# THE DESIGN AND ANTICIPATED ADOPTION OF AMBIENT INTELLIGENCE IN THE HOME

Somaya Ben Allouch

The studies described in this thesis were partly financially supported by the Netherlands Organisation for Scientific Research (NWO) and by the Centre for Telematics and Information Technology (CTIT) of the University of Twente.

Thesis, University of Twente
ISBN 978-90-365-2696-8


Cover Design: Erika Blikman
Printed by: Gildeprint B.V., Enschede

# THE DESIGN AND ANTICIPATED ADOPTION OF AMBIENT INTELLIGENCE IN THE HOME

PROEFSCHRIFT

ter verkrijging van
de graad van doctor aan de Universiteit Twente,
op gezag van de rector magnificus,
prof. dr. W. H. M. Zijm,
volgens het besluit van het College voor Promoties
in het openbaar te verdedigen op
vrijdag 27 juni om 16.45 uur

door

Soumaya Ben Allouch
geboren op 8 april 1979
te Enschede

Dit proefschrift is goedgekeurd door

de promotor: prof. dr. J. A. G. M. van Dijk
en de assistent-promotor: dr. O. Peters

All truths are easy to understand
once they are discovered;
the point is to discover them.

Galileo Galilei

# Contents

# 1

# Introduction

*In this chapter, first the context and the scope of the study will be presented, followed by an introduction of the emerging technology called "ambient intelligence". Next, the central research questions will be provided, followed by an overview of the content of the chapters.*

## 1.1 Context of the Study

In the present day, advanced societies are characterized by the constant introduction of new information and communication technologies in both private and public settings. A technology can become an instant success or a complete failure. It is not easy to determine in advance with which characteristics and under which conditions a technology will become successful, that is adopted by the anticipated population.

In 1988, "ubiquitous computing" was introduced by Mark Weiser as a vision for the future of computing. He referred to computing devices becoming invisible and unobtrusive thus allowing people to concentrate on whatever the task at hand (Weiser, 1988, 1991). "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991, p. 66). The initial embodiment of ubiquitous computing was created at PARC (Palo Alto Research Center, Inc.) where Weiser and his colleagues were working on products such as computing displays with different sizes called Tabs, Pads and Boards to start realizing the vision.

In 1997, on the occasion of the 50th anniversary of the Association of Computing Machinery (ACM) computer scientists from all over the world were asked their opinion on how information and communication technology would evolve and affect society in the next 50 years (Denning & Metcalfe, 1997). The scientists expressed one consistent view about the future of computing, namely they envisioned a world where people were surrounded by embedded, unobtrusive, invisible computing devices. An image of the future which was very similar to the thoughts of Weiser about ubiquitous computing. After this ACM conference, ubiquitous computing was almost immediately embraced by both academic and industrial research institutions all over the world and a new research area was born.

The European counterpart of ubiquitous computing was "ambient intelligence" (AmI) (Punie, 2003). Originally, Philips Research' vision of how people would live in future digital environments introduced the notion of ambient intelligence. "This is our vision of 'ambient intelligence': people living easily in digital environments in which the electronics are sensitive to people's needs, personalized to their requirements, anticipatory of their behavior and responsive to their presence" (Philips Research, 2005). Ambient intelligence should be seen as a natural evolution of ubiquitous computing by realizing unobtrusive environments which are aware and responsive to the presence of people (Aarts, 2004; Aarts & Encarnação, 2006).

The Information Society Technology Advisory Group (ISTAG) of the European Commission adopted the ambient intelligence vision in 2001. The European Commission used ambient intelligence for the launch of the Sixth Framework (FP6) in Information, Society and Technology (Aarts & Encarnação, 2006). Ambient intelligence was presented as a vision to illustrate how the information society will develop in the near future, around the year 2010 (ISTAG, 2001, p. 11):

> Ambient Intelligence stems from the convergence of three key technologies: Ubiquitous Computing, Ubiquitous Communication and Intelligent User Friendly Interfaces. …humans will be surrounded by intelligent interfaces supported by computing and networking technology which is everywhere, embedded in everyday objects such as furniture, clothes, vehicles, roads and smart materials even particles of decorative substances like paint. Ambient Intelligence implies a seamless environment of computing, advanced networking technology and specific interfaces. It is aware of the specific characteristics of human presence and personalities, takes care of needs and is capable of responding intelligently to spoken or gestured indications of desire, and even can engage in intelligent dialogue. Ambient Intelligence should also be unobtrusive, often invisible: everywhere and yet in our consciousness – nowhere unless we need it. Interaction should be relaxing and enjoyable for the citizen, and not involve a steep learning curve.

The convergence of ubiquitous computing, ubiquitous communication and intelligent user-friendly interfaces create the technological basis of ambient intelligence. A central role is assigned to people in the form of greater user-friendliness, more efficient services support, user-empowerment, and support for human interactions (ISTAG, 2001, 2003). The description of ambient intelligence is rather normative, since it aims to "design technologies for people and not make people adapt to technologies" (ISTAG, 2001, p. 11).

Currently, industry, governmental institutions and research communities are attempting to realize ambient intelligence. The European Commission reserved millions of Euros in the Sixth Framework (2002-2006) for research on ambient intelligence (CORDIS, 2002). Although ambient intelligence is still in its early development phase, the vision is starting to be realized by designers. Thus the first representation of what ambient intelligence really looks like is emerging.

The early stage of an innovation is considered to be important for research because the decisions reached here can be highly influential on the future development of the innovation (Rice & Rogers, 1980; Rogers, Collins-Jarvis, & Schmitz, 1994). Besides, ambient intelligence research and development needs a better understanding of human activity (Greenfield, 2006) to enable the inclusion of human and social aspects in the development process of this emerging technology. Finally, it is especially important to study ambient intelligence applications in an early stage of development because it is envisioned that ultimately this new innovative technology will permeate and impact every aspect of the daily lives of ordinary people.

## 1.2 Research Scope

Ubiquitous computing, pervasive computing, calm computing, everyware and tangible media are all used as synonyms for ambient intelligence; all give a glimpse into a future in which people are surrounded by embedded computing that is mostly invisible to the user (Birnbaum, 1997; Dertouzos, 1999; Greenfield, 2006; Weiser, 1988, 1991). Abowd and Sternbenz (2000) note that the different names emphasize different aspects of this vision, but that they all have one thing in common, namely the desire to create an enhanced symbiotic relationship between humans and their environment.

The focus of ambient intelligence is on the usage of consumer electronics that will bring a new kind of interaction with technology into our homes and personal domains to enhance our experiences and lives (Aarts, 2003). The new kind of interaction with technology that ambient intelligence will bring will mainly be realized by information and communication technologies. Future information and communication technologies will be better than today's information and communication technologies in several aspects such as being smarter, user-friendlier, and more context-aware (Aarts, 2003; Fersch & Mattern, 2004).

At what stage of development does ambient intelligence currently find itself? Ambient intelligence can be seen as a new technological innovation and therefore it can be located in one of the phases of an innovation process. Andriessen (1989) distinguishes three stages and six phases in the development and introduction of innovations. Andriessen's phases of the innovation process are based on Cozijnsen and Vrakking (1986), who initially outlined the phases in an innovation process (see Figure 1). At the time of writing, most ambient intelligent designs are only available at research labs where prototype applications are being developed and tested. Therefore, ambient intelligence can be currently located in the development phase with some designs entering the transfer phase. In the development phase the first designs are being developed, studied, tested and enhanced for future production. High-tech companies such as Philips and Samsung are now entering the market with prototypes of ambient intelligent applications. Actually, they are not fully developed "real" ambient intelligent applications because they do not yet have all the required characteristics specifying ambient intelligence such as being intelligent, context-aware and adaptive to people's needs. It would be better to see them as precursors. An example is the consumer product Ambilight TV, developed by the consumer electronics company, Philips, which has a built-in ambient lighting system which reflects the colors of the TV-screen so that the colors of the TV screen also surround the sides of the TV (Philips Research, 2007).

When a prototype design is developed into a product, the development stage is ended and the transfer stage is entered where the diffusion and adoption phases occur. The small number of designs that have already been transformed into consumer applications and brought to the market, can be located in an early transfer stage (the diffusion and adoption phases). In this phase, the first confrontation of ambient intelligent applications and their users will take place. As mentioned earlier, fully developed ambient intelligent applications are not yet on the market and therefore the implementation stage in which these applications will be introduced and incorporated into consumer households has not yet been reached. As can be seen in figure 1.1, presently we are gradually moving from the research and development phase towards the early diffusion of prototypes of ambient intelligent applications.

## 1.3 Technology Design and Adoption

The dominant research focus at the time of construction of the ambient intelligence vision was mainly technologically oriented; to enable and create the underlying technological conditions that create the technical potential of ambient intelligence. Recently a call has been made that ethnographical, sociological and psychological research is needed to provide insight into this new research area (Stewart, 2003). Scholars emphasize that attention should not only be focused on technological aspects of ambient intelligence but also on prospective users and social issues (Abowd & Mynatt, 2000; Edwards & Grinters, 2001; Friedewald et al., 2005; Punie, 2003) if ambient intelligence is to be a success, that means if it is to be adopted by prospective users.

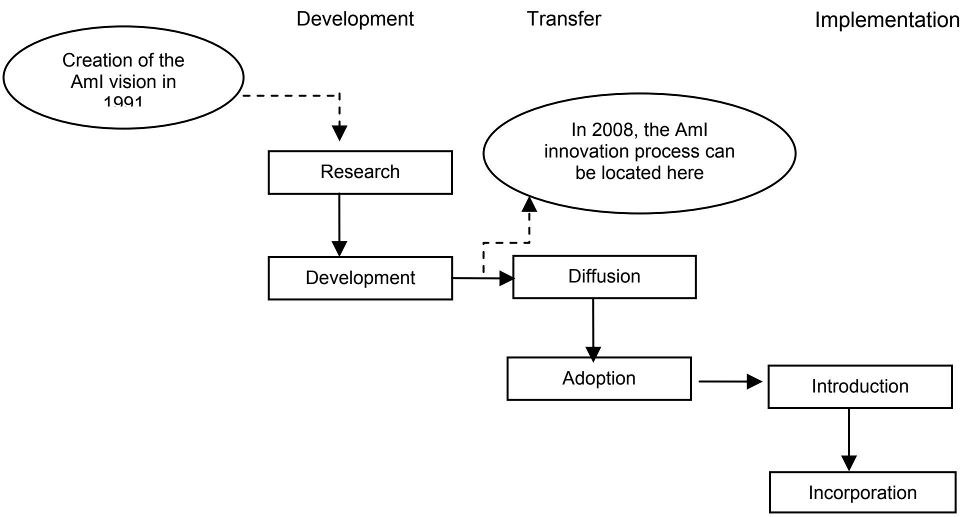


**Figure 1.1** Six phases of an innovation process of new technology (adapted from Andriessen, 1989, p. 18)

Scholars focusing on the relationship between technology and its (intended) use and users come from diverse disciplines such as communication science, sociology, social and feminist studies of science and technology and organizational and innovation studies (Bijker, 1995; Boczkowski, 1999; Kline & Pinch, 1996; Tyre & Orlikowski, 1994; von Hippel, 1988). These different disciplines make use of different theories that emphasize different objects of study. A well-known approach in the field of technology design and use is the so-called social constructivist approach.

Social constructivist theories imply that meanings of technologies do not reside in the technology itself, but are shaped through the interactions of designers, social groups and policymakers (Bijker, Hughes, & Pinch, 1987; Fulk et al., 1987; Latour, 1988; Poole & DeSanctis, 1990). The "mutual shaping of technology and users" perspective plays a central role in the theorizing of the relationship between technology and users: technology and users mutually shape one another. This perspective rests on the assumption that information and communication technologies are both agents of change that shape their contexts of use and objects of change that are reshaped and redesigned by producers, users and in user contexts. Information and communication technologies and their context of use interact in a process of mutual shaping.

Studies concerning the mutual shaping of technology and its users provide rich, qualitative descriptions of the design, introduction and use of technologies. These studies can have different focuses. For example, one group of studies which adopts the social construction of technology approach (Pinch & Bijker, 1984) is more focused on the design of technology whereas others focus on the configuration of the user (Woolgar, 1991a) or on the ultimate use of technology in private settings such as domestication studies (Silverstone & Haddon, 1996).

Theories and models originating from the field of communication science and information systems research, such as diffusions of innovations theory (Rogers, 1995) and user acceptance theories of technology (Davis, 1989; Venkatesh, Morris, Davis, & Davis, 2003) also study the introduction, acceptance and use of new technologies in the "diffusion and adoption of technology" perspective. This perspective is more quantitatively oriented than the mutual shaping perspective. However, the design process of an innovation is commonly not an object of study in user acceptance theories and models of technology. Additionally, the technological characteristics of an innovation are neglected in these models (Orlikowski & Iacono, 2001).

As mentioned earlier in paragraph 1.1, ambient intelligence is only in its early development phase and therefore there is as yet no process of mutual shaping between designers and users of this technology. However, the first designs of ambient intelligence are emerging and these can be confronted with potential users. This confrontation of design and adoption can best be understood as an anticipation of two sides: designers anticipating on future use and users and users anticipating on the potential adoption and use of ambient intelligent applications. This study tries to avoid the pitfall of focusing on either design or adoption and use by studying a technology in an early phase of its development to see how designers shape future use(rs) and how potential users anticipate the adoption of ambient intelligence.

## 1.4 Ambient Intelligence and the Home

The location in which Weiser envisioned ubiquitous computing happening was the office: "Activate the world. Provide hundreds of wireless computing devices per person per office, of all scales" (Weiser, 1988, p. 2). Recent developments have shown that the office is certainly not the only place where ambient intelligent applications will be introduced. The car, the home, public transport, health care and many more places are already being used as research environments for ambient intelligent applications. As posed by Aarts (2003), ambient intelligence is more focused on the home environment and the home is seen as one of the first places where ambient intelligent applications will be introduced. Therefore, in this thesis ambient intelligence will be studied in the context of domestic settings.

