthetics, and the potential that a product has to act as a value-laden symbol for its owners.

In all of the families who received a Roomba, interactions between people using the Roomba added social aspects to the activity of cleaning. Instances of using the Roomba in pairs were documented. People watched it work together, played with it together, did other cleaning tasks together while the Roomba did its work, and used the Roomba to learn about and understand robotic technology, the use of the laser barriers, and the remote control. Additionally, families performed cleaning activities together using the Roomba. Pat and Nate Long cleaned together with it, and Mr. Long helped Mrs. Long with her weekly housecleaning once the family had received the Roomba. The Long family also shared the Roomba between two households, and Pat Long would come by to see if his mother needed assistance with any cleaning tasks when he took the vacuum. Eva Smith and her friend made a game out of cleaning to see how well the Roomba would do. Eva Smith was also motivated to clean her room once the family

owned a Roomba; when only the upright vacuum was available to use, she ignored her mother's requests to keep her bedroom clean.

Although all three families made social attributions to the Roomba, no similar behavior was seen for the Flair. Two of three families named the Roomba, using a male-gendered name, and two of three heads of the household reported talking to the Roomba as it did its work:

Mrs. Smith: "We named the vacuum Manuel, as in the John Cleese show Faulty Towers, where Manuel is their butler who is always making blunders and doesn't speak English well. We named it because it has a personality, I mean well, it's doing the work of a person may be a part of it, and it seems to be sort of intelligent, has a little bit of intelligence in it."

Q: What kind of things do you say?

Mrs. Smith: "Hey, come on over here. You've already done that." It's just fun, though, to see the path that it took. I watched in the beginning to see how thorough it was. It looked freshly vacuumed, which is good."

Jane Jones said "excuse me" to the vacuum if she bumped into it when walking through the house.

The Long family had named previous vacuums in the family, using female gendered names such as Big Bertha the Hoover:

Pat Long: "Well, my parents named it Robby right away, after the old Robby the Robot. Nate called it I-Robot."

All three families who received a Roomba were interested in how their pets related to the Roomba. They made attributions about how the animals interacted socially and emotionally with the vacuum. Each family related stories about what the dog or cat did. One family reported that their cat liked to sit near the vacuum "to keep it company," and another that the geriatric dog was in fear of, and ran away from, the vacuum.

It seems that the sensemaking process for the Roomba, eliciting aesthetic, symbolic and emotional responses in the process of becoming familiar with its cleaning functionality was driven by a variety of associations to familiar things. Its novelty, autonomy, and ease of use triggered emotional and aesthetic responses, unlike the majority of other cleaning products, including the Flair and other household vacuums used by participants during the study.

6.5 Conclusion

This chapter presented the results of a semi-structured ethnographic study testing the constructs of the product ecology. The Roomba substantially affected how cleaning was done and how often it was done; who cleaned; how other cleaning products were used or no longer used; and how family members interacted with each other in using, and making sense of, the new vacuum. The Flair exhibited far less impact.

These findings help to illustrate how introducing a new technology products can affect factors within an existing product ecology, and ultimately lead to social product use. In the next chapter, the framework repurposed in a generative manner to conceptualize what factors and combinations of factors must be considered in the design of social technology products.

7: Ecological Practices for Social Product Design: Putting it all together

From the beginning of time, carefully designed artifacts have played an important role in the development of civilization. From the invention of the wheel and the hearth to DaVinci's forward-thinking concepts, from the materials enabling the industrial revolution to the products that populate the landscape today, augmentations to the world were have continually been made through design. These actions were shaped by external factors: the environment, society, culture, the need to care for other people, and many others. Humans have designed for survival, to continuously develop and improve the world they live in, and to foster communication and information exchange with one another through designed products.

This dissertation has introduced the concept of the product ecology, a theoretical framework grounded in interaction design that describes the social use of products in the environment in which they are used. Chapter 2 presented the product ecology as a design theory to describe factors shaping how a product is used. Chapter 3 described the context of the research: elders, the private home, and assistive products. Chapters 4, 5, and 6 described research that further explored the constructs within the product ecology. The research showed that the product ecology can be useful in helping to understand the factors contributing to product use. It also showed that new technology products can have great impact on existing product ecologies within the home.

In this final chapter, I situate the product ecology by comparing it to other descriptive theories examining context and experience in design, the field of human factors, and the method called Contextual Design. I argue that the product ecology is unique because it allows for exploration of new problems arising from groups of phenomena and changes in relationships among people, contexts, and aspects of products. I show how factors in the product ecology can be used alone and in combination as to understand the context surrounding future technology products. I suggest some research methods for ascertaining responses to the functional, aesthetic, symbolic, emotional, and social aspects of products. Finally, I provide a brief example to illustrate how the factors in the product ecology can be used for design.

7.1 The product ecology as a descriptive design theory

Design as a way of thinking, acting, and researching is a relatively young academic discipline. Compared to the well-matured intellectual

discipline of science, design is only beginning to develop an approach to research, and to build sensitizing concepts and theories. The product ecology emerges out of a short history of design researchers who have explored how complexity and context affect a design problem, ultimately shaping methods, approaches, and theories of experience and product use.

One of the first designers who was instrumental in transferring knowledge from the sciences and engineering to the design professions was Horst Rittel [Rith and Dubberly, 2006]. Rittel was trained as a mathematician, architect, and designer, and changed the field of design through his work at the Hochschule für Gestaltung (HfG) Ulm and then at Berkeley. His research group, the Design Methods Group, stimulated the Design Methods Movement that followed in the early 1960s. This movement advocated an alternative approach to the linear, step-by-step model of the design process promulgated by designers and design theorists in the 1960s [Lindinger, 1990].

Rittel sought to differentiate the approach of scientists and designers in solving problems, differentiating problem types as either tame or wicked. According to Rittel, tame problems are ones that have trivial concerns, are quickly identified, and are solved rationally, practically, and efficiently using linear problem solving methods [Nelson and Stoltermann, 2003]. On the other hand, wicked problems do not lend themselves to simple characterizations, or to simple procedures for solution. According to Rittel, wicked problems are a "class of social system problems which are ill-formulated, where the information is confusing, where many [shareholders] have conflicting values, and where the ramifications in the whole system are thoroughly confusing" [Churchman, 1967].

Nigel Cross also attempted to differentiate approaches to problem solving in design, contrasting the rational, positivist approach of Herbert Simon with the intuitive, constructionist approach of Donald Schön [Cross, 2001]. He noted the importance of design as a discipline to develop its own domain-independent approaches to theory and research, urging members of the discipline to focus on "the 'designerly' ways of knowing, thinking, and acting," the study of the practices and processes of design, and the study of the form and configuration of artifacts as embodiment of knowledge [Cross, 1999; Cross, 2001].

Subsequently, many theoretical frameworks have been developed and adopted to help understand how people interact with products, services, and systems. [For a comprehensive overview, see Battarbee, 2004]. These include contributions from design, business, philosophy, anthropology, cognitive science, social science, and other disciplines. These approaches examine user-product interactions and the resulting experience from a number of perspectives. These models can be

grouped into product-centered, user-centered, and interaction-centered approaches [Forlizzi and Battarbee, 2004].