More and more homes are connected to networked services (e.g., Venkatesh, 1996) and "the home and office of the 1990s has become a show place for advances in computerized technology" (Rosen & Weil, 1995, p. 55). Gaver (2001) suggests that using workplace concepts such as efficiency and productivity to inform domestic design can be dangerous since the activities and values at home are different from those at the workplace. Hindus (1999) argued that domestic settings are substantially different from workplaces and that the home should be regarded as an important topic for technology research for a number of reasons: (1) homes are technology-filled buildings; (2) homes and technology are too important economically to ignore and will become even more so; (3) home technology has the potential to improve everyday life for millions of users; (4) studying technology in homes is a rich research area; and (5) homes are a challenging design venue; they deserve the attention of talented practitioners and innovators (p.200). Furthermore, the home is the only place beside the car were the confrontation of design and use can be studied in its purest form because here individual consumers are free to adopt this technology without the interference of institutions as, for example, in the office and public domain.

## 1.5 Research Questions

In this thesis, the interplay of designers and prospective users of ambient intelligent applications for domestic settings is investigated. The key research questions to be answered in this thesis are:

> *RQ1: What are the characteristics of ambient intelligence and how is ambient intelligence in the home represented to the general public by its producers?*

*RQ2: What are the key assumptions of designers of domestic ambient intelligent applications regarding prospective users and their needs?*
*RQ3: What are users' attitudes and intentions anticipating the adoption of domestic ambient intelligent applications?*
*RQ4: What agreements and differences between the assumptions and attitudes and intentions appear when design and use of domestic ambient intelligent applications are confronted?*

The contribution of the present study is fourfold:

1. it examines the development of a technology, in this case ambient intelligence, in its early stage of development;
2. it examines the assumptions of designers about prospective users of this emerging technology;
3. it examines the perceptions and attitudes of the Dutch people towards ambient intelligence;
4. it confronts both perspectives of the same innovation, on the one side the assumptions of designers and on the other side the perceptions and attitudes of prospective users.

## 1.6 Outline

This thesis is an exploratory journey into an interdisciplinary field that is still emerging. The nature of this interdisciplinary field will be clarified in the following chapters where theories, approaches and methods will be used which have their origins in different fields, such as, communication science, science and technology studies, social psychology, and human computer interaction. In this thesis, multiple approaches are used to gain insight into the bipartite process of design and anticipated adoption of ambient intelligent applications for domestic settings. Research into information and communication technologies will be more fruitful when several research paradigms and several additional methods such as qualitative and quantitative ones are simultaneously used (Rice, 1999).

The remainder of this thesis is structured as follows:
In Part I, the fundamentals of this thesis will be described in respectively Chapters, 2, 3 and 4. Chapter 2 describes in more detail the technical characteristics of ambient intelligence, followed by an overview of the different stages of technology development the home has gone through. Next, the broad spectrum of domestic

technologies and how they relate to domestic ambient intelligent applications will be discussed. Finally, ambient intelligence and its relationship with new media will be considered as part of it is based on communication technology.

Chapter 3 gives an overview of the different focuses of studies within the mutual shaping of technology and people approach. Theories of technology acceptance and use which are commonly used in the field of communication science and information systems research will also be discussed. At the end of the chapter a combination of multiple theoretical perspectives and their potential contribution to study a technology in its early development phase and its anticipated adoption will be proposed as the theoretical basis for this thesis.

Chapter 4 presents a brief account of the various social issues which are inherent to ambient intelligence such as privacy, control and trust and which can become potential barriers for prospective users to adopt ambient intelligent applications.

In Part II, Chapters 5, 6 and 7, the empirical studies will be described and findings will be presented. First, Chapter 5 presents the findings of an empirical study of the characteristics of domestic ambient intelligent applications as presented in promotional material of initial producers. A content analysis is used to analyze the textual and visual promotional material of several international high-tech companies that design domestic ambient intelligent applications for prospective users.

In Chapter 6, a study is presented that explores the assumptions of international ambient intelligent designers regarding their domestic ambient intelligent designs and their assumptions about prospective users. Using a qualitative method in the form of in-depth interviews, the designers' perspective on ambient intelligence is assessed.

Chapter 7 describes the findings of a quantitative study held amongst Dutch citizens. The anticipated adoption of domestic ambient intelligent applications by prospective users was investigated via a large scale national survey. The impact of different variables, such as the perceived benefits and perceived disadvantages of domestic ambient intelligent applications, on the intention to adopt ambient intelligent applications is explored.

Part III concludes this thesis with Chapters 8 and 9. Chapter 8 presents the conclusions drawn from the findings of the empirical studies presented in this thesis and thereby provides answers to the central research questions as posed in this chapter. Finally, Chapter 9 discusses the conclusions and their implications for the design and adoption of domestic ambient intelligent applications by prospective users. In this chapter, theoretical and practical implications are addressed. The limitations of the study are also discussed and the chapter concludes with recommendations for future research.

# PART I

## Fundamentals

# 2

# Ambient Intelligence in the Home

*The aim of this chapter is to describe in more detail the technical characteristics of ambient intelligence. Next, the home as one of the prominent environments where ambient intelligence will become manifest will be discussed, followed by a brief description of domestic technology and how domestic technologies relate to ambient intelligent applications designed for the home. Finally, ambient intelligence and its relationship with new media will be considered.*

## 2.1 Introduction

High levels of mobility, digital convergence, and large scale services and infrastructures are seen as important drivers to enable ubiquitous computing environments (Lyytinen & Yoo, 2002). Ubiquitous computing and ambient intelligence are strongly related to each other and ambient intelligence can be seen as an evolution of ubiquitous computing (Aarts, 2004). The three above mentioned enablers for ubiquitous computing are thus also very important for the future development of ambient intelligence.

To get a better understanding of the building blocks and characteristics of ambient intelligence it is necessary to better understand how ubiquitous computing is conceived. "We are therefore trying to conceive a new way of thinking about computers, one that takes into account the human world and allows the computers themselves to vanish into the background" (Weiser 1991, p. 66). Hereby, Weiser refers to computing being ubiquitously and unobtrusively present via embedded networked sensors in the environment. This notion of the disappearing of computers into environments introduced the terms of "calm computing" (Weiser & Brown, 1997), the "invisible computer" (Norman, 1998), "pervasive computing" (Satyanarayanan, 2001), and "everyware" (Greenfield, 2006).

Weiser's notion of ubiquitous computing has spurred numerous engineering projects worldwide where different scholars have focused on different aspects to realize ubiquitous computing. Kleinrock (2001) states that transparency, integration, convenience, and adaptivity are required to make "invisible" computational devices supportive of people's needs. Natural interfaces, context awareness and the development of automated capture and access systems of everyday experiences are central research areas for ubiquitous computing (Abowd & Mynatt, 2000). The need for more natural interfaces is caused by the whish to make interfaces more supportive of the broad range of human expressions and the leverage of humans' implicit actions in the world (ibid.). For example, researchers are working on the development of "tangible user interfaces" to allow people to interact in physical environments in a more natural way with digital information (Ishii & Ullmer, 1997). Furthermore, context-awareness is necessary for the realization of ubiquitous computing because ubiquitous computing aims to be adaptive to people's behavior and provide services to them which are based on information derived from the users' physical and computational environment (Abowd & Mynatt, 2000). Finally, ubiquitous computing systems are programmed to automate and record daily experiences so that they can be more easily accessed (ibid.).

## 2.2 Ubiquitous Computing versus Ambient Intelligence

The above described characteristics of ubiquitous computing seem to have more similarities than differences with ambient intelligence. However, Aarts (2003) argued that the fundamental difference between these two visions is that ubiquitous computing and pervasive computing are more focused on the office as the main environment and on concepts such as efficiency and productivity in business environments. Ambient intelligence is supposed to be more focused on a new kind of interaction with technology in the home environment and the improvement of the quality of people's lives. Whether this difference is currently still a basic fundamental difference is arguable since applications that are currently being developed in the ubiquitous computing area also have a strong focus on the home and its inhabitants such as the MIT House_n (Intille, 2002) and the Aware Home Project (Kidd et al., 1999).

Punie (2003) notes that ambient intelligence is preferred above ubiquitous computing as a term because it stems from the convergence of three key technologies, namely: ubiquitous computing, ubiquitous communication and intelligent user friendly interfaces. For this reason ambient intelligence implies a seamless environment of computing, advanced networking technology and specific interfaces. Such an intelligent environment is aware of the specific characteristics of human presence and personalities, takes care of needs and is capable of responding intelligently to spoken or gestured indications of desire, and can even engage in intelligent dialogue (ISTAG 2001, p. 11; Punie, 2003, p. 8). Punie also argues that ubiquitous computing emphasizes computing that is ubiquitous and that ambient intelligence is a vision that is not only focused on computing becoming ubiquitous but also that the devices will be able to communicate with each other and with their users in unobtrusive, easy ways.

In addition, the ambient intelligence vision originates from the Dutch high-tech company Philips and was adopted by the European Information Society and Technology Advisory Group (ISTAG). Therefore, ambient intelligence can be seen as the European counterpart of "American" ubiquitous computing (Punie, 2003). Different terms are thus being used to describe the lives of people in the future and the role technology is supposed to play in them. However, though different locations of use (office or home environment) or purpose of use (efficiency or enjoyment) are emphasized, it is stressed by Punie (2003) that the term ambient intelligence has to be interpreted in a similar way as the technological requirements that Weiser proposed as necessary to attain ubiquitous computing. *"The technology required for ubiquitous computing comes in three parts: cheap, low-power computers that include equally convenient displays, a network that ties them all together, and software systems implementing ubiquitous applications"* (Weiser, 1991, p. 72). The focus on people at the core of the ambient intelligence vision and the empowerment of users would not be so prominent anymore if we were to interpret ambient intelligence as the technological requirements for realizing ubiquitous computing.

## 2.3 Technological Characteristics of Ambient Intelligence

The key technological characteristics of ambient intelligence are summarized in the literature as follows: embeddedness, context-awareness, personalization, adaptation and anticipation (see Table 2.1). The first two features refer to the integration of hardware devices into the environment and to embedded systems in general. Embeddedness and context-awareness are considered to be important for ambient intelligence because they account for the embedding of electronic devices into people's environment. The other three features involve the adjustment of electronic systems in response to people, where personalization refers to system adjustments on a short time

**Table 2.1** Key technology characteristics of ambient intelligence (Aarts & Marzano, 2003, p. 14; Aarts & Encarnação, 2006, p. 2)

| | |
|---|---|
| Embeddedness | Many networked devices are integrated into the environment through large-scale embedding of electronics |
| Context-awareness | Devices can recognize you and your situational context through user location and situation identification |
| Personalization | Devices can be tailored to your needs through interface and service adjustment |
| Adaptation | Devices can change in response to you through learning |
| Anticipation | Devices can anticipate your desires without conscious meditation through reasoning |

scale and adaptation refers to adjustments of changing user behavior over a longer time period. These adjustments are detected by monitoring users, for example via cameras or sensors. The anticipation feature involves behavior adjustments over a very long time period. This last feature is compared with a butler who knows people's routines and offers support without conscious mediation (Aarts, 2004). In the home environment, the living room is a place which is targeted to become smarter so that it can adapt to the activities of the people in that room such as currently is being investigated in the Easy Living project (Brummit, Meyers, Krumm, Kern, & Shafer, 2000).

Applications and appliances that are fully "ambient intelligent applications" currently are not widespread in homes, offices or in other areas. They can mainly be found in academic and commercial research labs where prototype applications are being developed and tested such as the Easy Living Room which is being developed by Microsoft. Furthermore, it is argued that current work on ambient intelligence is focused more on input automation and that only a very small number of ambient intelligence projects are actually working on calm, pro-active systems that are adaptive to people's activities (Spiekermann, 2007).

In sum, in the rest of this thesis ubiquitous computing will be broadly defined as the technical infrastructure required for bringing computing and networking capabilities to people's everyday contexts. Ambient intelligence will be interpreted as an emerging technology concerned with the applications derived from ubiquitous computing and with the question how these applications can enhance people's everyday experiences in various environments (derived from Aarts, 2004; Punie, 2003).

Now that the general technological characteristics of ambient intelligence have been introduced, the next paragraph will be dedicated to the context in which ambient intelligence is investigated in this thesis, namely the home. The home environment has gone through different stages of technology development in the last century resulting in the networked home that is currently becoming available in some parts of the world such as in Asia, North America and Europe.

## 2.4 The Home

Although ambient intelligence is a relatively new concept, visions of one of its elements, such as the smart home, have been around for some time now.
The Dymaxion House was probably one of the first so-called "homes of the future", designed in the late 1920s by the American designer Buckminster Fuller. In the 1920s this house was way ahead of its time, because it was filled with communication technologies, such as a television set, a radio, a phonograph and several domestic office machines (Spigel, 1992). Since that time many projections of ever more advanced houses have been made and a rich research tradition into domestic settings and technology has developed with various focuses such as gender issues (e.g., Berg, 1999; Cockburn, 1997; Cowan, 1983; Wajcman, 1991) and information and communication technologies in the home (Cawson, Haddon, & Miles, 1995; Barlow & Gann, 1998; Heimer, 1995; Venkatesh, 1985; Venkatesh, Kruse, & Shih, 2003; Skinner, 1994). Cowan (1976) showed that the technological revolution in the home began at the beginning of the twentieth century when electricity and electrically powered appliances were introduced into the home. Since then several stages of technology developments have taken place in the home.

In the 1980s and 1990s manufacturers both in Europe and the United States started to work on "automation"of the home. Later they also focused their attention on smart homes and intelligent homes and tried to help the home automation field forward. "Interaction among producers was….more influential in shaping evaluations of the feasibility of products than more consumer feedback…the enthusiasts, including some major firms, were successful at winning over the majority to consider the plausibility of the innovation" (Cawson, Haddon, & Miles, 1989, p. 7). Different industries such as the telecommunications industry, the information industry, the computer industry, and the entertainment industry viewed the home as the next place for technological development (Venkatesh, 1985). But it can be noticed that innovation inside the home is one of the longest running areas of innovation that never became a market, although up-market products exist and there is some market visible, especially in the upscale housing segments.

Nowadays, the above mentioned industries can still be seen as the main drivers behind the development of ambient intelligent applications for domestic settings. New initiatives of technology innovation in the home are increasing. For example, Orange created its future home project to investigate consumers' views on home technology; Microsoft has its Easy Living project where the focus is on the architecture and technologies for intelligent environments; Samsung created HomeVita to experiment with its own home networking products; and Philips created the HomeLab where futuristic technologies help researchers to learn more about user preferences. The four industries are also accompanied by "original" producers of white and brown goods such as Electrolux. Electrolux has developed "intelligent" household appliances such as the Screenfridge, which is an "intelligent" refrigerator with an Internet connection.

Two initiatives, namely the technology and community initiative are suggested as being responsible for the gained importance of networked homes (Venkatesh, Kruse, & Shih, 2003). The technology initiative describes the rapid development and availability of communication technologies. And the community initiative deals with the question whether communities accept these new technologies.

The renewed interest for technology innovation in the home and the increasing number of technologies in the home (Venkatesh, 1996) yields a whole range of different names to describe these homes, from smart homes to networked homes. Aldrich (2003) proposed five hierarchical classes of smart home which she has based on the distinction made by Gann, Barlow, and Venables (1999) between homes which contain only smart appliances and those which allow interactive computing inside and outside the home.

The five classes of smart home are (Aldrich, 2003, p. 35):

1. Homes which contain single, stand-alone intelligent objects.
2. Homes which contain intelligent objects that are able to exchange information amongst one another.
3. Connected homes which have internal and external networks allowing for interactive and remote control of systems and access to services from within and outside the home.
4. Learning homes which use recorded and accumulated data to anticipate on people's needs and to control the technology
5. Attentive homes where people's patterns of behavior are registered and used to anticipate on their needs

This classification is comparable with the one Venkatesh, Kruse and Shih (2003) propose to identify the four stages of evolution of technology in the home: (1) the electrification stage; (2) the automation stage (smart home 1); (3) the intelligentification stage (smart home 2); and (4) the human substitution (robotics) stage (smart home 3). The third stage (intelligentification), the stage the technological home is in right now, shows that companies are developing intelligent and programmable applications for home use and home communication systems at a rapid pace that is comparable to the connected homes in Aldrich's classification. Although, academia and industry are trying to realize domestic ambient intelligent applications on a small scale in attentive home projects such as the Georgia Tech Aware Home (Abowd et al., 2002; Kidd et al., 1999), MIT_n house (Intille, 2002), and HomeLab (Philips, 2002) attentive homes are as yet far from everyday reality. Connected homes are more representative of the current stage of technology innovation in the home in large parts of the Western world. The core idea here is to connect all products and services of the home by means of a home network (Gann, Barlow, & Venables, 1999; Harper, 2003) and therefore the term networked homes is often used when referring to this stage of technology evolution in the home.

Venkatesh, Kruse and Shih (2003) define a networked home in terms of two components: an internal household network, which primarily consists of network relationships with family and friends and social circles; and an external network connecting the home to outside agencies, such as schools, shopping centers, work/office, and other civic community centers. The authors describe three ways to conceptualize the networked home, namely it should be embedded in the overall concept of "home as living space", it should capture the elements of networking in a transparent fashion and the home is not only viewed as a structure, but as a site of human and social processes central to the functioning of the family. Ambient intelligent applications are envisioned to play an important role in the "networked home" where they can interact seamlessly with each other and with internal and external networks (Petriu et al., 2000). From a network perspective, the home of the future will be filled with digital connections and can therefore be seen as one of the "nodes" in the network society (Castells, 1996, p. 470).

However, the home is not only a place which can be filled with technology; especially in the Western world it is also seen as a "private" and "safe" place. "The home is the product of our practical and emotional commitment to a given space, and as such it can be seen to be a phenomenological reality in which our identities are forged and our security maintained" (Silverstone, 1994, p. 45). The home is not only a space where people live and where identities and relationships are shaped and maintained and where all kinds of different activities are undertaken, it can also be seen as the borderline between the outside world (the public sphere) and the inside world (the private sphere) (Singleton & Schement, 2003). The boundary of the home is still seen as the most culturally significant spatial demarcation (Putman, 1999, p. 144). Putman also notes that the modern home is transformed "into a terminal of technical infrastructures" (p. 146), which includes water, gas, telephone and broadcast media, such as radio and television. It can be argued that at present, high-tech companies are expanding the technical infrastructures of modern homes by introducing intelligent technologies to the home and ambient intelligence will probably not only expand the technical infrastructure of future homes but also make it "invisible" to its occupants. Besides, Meyer and Rakotonirainy (2003) state that "home activities are informal, not necessarily structured and focused on tasks that will make the occupants lives more: safe, supportive, convenient, pleasant, enjoyable, entertaining and relaxing" (p. 160). Ambient intelligence proposes to enhance the experiences of these home activities and that they will be performed in a more convenient and pleasant way when people adopt domestic ambient intelligent applications.

Domestic technologies have been adopted by people in various ways and for various reasons, but mostly because of their functionalities (and more and more for their design). In the next paragraph, domestic technologies are discussed in more detail to understand how ambient intelligent appliances for domestic settings fit into the broad spectrum of current domestic technologies.

## 2.5 Ambient Intelligence and Domestic Technology

MacKenzie and Wajcman (1985) note that innovative technologies do not suddenly appear, but rather emerge gradually out of more or less changing technologies or out of combinations of existing technologies. Weiser (1988) envisioned computers that would "disappear" and become unobtrusively embedded in people's environments. He created this ubiquitous computing vision based on existing technologies such as the personal computer which in his view was too prominently present. Ambient intelligence consists of three key technologies, namely ubiquitous computing, ubiquitous communication and intelligent user friendly interfaces (Punie, 2003). This means that the building blocks of ambient intelligence are still in essence microelectronics, computers and telecommunications networks.

The three key technologies enable the key technology features of ambient intelligence, namely integration, context-awareness, personalization, adaptation and anticipation. For instance, intelligent user interfaces are proposed to enable a more natural interaction of people via sound and gestures with environments embedded with better artificial memories so that they become "smarter" and information services can be provided. Ambient intelligent applications will be more connected with each other; this means that appliances in the home will be able to communicate with each other and with internal and external networks to provide people with ubiquitous communication. Finally, the third key technology, ubiquitous computing, implies that ambient intelligent applications are unobtrusive and have built-in sensors through which they can collect information about people's activities and their environment to recognize people's locations and situations. Applying the technical characteristics of ambient intelligence to domestic technologies the picture then arises of domestic applications being embedded with (more) sensors and "intelligent" computing technology (microelectronics and software) that is accommodated with more natural interfaces and appliances being connected to each other and the Internet.

Domestic ambient intelligent applications are difficult to locate in the broad spectrum of technologies because they are often a combination of a communication technology (e.g., the Internet) and a domestic technology (e.g., the refrigerator). One often used example of a potential ambient intelligent appliance is the "smart refrigerator" (whether this is a good example of an ambient intelligent appliance is another discussion). The idea of the smart refrigerator is that it will make our everyday life more convenient. For example, it will help create the shopping list by knowing (because of the Radio Frequency Identification (RFID) tags attached to the food products and an RFID tag reader in the refrigerator) which items it has to order from the grocery store to refill the refrigerator and maybe even do the ordering through an internet connection. Looking at the smart refrigerator as an example, where should one locate this ambient intelligent appliance? Is the smart refrigerator an old-fashioned white good equipped with sensors and an Internet connection or should we emphasize the Internet connection and its Internet services such as sending e-mails and browsing the Web. Does the smart refrigerator then becomes a member of the new media family? A closer look into domestic technologies may shed some light on this issue.

### 2.5.1 Domestic Technology

Domestic technology is often divided in "white goods" and "brown goods" (e.g., Cockburn & Ormrod, 1993). From a feminist approach domestic technology is called the "Cinderella" technology (Cockburn, 1997). Cockburn argues that domestic technologies do not get the full attention of technology designers and marketers because of their lack of interest in domestic technologies and the lack of knowledge about the user, namely the female user. Since the home is one of the areas where ambient intelligence will be introduced it could be expected that designers will pay more attention to the female user in their design and marketing of ambient intelligent applications for in the home. This will probably not go as far as with the current trend in the design of mobile phones, where producers focus on women as a specific niche and therefore adjust their colors, shapes and add diamanté (e.g., the Gucci phone) to their mobile phones. The main reason for this is that the mobile phone is a device for individual use and ambient intelligent applications will be used in the home where usually more people of different genders live together. Some differences between the characteristics and use of white goods and brown goods are shown in Table 2.2.

**Table 2.2** Indications of so-called white goods and brown goods (Aldrich, 2003, p. 34)

| Example | White goods<br>Washing machine, cooker, vacuum cleaner, microwave | Brown goods<br>Hi-fi, TV, VCR, PC, camcorder, cable, games console, Internet |
|---|---|---|
| Function | Domestic work | Leisure |
| Effect on time use | Time-saving | Time-using |
| Underlying technology | Mechanical<br>Electrical | Electronic<br>Computer |
| Orientation | Self-contained | Bring “outside in” |
| Designers’ attitude | “pedestrian” | “leading-edge” |
| Exposure in home | Behind the scenes | On show |
| Consumer uptake | Push | Pull |
| Gender stereotype | Female | Male |
| Workplace findings | Not relevant | Some limited relevance where technology is “domesticated” |

Although this classification is not entirely relevant for ambient intelligence, the first three rows show that domestic ambient intelligent appliances can be seen as the convergence of white goods and brown goods. This indicates that ambient intelligence brings the brown good characteristics into the white goods: ambient intelligence replaces the mechanical and electrical by computing and networking technologies. It also encompasses appliances which are aimed for both domestic work and leisure and which are both time-saving and time-using.

Ambient intelligent applications are envisioned to improve people’s quality of life. This can be interpreted in different ways of course, but one of the main aspects that is emphasized by producers of ambient intelligent applications is to make our everyday lives easier (Ben Allouch, van Dijk, & Peters, 2006). The claim is that everyday life will become easier because ambient intelligence will take care of people's routine tasks and therefore they will be able to focus their attention on other "more important things". The time-saving aspect of white goods would therefore be applicable to ambient intelligent applications. Bowden and Offer (1994) showed that time-using goods and time-saving goods have had different adoption rates since the 1920s in Britain and the United States. They refer to time-saving goods as goods which can reduce the time required for a specific task and increase the quantity of discretionary time. Time-using goods on the other hand require discretionary time and enhance its perceived quality. Due to the adoption of time-using goods and the time people spent on them, the time spent on time-saving goods was reduced (Bowden & Offer, 1994). In this light, Aldrich (2003) notes that time could be an aspect to pay attention to with regard to the diffusion of smart home technologies since time-using goods (such as the television) were adopted faster than time-saving goods (such as the washing machine) and they were less dependent on household income. If we look at current ambient intelligent appliances such as the smart refrigerator where both a white good function (refrigerator) and a brown good function (Internet) reside, the boundaries of time-saving and time-using are getting blurred since they are both available in one and the same appliance. So, a clear-cut distinction between the smart refrigerator belonging to either a brown or a white good cannot be made anymore.

The smart refrigerator encompasses a refrigerator which includes RFID sensor tags and internet capabilities. Under what category of goods does the smart refrigerator fall or is the distinction between white goods and brown goods not sufficient anymore with the introduction of ambient intelligent appliances into future homes? One of the main functions of the smart refrigerator is to keep food fresh for longer. This is of course still possible, but added features such as surfing the internet, communicating with family members through video messages or using the refrigerator as a time-saving good because it can order foods for you that can be delivered to your home makes it difficult to say that this refrigerator is just a refrigerator as we have known it for the last two centuries. If we separate the smart refrigerator into parts which are familiar to us, then the refrigerator can still be placed under the white goods and the internet and the communications capacities belong to the brown goods family. However, it will become more and more difficult to separate the white and brown goods characteristics in other, more fully developed ambient intelligent appliances due to the convergence of the characteristics of white goods and brown goods and the characteristics of ambient intelligence such as context-awareness, adaptation and anticipation. Due to the characteristics ascribed to ambient intelligent applications in general, it can be argued that in particular the ambient intelligent appliances that are being developed for the home environment can be currently viewed as a convergence between white goods and brown goods with additional computing (such as RFID technology) and networking features to perform specific tasks (e.g. notify that certain products are not in the fridge anymore).

Defining domestic ambient intelligent appliances as a convergence of white goods and brown goods and ambient intelligent characteristics is not the whole story. The evolution of an intelligent refrigerator becoming a communication medium through its changing interface and internet capabilities implies an evolution from domestic appliances towards a sort of communication medium. Thus within a general framework, ambient intelligence can also be seen as a convergence of domestic technologies with information and communication technologies whereby ambient intelligence creates new media as well.

## 2.6 New Media

A broad definition of media is given by Fiske (1990) who defines it as "the technical or psychical means of converting the message into a signal capable of being transmitted along the channel" (p. 18). Face-to-face communication is a medium, as is telephone, radio, e-mail, and SMS (Short Message Service). Thus this broad definition of media includes both face-to-face communication as well as mediated communication. In the literature a distinction is made between "media" and "new media". Williams, Rice and Rogers (1998) define new media as "those media technologies, mostly electronic and digital, that are undergoing expansion in our times. The key technologies underlying the new media include microelectronics, computers and telecommunications networks" (p. 3), which as indicated above, are also in essence the building blocks of ambient intelligence.

Other scholars (e.g., Arnbak, Van Cuilenberg, & Dommering, 1990) note that developments in new media are mainly the consequences of the convergence between the worlds of broadcast and video, computers and information technology. Furthermore, it is emphasized that the usage of digital code, the integration of telecommunications, data communications and mass communications in a single medium and interactivity of media are the defining characteristics of the new media (Van Dijk, 2006). The road from "old" to "new" media can be characterized by both a structural and technical communications revolutions (Van Dijk, 2006). Looking at these media definitions it can be argued that ambient intelligent appliances could also be placed under the umbrella of new media because these appliances are transforming into a kind of communication media, especially through their specific human/appliance interface and their telecommunication capabilities. Furthermore, when looking at the convergence of the three key technologies (i.e., ubiquitous computing, ubiquitous communication, and intelligent user friendly interfaces) which form the technological basis for ambient intelligence; these technologies essentially all consist of information and communication technologies.