Product-centered models provide straightforward applications for design practice, assisting designers and non-designers in the process of creating products. They describe the kinds of issues that must be considered in the design and evaluation of an artifact, service, environment, or system. These models usually take the form of lists of topics or criteria to use as a checklist when designing. For example, Alben [1996] provides a set of criteria for assessing the quality of experience of a designed product during conception, planning, and execution. Jääskö and Mattelmäki [2003] provide a set of design guidelines for understanding experiences and applying them in user-centered product concept development.

User-centered models help designers and developers to understand users. These models integrate knowledge from other disciplines to offer ways to understand people's actions, and aspects of experience that people will find relevant when interacting with a product. For example, Hassenzahl [2003] provides a theoretical model to describe people's goals and actions when interacting with products. It broadens traditional goal- and task-based thinking from cognitive science to include fun and action-oriented modes of behavior. Sonic Rim, a well-known US-based user research firm, defines the categories of "say, do, make" in research tools to learn of people's experiences with products and their expectations [Sonic Rim, 2005]. Cain, formerly of E-Lab and Sapient, developed similar user-based categories of "think, do, use" [Cain, 1998]. Mäkelä and Fulton-Suri [2001] use design to target people's motivations and actions, unfolding within particular contexts, as important in understanding user experience.

Interaction-centered models explore the role that products serve in bridging the gap between designer and user. Here, too, we see approaches from a number of disciplines. Wright et al. [2003] discuss product experience as consisting of four threads: compositional, sensory, emotional and spatio-temporal. The threads contribute to actions (such as anticipating and recounting) that create meaning. Margolin, a design historian, provides four dimensions that clarify how people interact with designed products — categorizing operational, inventive, aesthetic, and social uses [Margolin, 1997]. Overbeeke and Wensveen [2003] focus on the aesthetics of interaction and the ways in which form and behavior support feedforward and feedback. Information in interfaces and action are coupled in six ways: time, location, direction, modality, dynamics and expression. Battarbee and Koskinen articulate three approaches to applying and understanding user experience in design [2005]. The measuring approach measures people's emotional and physiological responses to certain situations; the empathic approach uses creative and inspirational techniques to

connect an individual's dreams and actual experience, and the pragmatist approach links action and meaning. My work with my colleagues Shannon Ford and Katja Battarbee looked at experience in interacting with products and systems. The framework describes user-product interactions as fluent, cognitive, and expressive, and dimensions of experience that include experience, an experience, and co-experience [Forlizzi and Ford, 2000; Forlizzi and Battarbee, 2004].

The product ecology is a product-centered model. It can be used to discover and understand the phenomena that arise from the aggregate of products, people/roles, environments and social norms, and the context of use around a particular technology product. It is a type of design inquiry used by a number of "design thinkers" [Buchanan, 1992; Buchanan, 2001; Margolin, 1995; Margolin, 1997; Simon, 1968; Battarbee and Koskinen, 2005; Jääsko and Mattelmäki, 2003]. Design inquiries have come from researchers in a number of disciplines ranging from economics to social science, from rhetoric to design. They create a mapping from product to other aspects of the environment and people, and begin a cultural tradition within which design frameworks and theories will situate. It is my hope that this dissertation will build on and extend that cultural tradition.

7.2 Moving beyond usability

Since the 1980s, designers of technology products have looked for ways to move beyond the usability studies that are traditionally done after all the aspects of a product's design have been fixed. The product ecology framework follows on a history of work in human factors and Contextual Design to describe methods that provide information about human knowledge and product use during product design.

7.2.1 Human factors

Human factors is defined as the study of factors and development of tools that facilitate human interaction with systems [Wickens, Gordon, and Liu, 1997]. The goals of the interaction are to reduce error, increase productivity, enhance safety, and enhance comfort. Human factors applies behavioral sciences, including psychology, perception, memory, thinking, and motor skills, and organizational and social psychology and biological sciences in the form of physiology, to the design of machines and human-machine systems.

Human factors in the United States emerged as a distinct discipline during and after World War II, as the US military began to understand that modern weapons of war required explicit engineering of the interface between human and machine [Sheridan, 2000]. This meant fitting the human to the machine through the design of aircraft cockpits, radar workstations, gun sights, etc. At this time, laboratory scientists collaborated with engineers to produce designs and design guidelines for future systems. In Europe, human factors arose as a

response to industrial accidents and rampant worker fatigue and errors.

After World War II, appreciation for human factors as an engineering discipline emerged. Human factors professionals redesigned displays and controls for defense systems. They developed scientific measures of human performance and a set of theoretical constructs, including feedback, signal detection theory, and decision theory. The field gradually migrated from "knobs and dials" studies of workstation design, to engineering studies focused on performance of information processing, and finally, human-computer interaction studies focused on how people use computers.

Despite this migration, human factors was never strongly integrated into university studies of technology or design. Even now, in HCI and design programs across the US, fewer than five offer undergraduate and graduate courses in human factors. A National Research Council report (chaired by Stuart Card) looked at 40 non-experimental methods in human factors, and found that almost none had a validation literature or any place researchers could go to learn them [NRC, 1992]. Card also asserted that most of today's human factors work is associated with evaluation of systems that have already been designed, whereas studies in HCI and design span the whole development process from discovery to evaluation [Card, 2006].

7.2.2 Human factors methods
The field of human factors largely relies on experimental research methods that explore the relationship between causal independent variables and resulting changes in one or more dependent variables. These experiments are structured as standard empirical studies that take place in a lab or a real world context. The overall goal is to generalize and make predictions about human behavior, through the process of constructing validity. There are roughly five steps in conducting an experiment: problem definition and hypothesis generation; specification of experimental plan; conducting the study; analyzing the data; and drawing conclusions [Williges, 1995]. Data are analyzed to understand whether or not the dependent variable actually did change as a function of the experimental condition. For example, did subjects take longer to perform tasks using a joystick as opposed to a mouse?

According to Wickens, Gordon, and Liu, there are a few cases where human factors problems might benefit from a descriptive approach, whereby research is conducted in a real-world setting [Wickens, Gordon, and Liu, 1997]. For example, in studying naturalistic decision making, command and control personnel might be observed in the context of their work, with a focus on human performance under complex conditions. In such cases where an abundance of data is

collected, data are usually sampled so a small subset can be subject to analysis, or a task or incident analysis of the data may be performed.

7.2.3 Contextual Design

The practice of Contextual Design was formalized in the mid-1980s, when a majority of industry was looking for ways to make better products. Usability as a practice was fairly well established, but could not significantly impact the structure or design of a product, because it happened after a product has been designed. Contextual Design, a set of practices for going into the field to see how the work practice unfolds, emerged in response to this need [Holtzblatt, 2003].

Contextual Inquiry, and subsequently, Contextual Design, was a response to the fact that both marketing and usability data lacked the detail needed to design new technology products that needed to support, extend, and transform existing work practice. By the early 1990s, practitioners had begun to collect detailed data on work practices, but lacked ways to analyze and synthesize the data. Holtzblatt and Beyer designed the process of Contextual Design over a decade of iterative work with teams [Holtzblatt and Beyer, 1998].