In the history of the media several communications revolutions have taken place. A structural communications revolution refers to fundamental changes that take place in the coordination of space and time and a technical communications revolution refers to fundamental changes which take place in the structure of connections, artificial memories and/or the reproduction of their contents (Van Dijk, 2005). Williams, Rice, and Rogers (1998) point out that new media can be very "new" but that in many cases a new medium is an extension of an older medium, for example television and its successor interactive television. With the arrival of new media especially a technical revolution took place with the introduction of digital code (Van Dijk, 2006).

The primary technical revolution of ambient intelligent appliances is that they become more connected, faster, and equipped with better artificial memories so that they become "smarter" and with an essential change in the interaction of people with appliances through changing interfaces.

The new media create a structural communication revolution as they transcend the limits of both space and time and link online and offline environments. Ambient intelligent applications are par excellence supposed to link physical environments with "online" environments and should transcend the limits of space and time. Therefore, it could be argued that ambient intelligence will create a structural communication revolution too.

This structural revolution has to be seen in the light of the changing relationship between people and ambient intelligent applications. The anticipation feature of ambient intelligence plays an important role here. Applications will need to make their own automatic decisions for people based on what they "know" of people's behavior, activities, and locations so that they can anticipate on that and "serve" people. Furthermore, ambient intelligence also transcends the limits of place and time in the interaction with the direct environment when these appliances are connected to the internet and to other applications. Just as the new media created structural and technical communications revolutions, ambient intelligence will probably also create these communications revolutions.

## 2.7 New Media and Social Contexts

People have adopted domestic technologies for a long time now and researchers have already focused on the daily usage of information and communication technologies in the home and how this changes social arrangements within the household (Haddon & Silverstone, 1994; Haddon, 1995). The technological characteristics are emphasized in the definitions of new media by Fiske (1990), Williams, Rice and Rogers (1998) and Van Dijk (2006). Lievrouw and Livingstone (2002) have included the social contexts in their definition of the new media. By new media they refer to information and communication technologies and their associated social contexts, incorporating three elements: 1) the artifacts or appliances that enable and extend our abilities to communicate; 2) the communication activities or practices we engage in to develop and use these appliances; and 3) the social arrangements or organizations that form around the appliances and practices (Lievrouw & Livingstone, 2002, p. 7). This definition of new media is interesting if ambient intelligence is also perceived as a new communication technology as is argued in the previous paragraph.

The home is a social context where a lot of communication activities take place that are supported by information and communication technologies. This also goes for the "improved" information and communication technologies which are currently being developed to realize ambient intelligence. For example, ambient intelligence aims to enhance or extend the ability to communicate, whether this will be between person-to-person, person-to-device or device-to-device. The communication activities that people will engage in to use ambient intelligent applications have not yet been extensively studied. It is most likely that people will develop new or adapted communication activities when using ambient intelligent applications remembering the new behaviors and social norms which evolved when people collectively started to use the mobile telephone and the Internet.

The social arrangements of people and between people that will be created around ambient intelligent devices are unknown and they are unpredictable at this moment. How these new media will be experienced by people, who will use them and what kind of behavior these people will display and what consequences the usage of ambient intelligent applications will have in everyday life are questions that cannot be answered yet. Evidently, some sort of social arrangement will occur around them; only the exact form is as yet unclear. As Dourish (2001) notes, previous research has shown that it is most likely that new modes of use emerge around new technologies.

In sum, based on the different arguments which are given in the previous paragraphs, domestic ambient intelligent applications can be seen both as a convergence of white good and brown good domestic appliances with additional ambient intelligence features (although not yet all features) and they can also be partly placed under the umbrella of the new communication technologies.

In this chapter it is clarified that several projects in academic and industrial settings are currently being undertaken to develop, demonstrate, deploy, and test domestic ambient intelligent appliances. They are being undertaken to find out how prospective users perceive and experience these appliances and what can be adapted to better suit their whishes and needs. This deployment of ambient intelligent appliances often not only reveals technical and usability problems but it also raises questions about the adoption and usage of ambient intelligence in domestic settings. In the next chapter, theories about the social shaping of technology and theories concerning the adoption and use of technology are discussed in order to better understand the design and anticipated adoption of ambient intelligence in the home.

# 3

# Technology Design, Adoption and Use

*This chapter focuses on two main theoretical perspectives which are commonly used to study the relationship between technology and its usage. First, the more general perspective, the "mutual shaping of technologies and users" will be described in more detail. Then, the "diffusion and adoption" perspective will be presented which is more specifically oriented on user acceptance models of technology will be presented. The chapter concludes by combining both perspectives in the empirical studies which will be presented in the following chapters.*

## 3.1 Technology and Society

It is encouraging that the founding fathers of ambient intelligence aim their focus on people. After all, this is not a regular focus. For a long time, technological determinism dominated the field and the focus was only on technology and its effects on society. Technological determinism is defined for example as "the belief in technology as a key governing force in society" (Smith, 1994, p. 2), and as "the belief that technical forces determine social and cultural changes" (Hughes, 1994, p. 102). In this view, technology has a direct impact on society and is independent of social, cultural or political forces and, finally, people are seen as passive receivers and users of technology.

Since the late 1970s the view shifted towards the inclusion of the user in technology development, and to adoption processes after the rejection of technological determinism (e.g., Fulk et al., 1987; Kling & Scacchi, 1982; Winner, 1977). In the so-called "Social Shaping of Technology" (SST) perspective (MacKenzie & Wajcman, 1985) technological determinism is rejected. SST addresses the content of the technologies and the process of innovations by opening the 'black-box' of technology (MacKenzie & Wajcman, 1985; Pinch & Bijker, 1984). The linear model of technology having a direct impact on society and its individuals is no longer viewed as a valid model of representing the relationship between technology and users.

At present, the relation between technology and its (intended) usage is studied in diverse disciplines such as communication science, information systems research, sociology, social and feminist studies of science and technology and organizational and innovation studies (Bijker, 1995; Boczkowski, 1999; Cockburn & Ormrod, 1993; Kline & Pinch, 1996; MacKenzie & Wajcman, 1985; Suchman, 1987; Tyre & Orlikowski, 1994; von Hippel, 1988; Venkatesh, Kruse & Shih, 2003). The main focus of this thesis is to understand how designers of ambient intelligence shape prospective users and how users anticipate the adoption of ambient intelligence in domestic settings. Therefore the research focus of theories and approaches that can provide insight into this relationship should include:

a) the nature of the technology and its design
b) user needs, acceptance and usage processes
c) a contextual approach to both the technology, its acceptance and usage and its (potential) implications.

A contextual approach is emphasized here since both the design of ambient intelligence and its adoption by prospective users and the specific research setting, the home, have to be considered in the light of their social and cultural contexts (historical and political contexts are also important, but beyond the scope of this study).

In the following sections, relevant theories and approaches from diverse disciplines that incorporate the three above mentioned elements will be presented and discussed to clarify how relationships between technologies and its usages are conceptualized.

## 3.2 The Mutual Shaping of Users and Technologies

Social constructivist theories represent the reciprocal relationship between users and technology. Social constructivist theories imply that meanings of technology do not reside in the technology itself, but are shaped through the interactions of designers, social groups and policymakers (Bijker, Hughes, & Pinch, 1987; Fulk et al., 1987; Latour, 1988; Poole & DeSanctis, 1990). A central concept in social constructivist theories is the "mutual shaping of technologies and users": technologies and users mutually shape one another. It rests on the assumption that technologies are both agents of change that shape their contexts of use and objects of change that are reshaped and redesigned by producers, users and in user contexts. Technologies and their context of use interact in a process of mutual shaping.

Several approaches can be distinguished within the general mutual shaping of technologies and users perspective, such as the Social Construction of Technology approach (SCOT) (Pinch & Bijker, 1984), semiotic approaches such as the configuration of the user (Woolgar, 1991b), the script-approach (Akrich, 1992, 1995) and users as producers of technologies approach (Mackay, Crane, Benyon-Davies, & Tudhope, 2000; Oudshoorn & Pinch, 2003). The focus of analysis in these approaches were technological systems such as electrical power networks (Hughes, 1983), the bicycle (Pinch & Bijker, 1984), missile guidance systems (MacKenzie & Wajcman, 1985) and communication technologies also followed as objects of study (Poole & DeSanctis, 1990; Fulk, 1993; Boczkowski, 1999).

Further we find Anthony Giddens' structuration theory that has inspired the development of the adaptive structuration theory (DeSanctis & Poole, 1994). Giddens (1984) postulates that human action influences and modifies institutional structures and arrangements. DeSanctis and Poole adapted Giddens' theory to study the relationship of groups with information and communication technology in an organizational setting. They criticize the technology-centered view of technology use and state that the impact of communication technologies is not a direct process but has to be viewed as a mediated one (DeSanctis & Poole, 1994).

The different approaches within the mutual shaping of users and technology perspective have in common that they see technology as a social product which does not follow any inner technical logic but is patterned by the condition of its creation and use (Williams & Edge, 1996). In addition, research in this field focuses on the ways in which social, institutional, economic and cultural factors have shaped (Williams & Edge, 1996, p. 868):

a) the direction as well as the rate of innovation;

b) the form of technology: the content of technological artifacts and practices;

c) the outcomes of technological change for different groups in society.

In addition, the mutual shaping perspective is characterized by its more general and qualitative nature and does not aim to develop models to explain or predict technology adoption or posit specific causal relations. Analyzing empirical causal relations to understand the relationship between technology adoption and usage is prevailing in more quantitative adoption research which is conducted in disciplines such as information systems research, psychology and communication science.

The focus of the mutual shaping of users and technology perspective on both the content of technology and on the outcomes of innovations on society offers interesting insights and opportunities to study emerging technologies such as ambient intelligence. Some of the well-known approaches within the mutual shaping perspective will be briefly summarized in the next section to see how the relation between technology and user is conceptualized in these different approaches.

## 3.3 Different Approaches within the Mutual Shaping of Technology

*Social construction of technology.* The social construction of technology (SCOT) approach was one of the first approaches where users are defined as a social group that played an important role in the construction of a technology (Pinch & Bijker, 1984). Different social groups such as men and women could assign different meanings to a technology, which came to be known as the concept of "interpretative flexibility of technology". After a number of social processes have occurred the interpretative flexibility of a technology reaches stabilization and a prevailing use of the technology is noticeable (Bijker, 1995; Bijker, Hughes, & Pinch, 1987). Although the SCOT approach included users as relevant social groups when investigating the relation between technology and its users, it is criticized for its limited awareness of the active role users could play in adopting and redesigning stable technologies (Mackay & Gillepsie, 1992) and for its tendency toward social determinism (Hughes, 1994). Furthermore, the primary focus on the design of a technology in the SCOT approach is criticized because alternative uses of technology are neglected as well as the question how technology is used in social relations is neglected (Cockburn & Ormrod, 1993; DuGay, Hall, Janes, Mackay, & Negus, 1997).

*Semiotic approach*. The metaphor of "technology as text" was introduced by Woolgar (1991a) to emphasize the interpretative flexibility of technology. Cooper and Woolgar (1994) explored the metaphor of "technology as text" in their study analyzing computer software to show the different ways technology can be read. The term "preferred readings" is used in this context to note that a certain use of technology is predetermined by the designers via the technical features to make users react in a particular way. Woolgar noted that reading the technology is limited since designers and producers configured the user' in this process. He describes the process of "configuring" as "defining the identity of putative users, and setting constraints upon their likely future actions" (Woolgar, 1991b, p. 59). The semiotic approach of technology focuses primarily on how users are represented by designers of technology. Although the semiotic approach seems to have resemblances with the SCOT approach, the semiotic approach differs from the SCOT approach in that it focuses more on the representation of users by designers in technological innovations and not so much on the implication of users and social groups in the technology development process

(Oudshoorn & Pinch, 2003). Scholars criticized Woolgar's work for being a one-way process where only designers configured users while designers are configured too by both users and the organizations they work for (Mackay et al., 2000).

Another key concept in the semiotic approach to users is the concept of script. Embedded in actor-network theory, Akrich (1992) compared technologies to film and noted that "like a script, technical objects define a framework of action together with that actors and the space in which they are supposed to act" (p. 208). The aim of the script-approach is to emphasize that "technical objects participate in building heterogeneous networks that bring together actants of all types and sizes, whether human or non-human" (Akrich, 1992, p. 206) and that not only people can have the status of actors in social constructivism approaches. Akrich (1995) indicated that innovators are interested in their future users from the start and that they construct many different representations of their future users, and they objectify these representations in technological choices. Following from this, designers "inscribe" their visions of future users into the technology and specific skills, practices, and responsibilities are attributed to and delegated to the envisioned users of the technology (Akrich & Latour, 1992). The script-approach is for example adopted by scholars to analyze how specific inscriptions of users in technologies can prevent the inclusion of certain groups of users (e.g., women) (Van Oost, 1995; Oudshoorn, 1996; Rommes, 2002).

The ethnographic approach is also used within the mutual shaping of users and technology perspective to emphasize that the attribution of meanings of people to technologies is more important than their technical features. Suchman (1987) provided a rich description in the case of human-machine interaction to show that the situational context of a person's action is necessary to understand the attributed meanings of users to a technology, even if these are technically skilled users.

*Domestication approach*. A related approach is the so-called domestication approach. From a sociological perspective and anchored in cultural and media studies, the "domestication" approach (Silverstone & Hirsch, 1992; Mansell & Silverstone, 1996) focuses on how information and communication technologies are domesticated by users in their everyday lives. The domestication approach focuses on the social and cultural consequences of the adoption and use of technologies (Silverstone & Haddon, 1996; Frissen, 2000; Berker, Hartmann, Punie, & Ward, 2006). Silverstone and Haddon (1996, p. 60) suggest that the innovation process of media and information and communication technologies can be seen as a process of domestication because it involves the "taming of the wild and a cultivation of the tame". By this they mean that new technologies that enter the home are both exciting and threatening and are brought under control by the members of the household. So, domestication refers to the ability and activities of people to make new technologies their own, to incorporate them in their daily lives. The domestication process is studied in the context of everyday life, especially in the micro-social context of the household.