7.2.4 Contextual Design methods

Holtzblatt describes Contextual Design as "a full front-end design process that takes a cross-functional team from collecting data about users in the field, through interpretation and consolidation of that data, to the design of product concepts and a tested product structure." Contextual Design can be used to address particular issues in a design, evaluate a design that has been planned, or to assess how a stepwise release in the design might be changed. Formulaic procedures are given for each step so that even team members who are unfamiliar with user-centered design processes can conduct Contextual Design. For example, when conducting a contextual interview, team members are taught four principles that are used to guide the interview: context, partnership, interpretation, and focus. After a brief introduction in the interview, the discussion is quickly moved to focus on the part of the work that is relevant to the design process. After the data are collected, they are used to populate five work models, which include the Flow Model, the Cultural Model, the Sequence Model, the Physical Model, and the Artifact Model. The models are then consolidated. These models, along with an affinity diagram which brings issues and insights across all customers into a wall-sized hierarchical diagram, are used to look at opportunities from different perspectives. Selected opportunities are storyboarded to test designs early on. Storyboards essentially function as a future scenario guided by the vision and reined in by the data.

7.2.5 How the product ecology differs

The product ecology framework provides an alternative way of understanding the complex physical and social context of use around a product. Like Contextual Design, it is focused on real world contexts, looks for patterns of behavior over small subject numbers, and plays a role in developing future products. However, unlike both human factors and Contextual Design, it allows for exploration of new phenonmena arising from groups of factors in combination, and the discovery of how people think about products, creating social, emotional, and symbolic relationships with them.

To further articulate the similarities and differences between human factors, Contextual Design, and the product ecology framework, two key points should be highlighted. First, the product ecology approach involves doing fieldwork over an extended period of time. This differs from human factors. It also differs from Contextual Design, in that numerous observations are done, and observations of several people interacting with the same product. In addition, product ecology fieldwork involves understanding related activities of all people, as well as the physical and social environment in which product use unfolds, and the interdependence of how people interact with product, how people interact with each other around product, and how the physical and social environment interact with products.

Second, the product ecology involves introducing a prototype (or a new product) into the context of the research. This activity serves several functions. First, the prototype acts as a codifier of understanding of the current situation. Next, it serves as a way to investigate a means of improving that situation. Finally, it allows researchers to understand the changes in the product ecology over time. In some cases, it may be useful to compare two prototypes or products, in order to see comparative changes.

The product ecology framework is useful for broadening the view of what a product is. Examples of this are clearly illustrated in Study 1 and Study 2, where I found that a cleaning product is much more than a functional object of use — it serves important emotional and social functions within a family. These uses and meanings of products evolve over time, and are often not revealed in single-visit fieldwork that is common to Contextual Design.

However, there are places where it is not advantageous to use the product ecology as a research method when designing new products. These include single-dimensional design problems (Rittel's "tame" problems), or where non-interdependent aspects of a design are being evaluated. For example, a designer may be seeking to understand if a speech notification or a sound notification is better for a robotic product. In this case, a simple comparison may reveal the answer

rather than a full field study, because the design problem has few constraints.

Table 6 provides a summary of the themes, context for study, methods, and qualities of typical research in human factors, Contextual Design, and the product ecology framework.

7.2.6 Understanding context through the product ecology

When working with the product ecology framework, researchers need to understand people, their activities, their interactions with products, and the functional, aesthetic, symbolic, emotional, and social aspects of the products themselves. Designers conducting research using this framework can offer a unique perspective on aspects of context and product factors. To do so, a deep understanding of those they are designing for is needed. Designers also need to become inspired by, and make use of theories from other disciplines that are relevant to the design problem.

To understand the factors of context, it is important to capture as much of a person's interactions with a product as possible in a real-world context without disruption. Observations, suspended cameras, and journaling by researchers are typically used. Additionally, having an articulation of experience during and after the fact, through interviews and directed storytelling, is useful.

Functional, aesthetic, and emotional product factors can be understood by researching product interactions. How can a new product improve one's current experience? Will the new product be functionally adaptable, learnable, and usable? Answers to these questions are best found in taking an objective perspective to the user's experience and interaction. What product stories are mentioned as memorable or important? What critical incidents come to light? What language is used to discuss changes in users and contexts of use? What emotional responses are elicited? Answers to these questions can be found through observation, photojournaling, task analysis, comparison to other products and product categories, and perceptive exercises.

To understand social and symbolic product factors, all of the potential conditions for collaborating around, communicating about, or sharing a product must be explored. How do users collaborate physically and virtually using products? What are the potential outcomes of collaborative product experience? Fruitful methods include introducing concepts, products, and prototypes into the user's world through semi-structured studies and participatory design activities, and acting out (or "bodystorming") potential situations of use. Prototyping can include building any or all of the design representations of a potential solution for the purposes of learning subjectively and objectively about those who will use the product. While traditional knowledge gained from

prototypes has focused on the product function and interface, we have found prototypes to also be very useful for learning about what social interactions can potentially unfold.

	Human Factors	Contextual Design	Product Ecology
Context for study	Lab Simulation Real world	Real world (workplace)	Real world (home, mobile, workplace)
Typical methods	Empirical methods Occasionally descriptive Study of causal independent variables and resulting change to dependent variables	Interviews, modeling of data, affinity diagrams, storyboarding, prototyping	Qualitative methods Research through design methods Interviews, modeling of data, affinity diagrams, storyboarding, prototyping, competitive analysis, artifact analysis
Qualities of good research	Construct validity, generalize to other people, tasks, settings	Discovering patterns of behavior in small numbers of subjects, creating innovative products, increase revenue for organizations	Discovering patterns of behavior in small numbers of subjects, creating innovative products, creating extensible knowledge for interaction design research
Themes	Task analysis Generalization of human behavior Prediction of human behavior	Focus within a design problem Design of new products	How people think about products How products change human behavior Social aspects of product use Design of new/future products

Table 6. A comparison of human factors, Contextual Design, and the product ecology framework as research and design methods.

7.3 How to use the product ecology

Researchers and designers can use the product ecology framework both to describe the current experience around the use of a product, and to generate opportunities for new products. The factors in the product ecology can be combined to understand the various phenomena within a particular design problem. At the most basic level, these are issues of people, place, and adaptation.

7.3.1 People

Unlike human factors, which seeks to generalize human behavior, the product ecology framework helps to elucidate differences among individuals that help form subjective issues relative to product use and adoption. These include personal history, age, lifestage, gender, one's role in a situation at any given time, and one's role in a group. For example, one's role within a social structure, an organization, or a

cultural setting can play a part in the social use of a product. Such issues, when combined with aspects of a social product, sketch out questions for design relative to accessibility, values, product adoption, and long-term product use.

Research methods for understanding people include interviews and directed storytelling, observation, shadowing, and self-documentation and diary studies, among others.

7.3.2 Place

The product ecology framework considers place, comprised of the physical and social environment, more broadly than Contextual Design. People, acting individually and collectively, actively structure situations where product use occurs. Issues of place relate to both the physical space and social and environmental norms described by the all of the factors within the product ecology. Physical context plays a role in how people interact socially. For example, a shared physical environment has been shown to promote informal social communication [Kraut, 1990; Whittaker, 1994]. The specific design of a place may simultaneously encourage some activities and discourage others [Alexander, 1979; Genereux, 1983]. A particular physical environment may describe behavioral norms that support certain kinds of interactions and discourage others. For example, the experience of drinking coffee at a conference break is vastly different from drinking coffee at a smoky coffeehouse while a jazz band provides ambient entertainment.