Four phases are specified in the domestication process, namely: appropriation, objectification, incorporation, and conversion. Appropriation refers to the stage where a technology or service is bought by individuals or households and becomes owned. In the objectification phase, the display of the technology reveals the "principles that inform a household's sense of its self and its place in the world" (Silverstone, Hirsch, & Morley, 1992, p. 22). In the incorporation stage, information and communication technologies are used by household members and incorporated into their everyday routines. In the final phase, conversion is referred to as the phase in which the use of technologies by the household members shape relations between the household members and those outside the house. The emphasis is now less on the internal structure of the household but more on how these technologies shape other people's understanding of the household members in terms of status and/or lifestyle (ibid., p. 25).

The domestication approach provides a lot of insight into how people make new technologies their own in domestic settings and how they shape and are reshaped by their users. The domestication approach would be very appropriate to investigate ambient intelligent applications in domestic settings. However, reality is that domestic ambient intelligent applications are currently not widespread in domestic settings over the world, they are largely still in the development and research phase and therefore it is not possible to see how ambient intelligent applications are being incorporated into households and how the adoption process develops. The domestication approach could therefore be very useful in a later stage when ambient intelligent applications are more common in people's everyday environments.

One of the latest contributions to the mutual shaping perspective is the focus on users and non-users as active agents of technological developments. Oudshoorn and Pinch (2003) emphasize that users are not passive recipients of technology but that they are active contributors and even co-producers of technologies. Concepts such as 'lead users' are adopted referring to users who produce their own innovations and share these innovations with other people who can adopt them so that the innovation can be improved (Von Hippel, 1986).

### 3.3.1 Shaping Ambient Intelligence

With all their differences, the above described approaches of the mutual shaping perspective have in common that they share the belief that both technology and people play an important role in understanding the influence of both on each other. Boczkowski (1999) argues that the crucial contribution of the mutual shaping perspective of technology-in-use is "not that every user's reconstruction should always be analytically deconstructed, but that any one could be deconstructed if necessary" (p. 92).

Applying this thought to ambient intelligence, this means that since this emerging technology is in its development phase people have not yet been confronted with this technology; at present there is no technology-in-use. How ambient intelligence shapes people's practices and how ambient intelligence is shaped by its users cannot be analyzed very well at the moment. In other words, the user of an ambient intelligent application does not reconstruct anything (yet). Therefore the user's relationship with the technology cannot (yet) be deconstructed. However, the approaches within the mutual shaping perspective discussed above provide multiple reference points to study the mutual shaping of ambient intelligence in its early development process for the construction of ambient intelligence by its designers (the first phase) and their construction of users. The script-approach is a very useful approach to study whether and how designers of ambient intelligence inscribe their visions of future users into ambient intelligent applications. The script approach is applied to answer the second key research question of this study concerning the designers' assumptions about prospective users of domestic ambient intelligent applications. Therefore, the mutual shaping perspective will be used throughout this thesis to help understand the relationship between ambient intelligence, its design, its anticipated adoption by users and its potential implications on both users and society.

## 3.4 Explaining and Predicting Technology Adoption

Although domestic ambient intelligent appliances are not yet commercially available, this does not mean that we or the designers who are creating these applications cannot already try to understand how people will anticipate on the adoption of ambient intelligence in domestic settings. As discussed above, the mutual shaping perspective provides important reference points for understanding the relation between technology and users. Specific causal relations to explain or predict technology adoption and usage are, however, not pursued in the mutual shaping perspective. Adoption research in other disciplines has focused on empirical causal relations between technology adoption and usage.

The disciplines of psychology and communication science and the field of information systems have been investigating the acceptance and use of information and communication technologies for decades now and empirical causal relations are pursued here. In these disciplines and this field theories have been adapted from, amongst others, social psychology to explain and predict how and why individuals adopt new information and communication technologies. In the rest of this section, some well-known user acceptance theories and models of technology will be presented and discussed to improve our understanding of how the adoption of ambient intelligent applications in domestic settings can be anticipated.

### 3.4.1 User Acceptance Theories of Technology

There are some well-known theories and models of technology acceptance and use, such as the diffusion of innovations theory (Rogers, 1995), the technology acceptance model (TAM) (Davis, Bagozzi, & Warshaw, 1989; Davis, 1993) and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003). Most of these theories and models were developed to study the acceptance and use of technologies in organization settings. Furthermore, the objects of study in adoption research, specific technologies, are often demonstrated in real life to the users or are already in use by them. Ambient intelligent applications are still in the development and research phase; they are only available in industrial and academic research labs and are not in use in homes. Therefore, at this stage, it is merely possible to anticipate the adoption of ambient intelligent applications. In order to explain and predict the anticipated adoption of ambient intelligent applications from their current development phase, we need theoretical models that focus on this early stage of development. The diffusion of innovations theory, the technology acceptance model and the unified theory of acceptance and use of technology could shed light on the anticipated adoption of ambient intelligent applications.

The diffusion of innovations theory focuses on technology adoption (Rogers, 1995). The adoption process in this rational choice theory consists of four stages: knowledge, persuasion, decision and confirmation. Use of technology is only viewed as continued adoption or rejection of a particular innovation. The advantage of this theory is that it is a broad theory that looks at macro-level sociological, psychological, communication and technological factors that influence the rational choice decision process for the adoption of an innovation. Looking at the current development stage of ambient intelligent applications, the phases of decision and confirmation in the diffusion of innovations theory have not yet been reached for this innovation; only the first two phases of knowledge about ambient intelligence and persuasion that it is a beneficial emerging technology for people are starting to become visible. Furthermore, the focus in this study is on the attitudes and intentions to adopt ambient intelligent applications on a micro-level, namely, at the individual level. The diffusion of innovations theory is too general for this study with its (partly) macro-level and linear causes for the adoption of a technology which makes it less suitable for this kind of research.

More promising might be the technology acceptance model (TAM) (Davis et al., 1989; Davis, 1993), which is based on the psychological theory of reasoned action and the theory of planned behavior (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980). TAM introduces two constructs, the perceived usefulness and the perceived ease of use of a particular technology as a function of attitude which causes actual use. The focus of TAM is on acceptance of new technologies instead of the use of technologies. TAM is often used in situations where technologies are in use by people or users have at least briefly used them in training sessions or during demonstrations so that users can make judgments about the perceived usefulness and the perceived ease of use of the new technologies. Unfortunately, it is not possible in this study that users will have first-hand experience of ambient intelligent applications, since they are not yet commercially available. Therefore, TAM is not fully appropriate for predicting the intention to adopt ambient intelligent applications.

Venkatesh et al. (2003) integrated several user acceptance models (including diffusion of innovation theory, theory of reasoned action, technology acceptance model, theory of planned behavior, social cognitive theory) into the unified theory of acceptance and use of technology (UTAUT). Both acceptance and use of technology are addressed in UTAUT and UTAUT outperformed the individual user acceptance models in terms of explained variance. The constructs performance expectancy, effort expectancy, social influence, and facilitating conditions are found to be significant direct determinants of user acceptance behavior. Venkatesh et al. (2003) excluded the attitude concept in their model arguing that attitude does not have a significant influence on behavioral intention and that attitude is only significant when the key predictors performance and effort expectancies are not included in the model. However, the attitudes of people towards ambient intelligent applications are important to consider when studying the acceptance of new technologies, anticipating the adoption of new technologies can be linked to general attitudes. And affective attitude is shown to be an important explanatory variable in other studies of new technology acceptance and use (McFarland & Hamilton, 2006; Pedersen, 2005). UTAUT therefore also does not provide all the necessary elements to study the anticipated adoption of ambient intelligent applications in domestic settings.

The social cognitive theory (Bandura, 1986) is a social psychological theory in which human behavior is defined as a triadic, dynamic, and reciprocal interaction of personal factors, behavior, and the environment. This triadic causal mechanism is mediated by symbolizing capabilities that transform sensory experiences into cognitive models that guide actions. Behavior is an observable act in the social cognitive theory and behavioral performance is to a great extent determined, according to LaRose and Eastin (2004), by the expected outcomes of behavior, which are expectations formed by our own direct experience (enactive learning) or mediated by vicarious reinforcements observed through others (observational learning). Outcome expectations, defined as judgments of the likely consequences of behavior (Bandura, 1997), provide incentives for enacting behavior, whereas expectations of aversive outcomes provide disincentives (Bandura, 1986). The social cognitive theory is aimed at current use of technologies and not on future acceptance of new technologies, therefore social cognitive theory as a whole is not very suitable to study the acceptance of technologies that are in their very early phase of development. Nevertheless, we think that outcome expectations can be helpful when exploring the anticipated adoption of a technology that is still in its development phase, since users will consider what the consequences are going to be for them when adopting ambient intelligent applications (e.g., "Will domestic life will be more convenient when using ambient intelligent applications?").

Expected outcomes are organized around six basic types of incentives for human behavior. These include monetary incentives, social incentives (such as obtaining approval from others), status incentives, sensory incentives (which involve exposure to pleasing or novel sensations) and activity incentives which are based on preferences for enjoyable activities. Furthermore, internal, self-reactive incentives can be distinguished; these result from comparisons of personal actions with standards for behavior. According to LaRose, Mastro and Eastin (2001), outcome expectations reflect current beliefs about the outcomes of prospective future behavior, but are predicated upon comparisons between incentives expected and incentives attained in the past. Outcome expectancies can play an important role in the adoption process of ambient intelligent technologies. If people perceive ambient intelligent applications as having positive outcome expectancies, such as making household activities more convenient or more enjoyable, people could be more inclined to adopt these applications.

In conclusion, none of the above-mentioned theories and models is completely suitable to study a technology which is in its early phases of development and which is developed for a specific setting, namely domestic settings. Even though, there is not one specific user acceptance model which is completely appropriate to study a technology in its early development phase in a domestic setting, these theories and models do provide useful insights which can be applied to study the adoption of ambient intelligence. Hence, a conceptual model is constructed which is based on different concepts derived from the above described user acceptance models of technology to explore the anticipated adoption of ambient intelligence applications. The model and its concepts will be explained and empirically tested in a national Dutch survey and its results will be presented in Chapter 7.

## 3.5 Complementary Perspectives on Technology Adoption

The two perspectives, the mutual shaping of technologies and users perspective and the diffusion and adoption of technology perspective, which are commonly used to study the relationship between technology and its usage, were presented in this chapter. The general, qualitative perspective, the mutual shaping of users and technology approach, and the more specific, quantitatively oriented, user acceptance theories of technology, both provide valuable contributions to the literature on technology, its design, acceptance, adoption and usage. As mentioned at the beginning of this chapter this research focus should include:

a) the nature of the technology and its design;
b) user needs, acceptance and usage processes;
c) a contextual approach to both the technology, its acceptance and usage and its (potential) implications.

And although both perspectives provide valuable contributions to the three criteria mentioned above, they do have their specific prominent concepts on which they focus. The mutual shaping perspective with its wide range of theories studying the relation between technology and its users is very general in its approach and lacks the capabilities of empirical testing with specific explanatory and predictive statements. However, the user acceptance models are linear, not dialectic; they do not specifically investigate the (re)constructed meaning of technologies by producers and users of technologies which some theories in the mutual shaping perspective clearly do.

Focusing on specific causal relations is the essence of the user acceptance theories and models in trying to understand the acceptance and usage of technology by individuals.

Applying these two theoretical perspectives to reach the goal of this thesis, namely, understanding how the designers of ambient intelligence shape prospective users and how users' anticipated adoption of ambient intelligence in domestic settings defines the potential acceptance of this technology, it can be argued that the mutual shaping perspective is very appropriate to investigate the nature of ambient intelligence on the current supply side of ambient intelligence. Thus, how designers are currently shaping ambient intelligent applications in this early stage of the development process and to investigate the contextual acceptance and usage of ambient intelligence by prospective users. But since ambient intelligence is not, at present, in use by people in their domestic settings, it is difficult to investigate the side of shaping by users of ambient intelligence via a mutual shaping perspective only. Most specific theories within the general mutual shaping of users and technology perspective assume that the user is already reconstructing (also shaping) the technology, such as in the social construction of technology approach and the domestication approach.

The user acceptance models of technology could then offer insight in this stage of ambient intelligence development to help predict and explain which factors could play a role in the adoption process of ambient intelligent applications. However, it does have to be emphasized that the user acceptance models are usually also applied to technologies which are fully developed and already in use. Therefore applying these models to a technology which is in its development phase means that only the anticipation of adoption and use can be investigated. For this purpose in Chapter 7, various constructs derived from these user acceptance models will be included in our own constructed conceptual model to investigate the anticipated adoption of domestic ambient intelligent applications.

In conclusion, both perspectives are very useful in an early development stage of technologies such as ambient intelligence finds itself in right now, and are therefore not only complementary to each other but also necessary to provide a better understanding of the potential of ambient intelligence. The empirical user acceptance models of technology add to and complete the general perspective of the mutual shaping of technology and users. In Chapter 6 and Chapter 7 empirical studies will be presented which are based on both the mutual shaping perspective and the user acceptance models discussed in this chapter.

# 4

# Critical Social Issues of Ambient Intelligence

*Social issues of ambient intelligence, such as privacy, surveillance, trust, and control are considered to be important for the acceptance and adoption of ambient intelligent applications by users. In this chapter, these social issues will be briefly introduced. In the following chapters, the social issues of ambient intelligence will be explored from both the perspective of designers of domestic ambient intelligent applications and from the perspective of potential users.*

## 4.1 The Promises of Ambient Intelligence

In the last century, technological innovations have often instigated considerable discussion with regard to their potential consequences for individuals and how they may affect society in general. Ambient intelligence is no exception to this area. With the development of the underlying technological infrastructure and networking systems to realize ambient intelligence, scholars have questioned its overall value and associated social opportunities and threats this emerging technology brings along.