Aspects of time can also contribute to issues of place. The ebbs and flows of hours of the day, days of the week, seasons, months and years, combined with the ages and lifestages of key people using a product, greatly shape the experience that results. For example, five of the six families in the study cited the season along with the ages and needs of particular family members as having great impact on what cleaning tasks needed to be done, and exactly how they were best accomplished.

Certain issues of place may create an unforeseen, but ready, context for product adoption and use. For example, I found that cleaning in the home is commonly undertaken by the female head of the household. In a different context, a female might be intimidated by robotic technology, and would not experiment with a robotic product like the Roomba. However, the privacy of the home and the desire to keep it clean may create a feeling of comfort that allows for experimentation, and subsequent adoption, of a new technology product.

Issues of place indicate ways that designers can discover how physical and social context might affect the design of future technology products. The role of context has also been examined through the

concept of embodied interaction, where appropriate use of technology is described over social and temporal structures [Dourish, 2004]. According to Dourish, social structures play a role in how people connect and collaborate with each other, and temporal structures describe how patterns of interaction change over time [Dourish, 2001]. Quentin Jones and his colleagues recently expanded the notion of context to describe a socially-defined place that determines a person's information-sharing and communication needs [Jones et al, 2004]. This view of context takes into account location, one's familiarity or lack of familiarity with a particular place, and the routine behaviors that happen there. The place-based view of context allows for the fact that people actively and collectively structure their environments, and have different information needs based on familiarity and activity at a given place and time. The product ecology framework takes these concepts into consideration, focusing on the product as a lens through which to view combined elements of place and time.

7.3.3 Adaptation

People's needs within a certain situation are always changing. Issues of adaptation relate to the product as an instigator for change — how it has an effect on people, place, and other products in use, effecting dynamic change on all of the factors in the product ecology. For example, a new social technology product might replace or augment other products that functionally accomplish the same thing, encouraging certain activities and discouraging others. In the study, both the Flair and the Roomba vacuum encouraged opportunistic cleaning. However, only the Roomba was seen as beneficial enough to entirely replace other floor cleaning products in use in the home. A product might force changes to a space, or evolve new features within a particular environment. For example, the Roomba inspired people to modify their homes by creating barriers and opening up floor space to make more efficient use of a product. Ultimately, as people adapt to a social product, the product should in turn adapt to the people who use it. For example, a cleaning robot might change behavior to accommodate cleaning in teams, using the capability to sense if someone is in the room and if conversation is present.

7.4 Using the factors in the product ecology

The factors in the ecology can be combined singly or in combination at the level of a single product, to understand what particular product features will inspire social product use, or at the system level, to understand how a particular product will have an impact on a system of products retained for similar functional, aesthetic, symbolic, social and emotional factors. Balance can be found in the product ecology when the factors work successfully in an interconnected fashion, as a result of the design of the product or system at the center.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Table 7 lists factors in the product ecology, questions relative to each factor, and example products that address the corresponding questions. Each factor can be examined singly or in combination with one or more of the other factors.

For example, consider the class of religious products that might be used in coordination in a home: bibles, display artifacts, altars, services such as television and music programs, and behavioral rituals. The product ecology framework can be used to discover ideas about how technology might play a role in designing religious artifacts, environments, services and systems for the home that socially connect members of a religious group through their display and use.

At the level of a single product or system of products, the product ecology framework helps to understand how new technology can replace or augment products that functionally accomplish the same task, to lend social aspects to the task at hand. For example, religious services delivered to the home might best interact with an individual or a family through a social interface, using a human-like agent to communicate with each member of a family. In this example, the new product would most likely augment, rather than replace, other religious products in use by the family.

At the level of the individual, the product ecology framework helps to describe individual differences in the potential adoption and use of religious social products. Researchers and designers can ask how age, gender, role, and lifestage differences might create differences in religious social product adoption and use. For example, a cell phone might be a good vehicle for delivering time-sensitive reminders for prayer and religious rituals, buy many young people are not allowed to carry phones with them into the classroom. Teenagers and young adults may shun religion as a common practice of their lifestage, but a technology game with lessons about religion may reduce some of the stigma, resulting in more readiness to adopt a religious social practice if it is delivered in a technological form.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Factor	Variable	Questions	Relevant Examples
Product	Function, aesthetics, symbolism, fit, accessibility, mutability	Is the function, appearance, or symbolic quality of the appealing enough to replace products that accomplish the same function? Does it bring social aspects to those functions?	Observations of product use, with think alouds [Bødker and Buur, 2002]; Field tests with working prototypes [Makela et al 2000; Tollmar and Persson, 2002]
System of products	Function, aesthetics, symbolism, fit, mutability, to fit with, replace, or augment other components of the system	Is the function, appearance, or symbolic quality enough to augment products that accomplish the same function? Does it bring social aspects to those functions?	Log data of a group of friends accessing a system of products [Koskinen et al 2002]; Diary studies [Frolich et al 2002]
Person/people	Age, gender, lifestage, attitudes, dispositions towards new technology	Is the product functionally beneficial? Can the product be valued for initiating or supporting social interaction, or shifting the role of the primary user?	Diary studies; design interventions in public places [Battarbee et al, 2002]; longitudinal studies [Forlizzi, 2007]
Roles	Cohort, attitudes, values, projection of values, social and cultural norms	Is the product functionally beneficial for more than one person within the group? Can the product be valued for initiating or supporting social interaction, or positively affecting roles of primary users within the group? Can it affect social structures in a meaningful, ethical way?	Diary studies; longitudinal studies
Environmental and social context: Place	Physical benefits and limitations of a particular place, social and behavioral norms of a particular place, temporal patterns of a particular place	Can the product help overcome limitations of place? Can a place adapt to the product?	Collect stories from people about product experience [Boess et al, 2002]

Table 7. The product ecology as a palette of sensitizing concepts, along with examples of relevant research methods to help understand each factor.

At the group level, the product ecology framework helps to understand how groups might collectively adopt a religious social product, while maintaining subjective perspectives on its use. For example, a set of products might address differences in religious perspectives and educate individuals about the religion of others. A religious social service might help the housebound feel as if they are still participating members of a religious community. New practices may be adopted as a result, if they are collectively valued by the group. Additionally, individuals within the group might have different experiences of the same product: one might participate due to personal behaviors of devotion, another might join to meet new friends, and a third might do it in preparation for death. A social technology product developed for housebound elders will need to offer fit in terms of functionality, while considering subjective issues of adoption such as privacy, ritual, and perceived benefits of a such a social product or service.

At the level of place (environmental and social context), the product ecology framework can help describe how distinct types of place and people's relationship to a place determine their social needs at a given time. For example, a visitor to a family home might have different religious needs and rituals that should be addressed independently of the family. People's needs for social intervention in religious rituals is related to how confident they are with performing a particular activity in a particular place, and how well the activity can transcend to other environments and social contexts: mobile travel, a public place, or another home.

Factors can be combined to better understand the context for design. For example, combining the factors of individual and place might bring into question issues of private and public display of religious behavior. Combining the factors of individual and systems of products might offer insights as to how to offer a consistent religious experience over a number of contexts. Combinations of factors may best explain the conditions for new technology products. Furthermore, the factors can be applied at the level of the individual or the level of a religious community to better understand how the use of new technology products might vary by setting.