Because of the potential benefits it may bring to individuals and society, ambient intelligence has been positively received in various research fields, from computing sciences to social psychology. Many universities world wide are introducing courses specifically devoted to ambient intelligence and its attention areas. The founding father of ubiquitous computing envisioned a world where people can focus on new goals when computing devices disappear in the environment: "All say, in essence, that only when things disappear in this way are we freed to use them without thinking and so to focus beyond them on new goals" (Weiser, 1991, p. 66). Ambient intelligence elaborates on the ubiquitous computing paradigm and envisions a world where people's everyday experiences are enhanced by surroundings which are sensitive and adaptive to them (Aarts, 2004). Aarts (2004) notes that ambient intelligence "aims to improve people's quality of life by creating the desired atmosphere and functionality through intelligent, personalized, interconnected systems and services" (p. 12). Furthermore, he suggests that in an ambient intelligent world people will have information, communication services, and entertainment at their disposal without any time or place constraints. Through connected and intelligent environments it is conceived that ambient intelligence will provide potential benefits to individuals and society at large such as empowering people, more convenience, an increased sense of safety and security, increased mobility, time and cost savings, healthier and happier lives, computing access for everybody, and stronger community ties and individual relationship due to a more connected world (Aarts & Marzano, 2003; Friedewald, Da Costa, Punie, Alahuhta, & Heinonen, 2005; ISTAG, 2001, 2003; Weiser, 1991).

Looking specifically at domestic settings, it is suggested that the introduction of ambient intelligence in this domain can support a wide range of activities. According to Friedewald et al. (2005) there are six main categories where ambient intelligence can support daily activities in the home. These activities include enabling communications between people inside and outside the home; enabling personalized access to various information services; increasing the chance of finding lost belongings such as keys; increasing the easiness of household tasks via the control over household appliances; increasing safety and security of people by using tracking and monitoring systems, and finally more comfort in people's lives and entertainment. These potential benefits of ambient intelligence, besides the potential economical benefits, (see Langheinrich, Coroama, Bohn, & Rohs, 2002 for an overview of the economic benefits of ambient intelligence) are the reason that many research institutions, designers, engineers, and international high-tech companies are working on systems and applications to realize an ambient intelligent world. Early ambient intelligent applications are introduced – besides domestic and office settings - in diverse domains such as health care settings such as hospitals (Hansen, Bardram, & Soegard, 2006; Stanford, 2002) and automobiles (Kun, Miller, & Lenharth, 2004) to get a better understanding of their "real life" implications. However, not only the potential positive side of ambient intelligence as outlined by its founding fathers has its followers, critical questions about the added value of ambient intelligence and its potential threats to individuals and society are also raised. In the next paragraph, some of these critiques will be discussed.

## 4.2 Critiques of Ambient Intelligence

The aim of ambient intelligence to enhance people's everyday lives and to empower people by making computers dissolve in the environment and embedding these environments with intelligent technologies so that they can monitor and adapt to people's needs is not embraced by everyone as a positive future development of the information society. Scholars have doubts about the promises of ambient intelligence and critical questions have been raised about the legitimacy of ambient intelligence (Araya, 1995; Lucky, 1999; Winner, 1999) and its proposed impact on everyday life. Araya (1995) argues that ambient intelligence only delivers marginal and irrelevant value to human needs, such as elevators automatically stopping at the right floor and rooms adjusting temperature when someone enters. He further notes that these new technologies have to be seen as "an attempt at a violent technological penetration of everyday life" (ibid., p. 237). Not only would ambient intelligence have marginal value for people's everyday life, it would also raise false expectations (Winner, 1999). Winner argues that these new technologies do not make our lives simpler, or save us time, or relieve us from mundane tasks as they primarily propose. On the contrary he argues, ambient intelligent technologies will not lead to more leisure time nor will it lead to more comfortable daily lives but instead people will have even more tasks to handle but be more productive and effective in the performance of their existing activities.

Criticism about the perceived marginal value of ambient intelligence is also endorsed by Rohs (2002). He emphasizes the false promise of what ambient intelligence is proposed to deliver to people and the loss of control people will experience when using these systems. Brey (2005) states that it is highly unlikely that ambient intelligence will enhance people's freedom; it is more likely that ambient intelligence will reduce it. He argues that since these systems still lack the capabilities of understanding people's environments they will probably make incorrect inferences about people's needs.

The critiques on ambient intelligence made scholars call for a close monitoring of ambient intelligence and its development process to assure that it is steered in the direction of Weiser's optimistic vision of the 21st century and not to the depressed picture of consumer terror and police state depicted in Hollywood movies such as Minority Report (Bohn, Coroamã, Langheinrich, Mattern, & Rohs, 2004). Social acceptance of ambient intelligence is dependent on the possible benefits and problems it could bring to individuals and society. It is envisioned that the information society will develop into a society where ambient intelligence will provide technology that better suits the needs of people (ISTAG, 2001, 2003). Key issues in the development process of ambient intelligence are identified which could be potential barriers of adoption for users (Abowd & Mynatt, 2000; Bellotti & Sellen, 1993; Bohn et al., 2004; Brey, 2005; Edwards & Grinter, 2001; Friedewald et al., 2006; Hilty, Som, & Kohler, 2004; Langheinrich, 2001; Nguyen & Mynatt, 2002; Punie, 2003; Roussos & Moussouri 2004; Weiser, 1993). These issues are primarily concerned with privacy, control, trust, security, surveillance, confidence, identity management, and autonomy. These issues arise because the main requisite that is needed to make ambient intelligence work is that information has to be collected first about users and their locations (e.g., by cameras or sensors) to be able to anticipate their behavior. The social issues of ambient intelligence will be discussed in more detail in the remainder of this chapter.

### 4.2.1 Privacy and Surveillance

"The old sayings that 'the walls have ears' and 'if these walls could talk' have become the disturbing reality. The world is filled with all-knowing, all-reporting things" (Lucky, 1999, p. 2). This quote catches remarkably well the essence of the great attention paid to the potential loss of privacy and surveillance ambient intelligence holds. Intelligent systems collecting and recording people's movements wherever they are also elicited the critique of viewing ambient intelligence as a vision which strives for "totality" and thus "totalitarianism" (Adamowsky, 2000). The necessary data collection to be able to anticipate on users' behavior raises questions. Additionally, the storage of these data that are shared between systems and devices is increasing privacy risks. These essential steps cause privacy and pervasiveness to be in conflict by nature (Dritsas, Gritzalis, & Lambrinoudakis, 2006).

Privacy concerns have long been acknowledged in modern societies (Westin, 1967) and privacy is still an aspect of importance in our current society (Udo, 2001). With the introduction and widespread use of the Internet, research has shown that Internet users have great concerns about privacy threats (Cranor, Reagle, & Ackerman, 1999). Online privacy concerns include anonymity, intrusion (e.g., spam, data mining), surveillance (individual and public) and autonomy (Metzger & Docter, 2003). A review by Metzger and Docter (2003) of public opinion polls, industry positions, enacted legislation and proposed legislation about online privacy protection between 1998 and 2001 showed that public concern about online privacy is high (74% of the respondents were concerned about their privacy when online), but that few policy options have been proposed to protect consumers' privacy online. Similar privacy concerns are related to ambient intelligent environments. Research on ambient intelligence has shown that concerns over issues such as personal data storage, mining and unauthorized access by third parties already exists by people (Little, Marsh, & Briggs, 2007) and that the feeling of being under surveillance is a potential risk of pervasive computing (Hilty, Som, & Kohler, 2004).

Privacy aspects should be accounted for from the start of the design process of ambient intelligent systems (Weiser, 1991). They should be addressed in the three environments where these systems operate, namely the social, technical and physical environment (Nguyen & Mynatt, 2002). Nguyen and Mynatt noted that ubiquitous computing creates a technical environment because of its use of computational systems. Since computing is envisioned as omnipresent it is proliferated throughout the physical environment and therefore the physical environment is an integral part of ubiquitous computing. Furthermore, because ubiquitous computing enables people to be connected in both their professional and private lives ubiquitous computing systems become part of users' social environment (ibid.).

Ackerman (2004, p. 430) identified the major privacy issues that users will probably encounter when using ambient intelligent appliances: 1) personal data will increase due to a growing number of interconnected devices; 2) people's anonymous presence in pervasive environments is no longer guaranteed due to perceptual interfaces and biometric recognition systems; and 3) tracking and capturing users' activities are necessary to adapt to the personal wishes and needs of individuals. If users of ambient intelligent applications also have these concerns, they will probably have a negative effect on the adoption process of ambient intelligent appliances.

Privacy is often defined as informational privacy, but actually privacy is a multidimensional construct (DeCew, 1997; Pedersen, 1999). Especially in relation to information and communication technologies, privacy incorporates different aspects as pointed out by Bohn, Coroamã, Langheinrich, Mattern, and Rohs, (2004) who refer to the work of Lessig (1999). Four aspects of privacy are identified in relation to information and communication technologies (Bohn et al., 2004, p. 7):

a) privacy as empowerment (people should have the power to be able to control the publication and distribution of private information),
b) privacy as utility (from the viewpoint of the persona involved, privacy is here seen as a way to protect oneself against unsolicited intrusion from outside in one's life),
c) privacy as dignity (being free from unsubstantiated suspicion as well as the equilibrium of information available between two people) and,

d) privacy as a regulating agent (privacy laws and moral norms can to an extent also be seen as a tool for keeping checks and balances on the powers of a decision-making elite.

Many different users are nowadays active on the web and their privacy preferences are numerous. Therefore different architectures have been proposed to allow optimal personalized settings in web-based environments (Kobsa, 2003). Researchers have started to work on solutions to incorporate privacy in the design of ambient intelligent applications and systems. Nguyen and Mynatt (2002) for example, propose designing ubiquitous computing systems where the social, the technical and the physical environment are included. Furthermore, to understand privacy issues related to ambient intelligent systems better it has been suggested to consider feedback and control mechanisms (Bellotti & Sellen, 1993). Researchers have described five privacy pitfalls which ubiquitous systems often fall into or that are not avoided by designers, namely: obscuring potential information flow, obscuring actual flow, emphasizing configuration over action, lacking coarse-grained control, and inhibiting established practice (Lederer, Hong, Dey, & Landay, 2004). Privacy design patterns are suggested to incorporate in designs of ubiquitous computing systems to avoid these pitfalls in the future (ibid.).

Prior research on privacy concerns has shown that individuals are willing to disclose their personal information if they receive any economic or social benefits in return (Milne & Gordon, 1993; Stone & Stone, 1990). Furthermore, individuals are more likely to view personal information collection procedures as less privacy-invasive when this information is collected in a fair way (see Bies, 1993; Culnan & Armstrong, 1999; Stone & Stone, 1990). Whether the ultimate aim of ambient intelligence to be everywhere and adapt to people's needs to serve them is perceived by individuals as yielding personal, economic or social benefits for them and if it is worth the costs in terms of loss of privacy and loss of control for people remains to be seen. In this early stage of the development of ambient intelligence applications it is still possible to hold account with privacy concerns when designing ambient intelligent applications. However, it will be difficult to banish all privacy concerns since Internet services remain an important part of the services that will eventually be provided by ambient intelligent environments. Sensors are likely to perceive not only aspects of the ambient intelligent environment people are in, but also aspects of people's behavior. This raises questions about who is in control of the information that is stored in the device or system about us. Memory amplification is much related to the sensing feature of ubiquitous computing because if our every action or movement is recorded who will be owner of all that information and who will be responsible, the user of the system or someone else? Who regulates the privacy of users: individuals, companies, services suppliers, or the government? Answers to these questions are not easy since legislation concerning information and communication technologies and new media depends on many factors and actors and in general runs behind technological development. If we look at the privacy policy of TiVo (a digital video recorder) then we notice that they are currently only allowed to gather data about the viewing habits of its customers, but not any personal information. The TiVo management is trying to change this policy (Hansell, 2006). Of course marketers and makers of commercials are very interested in the information that is collected by TiVo and will do their best to gather as much possible information about the viewers. The information that can be gathered about people who are going to use ambient intelligent applications is not only related to how they view commercials but probably to more personal behavior, maybe even emotions. This personal information can be stored and can be interesting to all kinds of companies and governments.

From the inception of ambient intelligence it is acknowledged that privacy is an important issue to consider (Punie, 2003; Friedewald et al., 2005) if producers want this technology to become successful, that is to say an accepted and adopted innovation. ISTAG (2003) notes that the balance between privacy and security is one of the core challenges for the future to make sure that the benefits of ambient intelligence will prevail. As mentioned earlier in paragraph 4.1, several solutions have been suggested to design ambient intelligent systems which incorporate privacy principles to minimize people's privacy risks. However, the existing mechanisms to preserve privacy in an ambient intelligent environment are not sufficient yet or not adequately addressed and recognized and should therefore be taken into account (Dritsas, Gritzalis, & Lambrinoudakis, 2006). Closely related to privacy issues of ambient intelligence is control or the loss of control which is also seen as a potential threat of ambient intelligent systems.

## 4.3 Control

Deleuze (1992) introduces the concept of "societies of control" to describe the changing role of control in societies. Control societies are characterized by the replacement of traditional, disciplinary institutions such as hospitals, factories, and schools into societies with numerous forms of control everywhere. He argues that the new control societies with their pledge of more flexible power structures may prove to be just as grim as their past confinements. One of the aims of ambient intelligence is to make people's lives more convenient and easier. To provide convenience by taking over routine tasks and for ambient intelligent systems to be able to anticipate people's needs without humans explicitly intervening in this process implies that people have to leave control and responsibility to the technological systems in order for it to work in the way it is meant to be working according to the designers. Thus, ambient intelligent applications take action and make decisions automatically as they assist people in their daily lives.

Loss of control is therefore often mentioned as a potential negative consequence of ambient intelligent applications (Barkhuus & Dey, 2003; Bellotti & Edwards, 2001; Bohn et al., 2004; Rohs, 2002). Brey (2005) criticizes the ambient intelligence vision which is supposed to bring more control to people's lives, but simultaneously threatens their autonomy. In addition, he argues that users can experience that control is taken away by these smart objects when they actually perform as they are expected to perform and that they feel a "psychological pressure that results from going against the will of a smart object that is supposed to have a good understanding of one's needs and desires" (p. 161).