7.5 Conclusion

This dissertation presented the product ecology, a theoretical framework to help understand the social use of a product. The product ecology is informed by social ecology theory, inspired by an ethnographic study of elders and products, and validated by a semi-structured study of cleaning in the home. A description for how the model can be used and a list of supporting research methods to generate new design concepts was also presented in this chapter.

Product Ecologies:
Understanding the Context of Use Surrounding Products

The work presented here assembles key elements in interaction design research into a single framework that provides a means for understanding and designing for elements of context and social product use. In this chapter, I have compared this approach to human factors and Contextual Design as generative methods to highlight their similarities and differences.

Of course, the product ecology needs to be tested in more design domains. It must be used and evaluated by a number of interaction designers and design researchers with different technology products in different contexts over time. The product ecology is not meant to replace other models that describe the social experience of product use. Instead, it contributes to a growing landscape of models that explain the phenomenon of experience of interacting with products. It is grounded in the discipline of interaction design, and provides a means for those collaborating with interaction designers (for example, social scientists, roboticists, and computer scientists) to understand how to best work with designers.

Any effort of this scale raises questions about limitations and creates directions for future research. One methodological limitation of this work is in the homogeneity of subjects, in terms of ethnicity and geographic location. More comparison is needed to flesh out the details of the product ecology. Future studies will collect data from more families and for longer periods of time. Additionally, larger, more diverse populations will be involved to determine the generality of these findings. In spite of these limitations, the trajectory of work presented here offers detailed information about the product ecology as a sensitizing concept, and suggests directions for future research.

There are several research directions that I identified based on the work described in this dissertation:

• Further examples. The product ecology should be tested with many other design problems. My first work will be to test this model with divorced families who share custody of children. Each year, more than 1 million children experience their parents' divorce (US Census, 2000). Cumulative projections indicate that by age 18, 40% of children will have experienced parental divorce. Thus, divorce and life in a single-parent household have become exceedingly common. This creates a dynamic situation for divorced families, where children share residences between both their mother's and father's home, often every week. For children, the context of home life must be collapsed and reinstated in both places; for parents away from children, a strong desire exists to at least have a sense of children's activities and their emotional state. These circumstances offer fertile ground for understanding the context of experience and designing new products to improve that experience.

Product Ecologies:
Understanding the Context of Use Surrounding Products

• Evaluation of product dimensions. The critical dimensions of products should be evaluated to understand how each might contribute to social use of a product. My first work here will be to test these dimensions with robots that assist people in industrial settings. We are currently conducting an ethnographic study of a delivery robot in a local hospital, and the engineering team that seeks to redesign the robot to make it more "social" in appearance and behavior. We are coding the data for mentions of the functional, aesthetic, symbolic, emotional and social dimensions of the designed product.

Bibliography

Aaker, D.A., and Myers, J.G. (1987). Advertising Management. New York: Prentice Hall.

Ahuvia, A.C. (2005). "Beyond the Extended Self: Loved Objects and Consumers' Identity Narratives." Journal of Consumer Research, 32, 171-184.

Alben, L. (1996). Quality of Experience: Defining the Criteria for Effective Interaction Design, interactions 3.3 May+June 1996, 11.

Alexander, C. (1979). The Timeless Way of Building. New York: Oxford University Press.

Bailey, M. (1986). Golden Years, Tarnished Hours: Ethnography of Two Elderly Residences in The Midwest. Unpublished doctoral dissertation, University of Michigan.

Battarbee, K., Baerten, N., Hinfelaar, M., Irvine, P., Loeber, S., Munro, A., and Pederson, T. "Pools and Satellites — Intimacy in the City." DIS02 Conference Proceedings. New York: ACM Press, 237-245.

Battarbee, K. (2003). "Defining Co-experience." Designing Pleasurable Products and Interfaces 2003 Conference Proceedings. New York: ACM Press, 109-113.

Battarbee, K. (2004). Co-experience: Understanding user experiences in social interaction. Doctoral dissertation, University of Art and Design Helsinki, Finland.

Battarbee, K. and Koskinen, I. (2005). "Co-Experience: User Experience as Interaction." CoDesign Journal v1n1.

Beggan, J.K. (1992). "On the Social Nature of Nonsocial Perception: The Mere Ownership Effect." Journal of Personality and Social Psychology, 62, 229-237.

Belk, R.W. (1988). "Possessions and the Extended Self." Journal of Consumer Research, 15, 139-168.

Bell, G. (1999). Making Sense of Museums. (Technical Report). Portland, OR: Intel Labs.

Bell, G. (2001). Looking Across the Atlantic: Using Ethnographic Methods to Make Sense of Europe. Intel Technology Journal, 3rd Quarter.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Birkel, R .C. (1987). "Toward a Social Ecology of the Home-Care Household." Psychology and Aging, V2N3, 294-301.

Blellis, M. (2005). The History of Vacuum Cleaners. http://inventors.about.com/library/inventors/blvacuum.htm, accessed August 2005.

Blumer, H. (1969). "The Nature of Symbolic Interactionism." Symbolic Interactionism: Perspective and Method. Englewood Cliffs, NJ: Prentice-Hall Publishers, 2-21.

Bødker, S. and Buur, J. (2002). "The desing collaboratorium: a place for usability design." ACM TOCHI, v9n2. New York: ACM Press, 152-169.

Boess, S., Durling, D., Lebbon, C., and Maggs, C. (2002). "Participative Image-Based Research as a Basis for New Product Development." In Eds. W.S. Green and P.W. Jordan, Pleasure with Products. London: Taylor and Francis, 221-245.

Buchanan, R. (1992). "Wicked Problems in Design Thinking." Design Issues v8n2, 5-21.

Buchanan, R. (2001). "Design and the New Rhetoric: Productive Arts in the Philosophy of Culture." Philosophy and Rhetoric, V34N3, 183-205.

Cain, J. (1998). Experience-Based Design: Towards a Science of Artful Business Innovation. Design Management Journal, Fall 1998, 10-14.

Card, S. (2006). Personal conversation, December 14, 2006.

Churchman, C.W. (1967). "Wicked Problems." Management Science, v4n14, B 141-142.

Cowan, R.S. (1983). More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave. New York: Basic Books.

Cowan, R.S. (1985). The industrial revolution in the home. In Donald MacKenzie and Judy Wajcman, (Eds.), The Social Shaping of Technology. Philadelphia: Open University Press.

Cross, N. (1999). Design Research: A Disciplined Conversation. Design Issues, V2N13, 5-10.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline Versus Design Science. Design Issue, V17N3, 49-55.

Product Ecologies:
Understanding the Context of Use Surrounding Products

DiSalvo, C., Gemperle, F., Forlizzi, J., and Kiesler, S. (2002). "All Robots are Not Created Equal: The Design and Perception of Humanoid Robot Heads." Designing Interactive Systems 2002 Conference Proceedings. New York: ACM Press, 321-326.

Dorfman, K.A. (1994). Aging into the 21st century: the exploration of aspirations and values. New York: Brunner/Mazel Inc.

Douglas, M. and Isherwood, B. (2001). The world of goods: towards an anthropology of consumption. New York: Routledge Press.

Dourish, P. (2001). Where the Action Is: Foundations of Embodied Interaction. Cambridge, MA: MIT Press.

Dourish, P. (2004). What We Talk About When We Talk About Context. Personal and Ubiquitous Computing, 8(1), 19-30.

Edmondson, A.C., and McManus, S.E. (2007). "Methodological Fit in Management Field Research." Academy of Management Review (in press).