The critiques of the potential loss of control that scholars have reported have resulted in several research projects that try to solve the problem in a technical way. Davidoff, Lee, Yiu, Zimmerman, and Dey (2006) state that the control issue is often framed as an end-user programming problem (e.g., Crabtree, Rodden, Hemmings, Benford, 2003; Gajos, Fox, & Shrobe, 2002). However, it has been shown that intelligent systems providing assistance to users can leave users feeling overwhelmed and actually not in control of that technology (Barkhuus & Dey, 2003; Bellotti et al., 2002; Grinter & Edwards, 2001). A study by Misker, Lindenberg and Neerincx (2005) showed that users prefer to have control over a device even if this requires extra time and effort (such as the pressing of a button) to stay in control. Hamill (2006) suggests that smart domestic devices should put people firmly in control. She notes that even if smart devices know what actions have passed and what the current state of the user is, they cannot know what the user wants to do next. Furthermore, it is suggested that for users, control over ubiquitous devices is not enough; they would rather like to have control of their lives (Davidoff et al., 2006).

## 4.4 Trust, Social Acceptance and New Divides

The wired city innovation was a planned, supply-led innovation rather than an innovation which was demand-driven by masses of people, as was the television (McQuail, 1987). McQuail pointed out that the wired city was looking for a social use rather than meeting a clear and obvious demand. At this moment, ambient intelligent applications are also a planned, supply-led innovation rather than a massive, demand-driven innovation. When (or if) introduced, people may adopt ambient intelligent applications, but ultimately people will have to find the relative advantage of a social use for ambient intelligent applications, since it lacks a clear demand. Therefore not only the potential technical barriers of ambient intelligence will be important for its widespread acceptance. Social and societal aspects are at least as important in our view. Punie (2003) notes that technical progress is important to shape ambient intelligence, but demographic and social trends will also be important enablers for acceptance of ambient intelligence.

Trust in ambient intelligent applications is identified as an important enabler of acceptance of ambient intelligence (Little, Briggs, & Coventry, 2005). Trust is already recognized as an important factor in various settings, such as in telemedicine (Brown, Poole, Rodgers, & Van Walsum, 2003) and virtual relationships (Jarvenpaa, Knoll, & Leidner, 1998). Trust is identified as an important factor which influences the decision to exchange information between systems (Soliman & Janz, 2004). Already, for example, when people shop online they perform acts of trust (Lee & Turban, 2001) and also when using online bulletin boards on the Internet people have some kind of “trust” in these services (Corritore, Kracher, & Wiedenbeck, 2003). With regard to ambient intelligent applications trust is very relevant for the social acceptance of these systems. Research has shown that lack of trust or people being afraid of identity theft and hackers are issues which decrease the users acceptance of Internet services and it is suggested that these issues are even more relevant for the services ambient intelligence will provide (Roussos & Moussouri, 2004). Currently, various trust related questions still have to be resolved and clear cut answers are not available. Studies have already shown that users create a relationship with their technical systems and see them as social actors (Reeves & Nass, 1996). It is promising that the trust issue is picked up by the ambient intelligence community in an early development stage to minimize irrevocable damage to people’s mediated relationships.

Finally, the introduction of new technologies involves - sometimes unwillingly - the creation of new divides between individuals and groups in society such as the digital divide in the information society (Van Dijk, 2005). Ambient intelligence could also create a digital divide and social exclusion. Therefore equal access for everybody should be aimed for (Friedewald et al., 2005; Punie, 2005). Ambient intelligence is supposed to be omnipresent and for everybody, so a potential divide between individuals and groups in society would be a very interesting phenomenon to study. Furthermore, the widespread and invisible network of ambient intelligent systems creates possibilities to monitor our public and private lives (Bohn et al., 2004). Brey (2005) suggests that these intelligent systems could represent other interests than those of the user, such as interests of a governmental institution or service providers. This could then also lead to the feeling of a loss of control by users. Bohn et al. (2004) note that "Although many concepts have already been tested as prototypes in field trials, the repercussions of such extensive integration of computer technologies into our everyday lives are difficult to predict" (p. 5). Although this observation is very true, researchers can try to find out in which directions ambient intelligence is heading.

In sum, in this chapter several social issues related to the development of ambient intelligent systems have been briefly described. It is beyond the scope of this thesis to focus on all of them. In the following chapters, the focus will be primarily to get a better understanding of privacy and control issues since these two issues are recognized from the start of the development of ambient intelligence as important potential barriers of acceptance for users (Abowd & Mynatt, 2000; ISTAG, 2003; Weiser, 1991). In Chapter 7 the control issue described here will be investigated from a designers' perspective and in Chapter 8 from the perspective of users of domestic ambient intelligent systems.

# PART II

## Empirical Studies

# 5

# The Representation of Ambient Intelligence in the Home

*Characteristics of domestic ambient intelligent applications can be observed in, amongst other things, the promotional material of initial producers. In this chapter, a content analysis of the promotional material of eight high-tech companies who produce domestic ambient intelligent applications is used to investigate how ambient intelligence is represented to the general public. First, the method will be described in more detail. Subsequently, the findings of the analysis of the textual and visual material are presented. At the end of this chapter the findings of this study will be discussed.*

## 5.1 Introduction

In the previous chapters it has been clarified that the focus of ambient intelligence is on the use of consumer electronics that will bring a new kind of interaction with technology into homes and personal domains to enhance our experiences and lives (Aarts, 2003). As mentioned in Chapter 1, ambient intelligent applications can be located in the development phase and are heading towards the first stages of diffusion due to the increasing potential of new technologies. In this development phase the first designs are being developed, tested, and redesigned for future production. Companies are currently entering the market with prototypes that are not fully developed ambient intelligent applications because they do not yet have all the required characteristics specifying ambient intelligence such as being adaptive, intelligent, personal, and aware of people's locations and needs. Thus, as argued in Chapter 2, it would be better to see these prototypes as precursors of "real" ambient intelligent applications.

High-tech companies, that produce these consumer products as examples of precursors of real ambient intelligent applications, exhibit their latest products in demonstration houses that are open to the public. Via these demonstration houses, such as The Future Home of Living Tomorrow (Living Tomorrow, 2007) in Amsterdam where products from different companies are demonstrated, the general public is offered a way to become familiar with the applications that are being designed and help the diffusion of the products. In this way, producers of ambient intelligent applications primarily want to make people aware of what is currently possible with the latest technologies and how future homes and offices could look.

## 5.2 Representation of Ambient Intelligence

Advocates of ambient intelligence are emphasizing that the potential benefits of ambient intelligence will support the activities in the home to be performed in a more pleasant and an easier way. This means that there are implicit presumptions that ambient intelligence embodies about people and their interactions in everyday life. These presumptions can appear in the design and in promotional material of ambient intelligent applications. For example, comfort, freedom, privacy, control, and responsibility can be embedded in the design. The concept of design is used here to refer to the real characteristics of applications that are created according to the ambient intelligence vision and to perceivable presumptions about use and users that are communicated by designers and engineers and via promotional material. Both, characteristics and presumptions, can be incorporated in the design of applications. One of the main presumptions of user needs in the ambient intelligence vision is that users first of all want comfort in their daily lives and ambient intelligence will provide this. Users will have to give up some freedom which means options of choice and action, as users leave certain choices and actions to be executed by the technology (Punie, 2003). It is also assumed that users are willing to relinquish part of their privacy to be able to use this technology. The input and registration required for using many applications, enables both providers and people in the environment to derive personal information. Furthermore, users have to leave control and responsibility to technology in order to work in the way it is foreseen by its developers.

The current characteristics of ambient intelligence make its introduction in domestic settings different from earlier notions about the smart home (see Chapter 2). The home will be potentially more and more embedded with networked computing and this will enable the applications to communicate with each other and with the outside world without the interference of users and the home environment to be automatically responsive and adaptive to the needs of its inhabitants. Earlier the emphasis was on separate applications each having intelligence in them, now the intelligence is in the network and in its environment.

The above mentioned characteristics of ambient intelligence and the presumptions are not yet apparent. Still, designers, producers and policy makers will have to take them into account to make sure that people are the central focus of ambient intelligence and to anticipate future problems with the technology in everyday life. Thackara (2001) points out that, for example, interaction design could help in shifting the focus of innovation from pure technology to the contexts of daily life.

Presumptions about use and users can be observed in different ways. The first way is to observe the materialized designs in the shape of consumer ambient intelligent applications or in the form of whole adaptive houses. The second way is to ask designers of the applications about their beliefs and assumptions regarding use and users of ambient intelligence at home. The third way is to observe and analyze the presentations of high-tech companies that are developing ambient intelligent applications. These presentations can be in the form of promotional material made by these companies to make the public aware of their vision. These promotional materials do not necessarily have to reflect the design rationales of the engineers and designers of these companies. However, the materials do give a first image of how ambient intelligence is represented to the general public. Promotional material of producers of domestic ambient intelligent applications was investigated by means of a content analysis. The results are presented in the rest of this chapter, but first the specific research questions will be addressed.

## 5.3 Research Questions

This study is a first step to a better understanding of the representation by high-tech companies of ambient intelligence in the home, to be seen as a technological innovation that consists of enhanced information and communication technologies. If this technological innovation is to affect society as a whole and to become a reality in the future, it is important to know which ideas about use and users are currently displayed to the public in order to anticipate as researchers and policy makers and see what can be expected from ambient intelligence. When observing and analyzing the promotional material of high-tech companies that develop ambient intelligent applications we can gain valuable preliminary understanding about the representation of users, use and the social and technical aspects of ambient intelligence. Therefore, the first research question is stated as follows:

*RQ1: What are the implicit ideas about users and the use of ambient intelligence of high-tech companies that are developing consumer applications as made explicit in the attributes of these applications described in textual and visual representations of their promotional material?*

Exploring the visual representations it will become evident which aspects are currently emphasized by the high-tech companies engaged in the development of applications that are supposed to realize the ambient intelligence vision. For example, is a central role really assigned to the user? (see ISTAG, 2001). Coleman and Wasike (2004) argue that visual and verbal communication are not separate things, rather they influence each other in a reciprocal process. Through the analysis of both text and visual elements a better understanding of the content can be reached. Visuals have several effects, such as improving recall and comprehension (Paivio & Csapo, 1973), attracting readers to stories (Garcia & Stark, 1991), and influencing opinions and attitudes (Gibson & Zillmann, 2000). It is also known that the size of a photograph can influence readers' perception of importance (Wanta, 1988). Visual representations are the object of observation in the second research question:

*RQ2: What is the focus of attention on the pictures that are used in the promotional material of high-tech companies in the field of ambient intelligence, specifically in domestic settings?*

To be able to answer research question two, the following sub questions concerning both the content and the form of the pictures, were formulated:

2a) is the focus on the pictures on humans, on technical applications, or on both of them?

2b) what is the gender, age, sort of action performed by pictured humans and what is the goal of action of the pictured humans?

2c) in which locations in the home are the ambient intelligent applications and humans portrayed?

2d) what is the relative size of the pictured humans and of the technical applications used in the promotional material?

## 5.4 Method

A content analysis has been used to analyze the documentation of international high-tech companies that are currently designing (prototype) ambient intelligent applications. Content analysis is used for communication messages to uncover the characteristics and the meaning of the messages. Krippendorf (1980) defined content analysis as "a research technique for making replicable and valid inferences from data to their context" (p. 21). The data for this study were collected in the period between April 2003 and December 2003, and the coding was completed from January through February 2004.

### 5.4.1 Sample

No official list of companies that produce ambient intelligent applications was available when the collection of promotional material of ambient intelligence started. Therefore, such a list was made by the researchers themselves. The list consisted of the companies which were included in the Massachusetts Institute of Technology (MIT) Oxygen project. The MIT Oxygen project is an initiative of MIT researchers to work together with technology companies to develop technologies and applications to realize ambient intelligence. These companies included: Acer Group, Delta Electronics Inc., Hewlett-Packard Company (HP), Nippon Telegraph and Telephone Corporation, Nokia, and Philips (MIT, 2000).

Furthermore, an internet search using the search machine Google (14 April, 2003) was conducted to see if there were other companies operating in the field of ambient intelligence that could possibly participate in the study. The following search terms were used: intelligent home, digital home, connected home, networked home, smart home, interactive home, home of the future, ubiquitous computing, ambient intelligence, ambient intelligent applications, intelligent devices/appliances, pervasive computing, calm computing, and embedded computing. The search operation resulted in an additional number of seven companies, namely: Microsoft, LGE, IBM, Orange, Living Tomorrow, Georgia Institute of Technology, and JEITA. Thus the companies cooperating in the MIT Oxygen project and the companies found via the internet search were all approached to send promotional material about ambient intelligence that was currently being used to communicate to a public of potential consumers.

Unfortunately some companies (Acer Group, Delta Electronics, Inc., Nippon Telegraph and Telephone Corporation, Nokia, IBM and MIT) did not reply to our request (in time) and could therefore not be included in the sample. Apart from Philips, two other companies replied (HP and Living Tomorrow) and did send promotional material and referred us to their web site for more information about this subject. Three companies (Orange, LGE and Microsoft) replied that all the information about their vision of ambient intelligence and their (prototype) consumer applications for the home could be found on their corporate website, and therefore their websites were used. IBM and MIT[1] did not reply to our request, but their web sites provided relevant information and were therefore included in the sample. One institution (JEITA) replied that they only had Japanese information about ambient intelligence on their website. Japanese and English words about ambient intelligence are not entirely similar. A valid and reliable content analysis had to be limited to English texts. This does not apply to pictures, but since pictures are often accompanied by text, promotional material with both verbal and visual presentations were needed for comparison. Therefore the Japanese promotional material was not taken into account. The research institution Georgia Institute of Technology provided slides of a research presentation. Unfortunately, the slides did not meet the criteria (see below) to be included in the sample, so these were also excluded from the analysis.