Ettner, S., and Grzywacz, J.G. (2001). Workers' Perceptions of How Jobs Affect Health: A Social Ecological Perspective. Journal of Occupational Health Psychology, V6N2, 101-113.

Evans, G.W., Lepore, S.J. and Schroder, A. (1996). The role of interior design elements in human response to crowding. Japanese Psychology Research, V15N2, 118-129.

Fernie, G. (1991). Assistive Devices, Robotics, and Quality of Life in the Frail Elderly. In J.E. Birren, J.E. Lubben, J.C. Rowe, & D.E. Detuchman (Eds.), The Concept and Measurement of Quality of Life in the Frail Elderly. (pp.142-167). New York: Academic Press, Inc.

flickr.com (2006). http://www.flickr.com, accessed May 2006.

Forlizzi, J., Ford, S. (2000). "The Building Blocks of Experience: An Early Framework for Interaction Designers." DIS 2000 Conference Proceedings, New York: ACM Press, 419-423.

Forlizzi, J. and Battarbee, K. (2004). "Understanding Experience in Interactive Systems." DIS04 Conference Proceedings. New York: ACM Press, 261-268.

Forlizzi, J., DiSalvo, C., and Gemperle, F. (2004). "Assistive Robotics and an Ecology of Elders Living Independently in Their Homes."

Product Ecologies:
Understanding the Context of Use Surrounding Products

Journal of HCI Special Issue on Human-Robot Interaction, V19 N1/2, January, 2004, 25-59.

Forlizzi, J. and DiSalvo, C. (2006). Assistive Robots and Domestic Environments: A Study of the Roomba Vacuum in the Home. Proceedings of HRI06, 258-265.

Forlizzi, J. (2007). How Robotic Products Become Social Products: An Ethnographic Study of Cleaning in the Home. To be published in HRI07 Proceedings.

Forty, A. (1986). Objects of Desire: Design and Society Since 1750. New York: Thames and Hudson.

Frohich, D., Kuchinsky, A., Pering, C., Don, A., and Ariss, S. (2002). "Requirements for Photoware." CSCW02 Conference Proceedings. New York: ACM Press, 166-175.

Genereux, R.L., Ward, L.M., Russell, J.A. (1983). The behavioral component in the meaning of places. Journal of Experimental Psychology, 3, 43-55.

Golant, S.M. (1984). A Place to Grow Old: The Meaning of Environment in Old Age. New York: Columbia University Press.

GuideCane, (2002). http://www-personal.engin.umich.edu/~johannb/GC_News/GC_News.html, accessed May, 2002.

Guralnick, J., LaCroix, A., Abbott, R., Berkman, L., Satterfield, S., Evans, D., & Wallace, R. (1993). Maintaining mobility in late life. Am. J. Epidemiol, 137(8), 845-857.

Hansson, R.O., and Carpenter, B.N. (1994). Relationships in Old Age: Coping with
the Challenge of Transition. New York: Guilford Press.

Haptica, (2002). http://www.haptica.com/whatwedo/walker.html, accessed May, 2002.

Harris, M. (1979). Cultural Materialism: The Struggle for a Science of Culture. New York: Vintage Books.

Hassenzahl, M. (2003). The Thing and I: Understanding the Relationship Between User and Product. In: Eds. M. A. Blythe, C.J. Overbeeke, A.F. Monk, and P.C. Wright, Funology: From Usability to Enjoyment. Dordrecht, The Netherlands, Kluwer Academic Publishers, 31-42.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Hazan, H. (1994). Old age: constructions and deconstructions. Cambridge, England: Cambridge University Press.

Heise, L.L. (1998). "Violence Against Women: An Integrated, Ecological Framework." Violence Against Women, V4N3, 262-290.

Heskett, J. (1980). Industrial Design. London: Thames and Hudson.

Heskett, J. (2002). Toothpicks and Logos: Design in Everyday Life. Oxford, UK: Oxford University Press.

Hindus, D., Mainwaring, S.D., Leduc, N., Hagström, A.E., and Bayley, O. (2001). Casablanca: Designing Social Communication Devices for the Home. Proceedings of CHI 2001 Conference. New York: ACM Press, 325-332.

Hirsch, T., Forlizzi, J., Hyder, E., Goetz, J., Stroback, J., & Kurtz, C. (2000). The ELDeR Project: Social and Emotional Factors in the Design of Eldercare Technologies. Proceedings of the CUU 2000 Conference on Universal Usability, 72-79. New York: ACM.

Hoglund, W. and Leadbeater, B. (2004). The effects of family, school and classroom ecologies on changes in children's social competence and emotional and behavioral problems in first grade. Developmental Psychology, 40, 533-544.

Holtzblatt, K. and Beyer, H. (1998). Contextual Design: Defining Customer-Centered Systems. San Francisco, CA: Morgan Kaufmann Publishers.

Holtzblatt, K. (2003). Contextual Design. In Julie A. Jacko and Andrew Sears, (Eds.), The Human-Computer Interaction Handbook. Mahwah, NJ: Lawrence Erlbaum Associates, 941-963.

Howell, W.C. (1994). Human Factors in the Workplace. In Mark Dunnette, L. Hough, H. Triandis (Eds.), Handbook of Organizational and Industrial Psychology. Palo Alto, CA: Consuting Psychology Press.

ICSID (2005). International Council of Societies of Industrial Design. http://www.icsid.org, accessed February 2005.

IDSA (2005). Industrial Design Society of America. http://www.idsa.org, accessed February 2005.

Intille, S.S., Larson, K., Beaudin, J. S., Nawyn, J., Munguia Tapia, E., and Kaushik, P. (2005). "A living laboratory for the design and

evaluation of ubiquitous computing technologies." CHI 2005 Conference Extended Abstracts. New York: ACM Press, 1941-1944.

Jääskö, V. and Mattelmäki, T. (2003). Observing and Probing. Designing Pleasurable Products and Interfaces 2003 Conference Proceedings. New York: ACM Press, 126-131.

Jones, Q., Grandhi, S.A., Whittaker, S., Chivakula, K., and Terveen, L. (2004). "Putting Systems Into Place: A Qualitative Study of Design Requirements for Location-Aware Community Systems." Computer Supported Collaborative Work Conference Proceedings. New York: ACM Press, 202-211.

Junestrand, S., and Tollmar, K. (1998). The dwelling as a place for work. CoBuild 1998 Conference Proceedings. Heidelberg, Germany: Springer-Verlag, 230-247.

Kaplan, D.L. and Casey, M.C. (1958). Occupational Trends in the United States, 1900-1950. US Census Bureau Working Paper N5.

Kidd, C.D., Orr, R.J., Abowd, G.D., Atkeson, C.G., Essa, I.A., MacIntyre, B., Mynatt, B., Starner, T.E., and Newstetter, W. (1999). "The Aware Home: A Living Laboratory for Ubiquitous Computing Research." CoBuild 1999 Conference Proceedings. Heidelberg, Germany: Springer-Verlag, 199-207.

Kleemeier, R.W. (1961). Aging and Leisure. New York: Oxford University Press.

Koskinen, I., Kurvinen, E., and Lehonen, T.-K. (2002). Mobile Image. Helsinki, Finland: IT Press.

Kraut, R., Fish, R., Root, R., and Chalfonte, B. (1990). Informal communication in organizations: Form, function, and technology. In Robert Baecker, (Ed.), Readings in groupware and CSCW. San Francisco, CA: 287-314.

Kraut, R., Scherlis, W., Mukhopadhyay, T., Manning, J., and Kiesler, S. (1996). The HomeNet field trial of residential Internet services. Communications of the ACM, V39N12, 55-63.

LaGory, M. and Fitzpatrick, K. (1992). The Effects of Environmental Context on Elderly Depression. Journal of Aging and Health, V4N4, 459-479.

Lawton, M.P. (1974). "Social Ecology and the Health of Older People." American Journal of Public Health, January, 257-260.

Lawton, M.P. (1982). "Competence, environmental press, and the adaptation of older people." In M.P. Lawton, P.G. Windley, and T.O. Byerts (eds), Aging and the Environment: Theoretical Approaches. NY: Springer Publishing.

Lawton, M.P. (1990). "Residential Environment and self-directedness among older people." Journal of American Psychology, 45(5), 638-640.

Lindinger, H. (1990). Ulm Design: The Morality of Objects. Cambridge, MA: MIT Press.

Living at Home, (2002). Interviews with staff, Living at Home Program, University of Pittsburgh Medical Center. Pittsburgh, PA.

Lucie-Smith, E. (1981). The Story of Craft. New York: Van Nostrand Reinhold Company.

Luscombe, B. (2003). This Bold House. http://www.aarpmagazine.org/lifestyle/Articles/a2003-08-28-bold_house.html, accessed August, 2005.

Mäkelä, A., Giller, V., Tsheligi, M., and Sefelin, R. (2000). "Joking, storytelling, artsharing, expressing affection: A field trial of how children and their social network communicate with images in leisure time." CHI00 Conference Proceedigns. New York: ACM Press, 548-555.

Mann, W.C., Hurren, D., Tomita, M., & Charvat, B. (1995). An Analysis of Problems with Walkers Encountered by Elderly Persons. Physical & Occupational Therapy in Geriatrics, 13(1/2), 1-23.

Marcoux, J-S. (2001). The 'Casser-Maison' Ritual. Journal of Material Culture, 6(2), 213-235.

Margolin, V. (1995). "The Product Milieu and Social Action." In Richard Buchanan and Victor Margolin (Eds.), Discovering Design: explorations in design studies. Chicago, IL: University of Chicago Press, 121-145.

Margolin, V. (1997). "Getting to Know the User." Design Studies, V18N3, 227-234.

Mateas, M., Salvador, T., Scholtz, J., and Sorensen, D. (1996). "Engineering ethnography in the home." CHI 1996 Conference Proceedings. New York: ACM Press, 283-284.

McCormack, M., & Forlizzi, J. (2000). Listening to User Experience: Integrating technology with proactive wellness management. Proceedings of the PDC 2000 Participatory Design Conference, 296-300. Palo Alto, CA: CPSR.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Mihailidis, A., Carmichael, B., and Boger, J. (2004). The use of computer vision in an intelligent environment to support aging-in-place, safety, and independence in the home. IEEE Transactions on Information Technology in Biomedicine (Special Issue on Pervasive Healthcare), 8(3), 1-11.

Moholy-Nagy, L. (1947). Vision in Motion. Chicago: Institute of Design Press.

Morris, M., Lundell, J., Dishman, E., and Needham, B. (2003). New Perspectives on Ubiquitous Computing from Ethnographic Studies of Elders with Cognitive Decline. Proceedings of Ubicomp 2003. New York: Springer Verlag, pp. 227-242.

Moss, P. (1997). Spaces of Resistance, Spaces of Respite: franchise housekeepers keeping house in the workplace. Gender, Place and Culture, V4N2, 179-196.

MOVAID, (2002). http://www-arts.sssup.it/research/projects/MOVAID/default.htm, accessed May, 2002.

Mynatt, E.D., Essa, I., & Rogers, W. (2000). Increasing the opportunities for aging in place. Proceedings of the CUU 2000 Conference on Universal Usability, 65-71. New York: ACM.

NAIC: National Aging Information Center. (1989). "Limitations in Activities of Daily Living Among the Elderly." http://www.aoa.gov/aoa/stats/adllimits/httoc.htm, accessed August, 2003.

Nardi, B.A., & O'Day, V.L. (1999). Information Ecologies: Using Technology with Heart. Cambridge, MA: MIT Press.

Nass, C., and Brave, S. (2005). Wired for Speech: How Voice Activates and Advances the Human-Computer Relationship. Boston, MA: MIT Press.

National Research Council. (1992). Human Factors Specialists' Education and Utilization: Results of a Survey. Washington, D.C.: National Academy of Sciences.

NavChair, (2002). http://www-personal.engin.umich.edu/~johannb/navchair.htm, accessed May, 2002.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Nelson, H. G. and Stoltermann, E. (2003). The Design Way. Englewood Cliffs, NJ: Educational Technology Publications.

Netting, R. (1986). Cultural Ecology (Second Edition). Prospect Heights, IL: Waveland Press.

Nelson, H.G. and Stoltermann, E. (2003). The Design Way: Intentional Change in an Unpredictable World. Englewood Cliffs, NJ: Educational Technology Publications.
Norman, D. (1990). The Design of Everyday Things. New York: Basic Books.

Norman, D. (2001). "Applying the Behavioral, Cognitive, and Social Sciences to Products."
http://www.jnd.org/dn/mss/BCSSandProducts.html, accessed September 2001.

O'Brien, J., Hughes, J., Ackerman, M. and Hindus, D. (1996). Workshop on extending CSCW into domestic environments. Proceedings of CSCW 1996. New York, ACM Press, 1-2.

Overbeeke C.J., and Wensveen, S.A.G. (2003). Reflection on pleasure: From perception to experience, from affordances to irresistibles. DPPI03 Conference Proceedings. New York: ACM Press, 92-97.

PA Census (2000).
http://www.city.pittsburgh.pa.us/cp/html/census_information.html, accessed June, 2005.

Pirkl, J.J. (1994). Transgenerational design: Products for an aging population. New York: Van Nostrand Reinhold.

Pirkl, J.J. (2005). Transgenerational House.
http://www.universaldesign.net/news/nov00.htm#Pattie%20Moore, accessed August, 2005.

Pirolli, P. and Card, S. (1995). Information Foraging in Information Access Environments. Computer-Human Interaction 1995 Conference Proceedings. New York: ACM Press, 51-58.

Prassler, E., Ritter, A., Schaeffer, C., and Fiorini, P. (2000). A Short History of Cleaning Robots. Autonomous Robots, V9, 211-226.

Rafaeli, A. and Vilnai-Yavetz, I. (2004). "Emotion as a Connection of Physical Artifacts and Organizations." Organization Science, v15n6, November-December, 671-686.

RAID Workstation, (2002). http://www.oxim.co.uk/std.html#RAID, accessed May, 2002.

RAIL, (2002). http://www.robotics.lu.se/Robotics/research/projects/RAIL/RAIL.html, accessed May, 2002.

Reeves, B. and Nass, C. (2003). The Media Equation: How People Treat Computers, Television, and New Media Like Real People and Places. Palo Alto, CA: Stanford University Press.

Rith, C. and Dubberly, H. (2006). "Why Horst W.J. Rittel Matters." Unpublished white paper.

Rittel, H., and Webber, M. (1974). "Dilemmas in a general theory of planning." In Nigel Cross (Ed.), Developments in Design Methodology. Chichester, UK: John Wiley and Sons, 135-144.

Salvador, T., Bell, G., Anderson, K. (1999). "Design Ethnography." Design Management Journal, pp. 35-41.

Sanders, E. B.-N. (2002). "Scaffolds for Experiencing in the New Design Space." Information Design, The Institute for Information Design Magazine (in Japanese). Tokyo, Japan: Graphic-Sha Publishing Company, Ltd.

Scherer, M.J., & Galvin, J.C. (1994). Matching people with technology. Rehabilitation Management, Feb/Mar, 128-130.

Shedroff, N. (2007). "A Unified Field Theory of Design." http://www.nathan.com/ed/glossary/index.html, accessed January, 2007.

Sheridan, T. B. (2002). Humans and Automation: System Design and Research Issues. Santa Monica, CA: HFES Press.

Silverman, P. (1987). Community settings. In P. Silverman (Ed.), The Elderly as Modern Pioneers. (pp. 234-262). Bloomington, IN: Indiana University Press.

Simmons, L. (1945). The Role of the Aged in Primitive Society. New Haven: Yale University Press.

Simon, H. (1968). The Sciences of the Artificial. Boston, MIT Press.

Social Ecology Web. (2006). http://www.seweb.uci.edu/cse/cse.html, accessed October, 2006.

Sonic Rim (2005). http://www.sonicrim.com, accessed June, 2005.

Stokols, D. (1992). Establishing and Maintaining Healthy Environments: Toward a Social Ecology of Health Promotion. American Psychologist. 47(1), 6-22.

Strasser, S. (1982). Never Done: A History of American Housework. New York: Henry Holt and Company, Owl Books.

Strauss, A.L. and Corbin, J. (1998). Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. Thousand Oaks, CA: Sage Publications.

Tollmar, K. and Persson, J. (2002). "Understanding Remote Presence." NordCHI02 Proceedings. New York: ACM Press, 41-49.

US Census (2000). http://www.census.gov/, accessed June, 2005.

Ward, R.A., La Gory, M., & Sherman, S.R. (1988). The Environment for Aging. Tuscaloosa, AL: University of Alabama Press.

Waters, J. E. and Gavin, A.B. (1980). "Social Ecology: A Method of Evaluating Groups." International Journal of Social Psychiatry, 26/4, 272-279.

Weick, K. E. (1993). "Sensemaking in organizations: Small structures with large consequences." In J.K. Murninghan (Ed.), Social Psychology in Organizations. Englewood Cliffs, NJ: Prentice Hall, 10-37.

Wheelesley, (2002). http://www.ai.mit.edu/people/holly/wheelesley/, accessed May, 2002.

Whittaker, S., Frohlich, D., and Daly-Jones, O. (1994). Informal communication: what is it like and how might we support it? CHI94 Conference Proceedings, 131-137.

Wickens, C.D, Gordon, S.E., and Liu, Y. (1997). An Introduction to Human Factors Engineering. New York: Longman/Addison Wesley.

Wikipedia, (2005). http://en.wikipedia.org/wiki/Vacuum_cleaner, accessed August 2005.

Willeges, R.C. (1995). Review of Experimental Design. In Ed. J. Weimer, Research techniques in human engineering. Englewood Cliffs, NJ: Prentice Hall.

Wright, P., McCarthy, J., and Meekison, L. (2003). Making Sense of Experience. In: Eds. M.A. Blythe, C.J. Overbeeke, A.F. Monk, and P.C.

Product Ecologies:
Understanding the Context of Use Surrounding Products

Wright. Funology: From Usability to Enjoyment. Dordrecht, the
Netherlands: Kluwer Academic Publishers, 43-53.

Appendix 1: Interview protocols

First interview protocol

A Introduction

1. We'd like to begin by getting to know you and your surroundings a bit. Tell us a little bit about yourself – where you were born, how long you have lived in Pittsburgh?

2. This is a nice home. How long have you lived here? Where did you live before? How would you compare this home with your previous home?

3. Who are the members of your immediate family (spouse, children, grandchildren)? Where do they live? How often do you see them? How do you stay in touch with them, and how often?

4. Who are the people you rely on most for help or in an emergency?

5. I'd like you to tell me about your day yesterday. Start when you woke up and "talk me through" your day.

6. Was yesterday different from an average day? If so, how?

B ADL/IADL/EADL

7. What do you feel are the most important things to do to keep your household running smoothly?

For each one:
• how often is it done?
• does anyone help you?
• what products do you use to do it?
• name one thing you like and one thing you dislike about this task.

8. Has doing these tasks changed for you in the past 10 years? 5 years? If so, how?

9. You mentioned (or did not mention) cleaning the house. I would like to ask you a few questions about housecleaning.

• describe the last time you cleaned your house. What did you do? Why?
• is planned housecleaning important? Why or why not?
• how often do you do housecleaning tasks?

Product Ecologies:
Understanding the Context of Use Surrounding Products

• does anyone help you?
• what products do you rely on for housecleaning?
• which ones do you like or dislike? Why?

10. Can we walk around the home and see:

• where cleaning products are stored?
• where mess and dirt collect most frequently in your home?

Final interview protocol

A The Product
1. What did you and your family think about the vacuum that was given to you?

2. Did you use the vacuum that was given to you?

3. (If yes) Tell me about the last time you used the (R, E).

4. Name three things that you liked and three things that you disliked about the (R, E).

5. Was the (R, E) easy to use or hard to use?

6. Was the (R, E) ineffective or effective in helping you clean?

7. Did the (R, E) change the way that you clean?

8. Did the (R, E) change how often you clean?

9. Did anyone else use the (R, E)?

10. Did others' use of the (R, E) change the amount that you cleaned?

B Perceived role

11. Please brainstorm all the kinds of vacuums you can think of.

12. Please tell me if the (R, E) cleans better or worse than.
__Eureka upright   __Shark Pro   __Broom
__Hoover upright   __Rainbow upright   __Dust mop
__Dirt Devil   __Shop vac
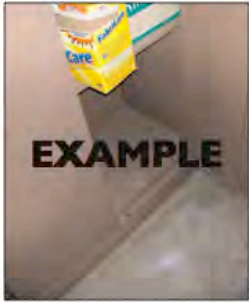
13. Is the (R,E) appropriate for you? Why or why not?

14. Would you buy the (R, E)? Why or why not?

15. Who is the (R, E) designed for?

Appendix 1: Journal protocols

Sample journal page

Date: 3/30
Time: 6:35 PM
Exposure: 26

Describe your mood at the time you took the photo.
Stressful, frustrated

How long have you been in this mood?
☞ Less than one hour   X ☞ About an hour
☞ Several hours   ☞ All day
☞ Other

A Study of Cleaning in the Home | Carnegie Mellon University

Describe the activity or situation you took a picture of:
I was running downstairs to do some laundry and I spilled the Tide. I was frustrated because I have to clean it up right now, but if I ignore it it will get worse.

Did you plan to do this activity? ☞ Yes X No

Describe the other products in the picture if there are any.
Box of Tide, which never stays shut after it is opened. Metal cabinet that holds the laundry supplies by the washer.

A Study of Cleaning in the Home | Carnegie Mellon University