The *research units* of this study were (parts of) brochures and printed websites of the above described approached companies and institutions containing presentations of ambient intelligence in the form of text or visuals. Promotional material that was included as a research unit for the content analysis was chosen on the following criteria: a) it had to come from high-tech companies and institutions which had a "smart home" or that develop (prototype) consumer applications in the field of ambient intelligence; b) it had to provide information about the company's vision of ambient intelligence; c) it had to provide information about the (prototype) consumer applications for home usage (e.g., purpose, price, expected date to appear on the market). Information related to the office and public area was excluded from the sample just as were purely technical aspects of applications (e.g., speed, memory, etc.). The research units were divided into textual and visual units. The textual units were sentences of the promotional material and the visual units were pictures.

The *recording units* in this study were separate sentences and separate pictures. As for the pictures, this was the only generally available mode to portray ambient intelligence applications in the promotional material. As mentioned before, besides brochures printed web sites were also used. Esrock and Leichty (2000) argue that "corporate websites should be viewed as an intentional act of communication that signifies an organization in its multiple facets to its multiple publics" (p. 329). Because the aim of this study was to look at the communication of high-tech companies to the public about ambient intelligence, the websites were also included in the sample. Relevant information was printed and navigation links on web sites were excluded from analysis. Hyperlinks were clicked on to see if they displayed relevant information for the study and if so, the text pages and pictures (if available) were printed as well.

The visual units of the promotional material contained primarily pictures about the home environment, but there were some pictures referring to the "smart office of the future". However, only the pictures that were related to the home were included in the sample. This could be evident from the picture itself or from the text accompanying the picture. Coders received instructions for selection accordingly.

In sum, the final sample included 2400 sentences and 202 pictures derived from promotional material of eight different international high-tech companies that develop domestic ambient intelligent applications.

### 5.4.2 Coding

A codebook was developed to record information on what the companies were presenting to the public. The codebook included different sections for the written communication and the visual communication. Two coders (both recently graduated masters in communication science) were involved in the coding process and were extensively trained on how to code the written and visual communication. The codebook contained a list of attributes[2]. The attributes were derived from the literature (Aarts, 2003; Bohn et al., 2004; Edwards & Grinter, 2001; ISTAG, 2001; Punie, 2003; Weiser, 1991) that indicates both social and technical attributes of ambient intelligence in the home. The words adaptability, comfort, busy, everyday life, flexibility, save time, improving quality of life, user-centered, and utility were added by the researchers, because of their relevance to the social and technical aspects of ambient intelligence.

In this study not only was text analyzed but also the visual elements in the form of pictures. The second section of the codebook related to the visual units of the promotional material. Bell (2001) emphasizes that "visual or verbal representations differ from each other in many ways - on many dimensions or qualities" (p. 15). He suggests that variables should be defined in terms of one principal feature of representation to prevent ambiguous measures. The pictures differed in size and the absolute size of the picture was not relevant for our research question. We were interested to see if there were differences in the size of the pictured humans and appliances. Therefore the absolute size of the picture is not an appropriate variable in this study. Instead, the relative measure (in $cm^2$) of the pictured human(s) and device(s) was taken into account.

The picture variables which were derived from the research questions 2a through 2d, included person or device depicted, age, gender, location, type of consumer appliance, sort of action performed by pictured human(s) and goal of action, and relative size of pictured humans and devices. The coders pre-tested the codebook for verbal descriptions and for the visuals and adjustments were made (e.g., alphabetizing the verbal descriptions).

### 5.4.3 Reliability

The coders worked independently in coding the material. To obtain intercoder reliability (Cohen's κ), the coding coefficient calculation formula (see Siegel & Castellan, 1988) was used. Coders pre-tested the codebook and 10% of the material (both text and pictures). Cross-coding was conducted on 10% of the sample size for both text and pictures. The intercoder reliability for the text was 100% ($\kappa = 1.00$). The intercoder reliability for the different variables between the two coders for the pictures was 100% ($\kappa = 1.00$) with the exception of the variables which measured a sort of pictured action of human(s) with the appliance(s) and aim of action of the human(s) with the appliance(s) (e.g., looking at pictures of the appliances, searching information, and visual communication). These variables had kappa's lower than .70 and were not taken into further analysis. Based on the obtained intercoder reliability results, the text and pictures were analyzed.

## 5.5 Results

For this study it was important to understand which attributes and applications are used by the high-tech companies in their communication to potential consumers about consumer devices that are being developed for the ambient intelligence vision. The total sample of text contained 2400 sentences and 202 pictures. Philips was the largest contributor with 1274 sentences and 135 pictures, and Orange contributed the fewest with 66 sentences and eight pictures (see Table 5.1). These unequal distributions were taken fully into account in the analysis. Each sentence and picture was coded according to the items in the codebook.

### 5.5.1 Textual Material

The first research question explored which attributes were used in the text of the promotional material by the companies to communicate to potential consumers. The results from the text analysis (N = 2400) showed that the following attributes were frequently mentioned in the promotional material: connectedness (218 times in total), control (174), easiness (168) and personal (157). Reliability and busy (4), freedom (5) and interoperability (6) were the least frequently mentioned attributes. As can be seen in Table 5.1, the sample did not contain equal amounts of sentences and pictures per company. Table 5.1 shows an overview of how frequent an attribute was counted per company in the 2400 sentences. Attributes that were counted less than 50 times in the sample were not included in table 5.1, these were: ambient (34), convenience and user-centered (33), adaptability (32), utility (26), improving quality of life (25), everyday life (19), privacy (17), flexibility (16), save time (14), comfort (13), interoperability (6), freedom, (5), busy (4) and reliability (4).

To control for an effect of the unequal distribution of the sentences and pictures per company, the means of the attributes were analyzed using an unrelated one-way analysis of variance. When all means of the eight companies on a particular attribute were analyzed, most of them appeared to be significant at the 5% level of significance (see Table 5.1). The attributes “comfort” ($F(3, 1810) = .27$, $p = .85$), “freedom” ($F(2, 1790) = 1.58$, $p = .21$), “improving quality of life” ($F(4, 2003) = .63$, $p = .64$), “reliability” ($F(2, 1790) = 2.57$, $p = .08$) , and “smart” ($F(6, 2127) = 1.26$, $p = .27$) did not differ significantly between the companies’ presentations. The Scheffé test, was used to compare pairs of group means in order to assess where exactly the differences lie among the attributes that did differ between the companies’ presentations. Using this test it was found that at the 5% level of significance, the means for the attributes “connectedness”, “control” and “interactivity” did not differ significantly between the companies.

It was also found at the 5% significance level that there were differences between the companies considering the other attributes. MIT presentations scored significantly higher on “adaptability” than Philips, HP and Microsoft, but the means for the other companies did not differ from each other. HP presentations scored significantly higher on the attribute “ambient” than Philips, and MIT also scored significantly higher on

**Table 5.1** Total count scores, means and standard deviations of attributes per company

| Companies / Attributes | Philips (n = 1274) | Microsoft (n = 266) | MIT (n = 253) | LGE (n = 192) | HP (n = 181) | Living Tomorrow ( n = 95) | IBM (n = 73) | Orange (n = 66) | Total (N = 2400) |
|---|---|---|---|---|---|---|---|---|---|
| Connectedness | 126 (.10/.35) | 18 (.07/.27) | 14 (.06/.23) | 26 (.14/.37) | 19 (.11/.32) | 1 (.01/.10) | 6 (.08/.28) | 8 (.12/.33)* | 218 (.09/.32) |
| Control | 87 (.07/.28) | 20 (.08/.28) | 15 (.06/.28) | 24 (.13/.39) | 5 (.03/.16) | 3 (.03/.23) | 11 (.15/.40) | 9 (.14/.43)** | 174 (.07/.29) |
| Easiness | 81 (.06/.27) | 46 (.17/.39) | 15 (.06/.24) | 12 (.06/.26) | 10 (.06/.23) | 1 (.01/.10) | 2 (.03/.16) | 1 (.02/.12)*** | 168 (.07/.27) |
| Personal | 82 (.06/.26) | 26 (.10/.32) | 17 (07/.25) | 1 (.01/.07) | 20 (.11/.35) | 4 (.04/.20) | - | 7 (.11/.36)** | 157 (.07/.27) |
| Interactivity | 86 (.07/.27) | - | 17 (.07/.25) | 3 (.02/.12) | 3 (.02/.13) | 2 (.02/.14) | 1 (.01/.12) | 2 (.03/.17)** | 114 (.05/.24) |
| Smart | 60 (.05/.22) | - | 11 (.04/.22) | 3 (.02/.12) | 13 (.07/.32) | 2 (.02/.14) | 3 (.04/.20) | 4 (.06/.24) | 96 (.05/.22) |
| Enjoyment | 34 (.03/.17) | 18 (.07/.25) | 1 (.00/.06) | 4 (.02/.14) | - | 3 (.03/.18) | - | 1 (.02/.12)** | 61 (.03/.17) |
| Safety | 7 (.01/.10) | 17 (.06/.36) | 15 (.06/.33) | 8 (.04/.29) | 7 (.04/.27) | 2 (.02/.14) | 1 (.01/.12) | 1 (.02/.12)*** | 58 (.02/.21) |
| Mobility | 15 (.01/.13) | 8 (.03/.19) | 13 (.05/.22) | 2 (.01/.10) | 16 (.09/.28) | - | - | 1 (.02/.12)*** | 55 (.02/.17) |
| Automation | 20 (.02/.12) | 6 (.02/.15) | 16 (.06/.29) | 6 (.03/.17) | 2 (.01/.10) | 1 (.01/.10) | 1 (.01/.12)** | - | 52 (.02/.16) |

*Note.* Values enclosed in parentheses represent mean and standard deviation.

*$p$ < .05. **$p$ < .01. ***$p$ < .001.

on ambient than Philips. For "automation", there were no significant differences between the companies, with the exception of MIT. MIT presentations scored higher on this attribute than Philips. LGE presentations were higher on "convenience" than Philips and Microsoft presentations. Microsoft also had a higher score on convenience than Philips. Microsoft presentations were higher on the attribute "easiness" than all the other companies in the sample. Microsoft presentations also scored higher on "enjoyment" than Philips and MIT presentations and Microsoft presentations scored significantly higher on "everyday life" than Philips presentations.

As for the attribute "mobility", HP presentations scored significantly higher than Philips, LGE and Microsoft presentations. HP presentations scored significantly higher on "personal" than LGE presentations and Microsoft presentations also scored significantly higher on personal than LGE presentations. MIT presentations scored significantly higher on the attribute "user-centered" than Philips and HP presentations and MIT presentations also scored significantly higher on "utility" than Philips presentations. Finally, considering the last attribute "safety", Microsoft presentations scored significantly higher on this attribute than Philips presentations.

If the attributes that are related to each other are clustered on the basis of a semantic analysis, three main groups can be distinguished, namely Convenience, Adaptation and Empowerment (see Table 5.2). Adaptation is the largest cluster and consists primarily of technological attributes of ambient intelligence. This could indicate that the current focus of attention in the development process of ambient intelligent applications is more technology-oriented than human-oriented.

**Table 5.2** Clustering of attributes (in parentheses total times mentioned in the sample)

| | Convenience | Adaptation | Empowerment |
|---|---|---|---|
| | Easiness (168) | Connectedness (218) | Control (174) |
| | Enjoyment (61) | Interactivity (114) | Personal (157) |
| | Convenience (33) | Smart (96) | Safety (58) |
| | User-centered (33) | Mobility (55) | Improving quality of life (25) |
| | Utility (26) | Automation (52) | Everyday life (21) |
| | Save time (14) | Ambient (34) | Privacy (17) |
| | Comfort (13) | Adaptability (32) | Freedom (5) |
| | Busy (4) | Flexibility (16) | Reliability (4) |
| | | Interoperability (6) | |
| **Total** | **352** | **623** | **461** |

### 5.5.2 Visual Material

To understand what the focus of attention is on the pictures that are used in the promotional material of high-tech companies in the representation of ambient intelligence, we tried to answer research questions 2a through 2d and therefore looked at the following categories: humans/no humans pictured, gender and age of humans pictured, locations humans and appliances pictured, kind of appliances, and size of humans and appliances.

Humans were pictured on 45% of the pictures, 46% of the pictures contained no humans, only devices and on 9% of the pictures only hands could be seen holding a device. To control for an effect of the unequal distribution of the pictures per company, the means of the attributes were analyzed using an unrelated one-way analysis of variance. There was no significant effect between the companies on pictured humans or devices ($F(7, 194) = 1.87$, $p = .08$). Of the 45% pictured humans, the most frequently pictured was a man (24%), followed by a woman (14%), man and woman together (6%) and on 0.5% of the pictures it was unclear if it was a man or a woman. Here also, there was no significant effect between the companies on gender of the pictured humans ($F(7, 194) = .40$, $p = .90$). Furthermore, young adults (26%) were the most frequently pictured humans, followed by children (10%), adults (7%) and elderly (2%). Nine per cent of the pictures were coded as 'not clear' considering the age of the pictured humans. There was a significant difference ($F(7, 194) = 4.38$, $p = .00$) between the companies considering the age of the pictured humans. Consequently, the Scheffé test was used to compare pairs of group means in order to assess where the differences lie. It was found that at the 5% level of significance that the means for age did not differ between the companies.

The appliances that are used in the pictures to represent consumer appliances for the ambient intelligence vision at home were also analyzed to address research question 2c. The results show that a wide screen (45 times in total) was the most frequently pictured appliance, followed by a small screen (35), a home control panel (27) and a projection screen (25). The least frequently pictured appliances were the digital TV, digital video recorder, identification apparatus and the video phone (all 1). Table 5.3 shows an overview of the total score of how frequent an appliance was visible in the pictures ($N = 202$) per company. Appliances that were counted less than 10 times in the sample were not included in Table 5.3, these appliances were: laptop (9), internet microwave oven (9), internet fridge (8), mobile phone (8), internet washing machine (7), digital video camera (7), computer with LCD screen (5), internet air conditioner (6), telephone (3), digital TV (1), digital video recorder (1), videophone (1), and identification apparatus (1).

To also control for an effect of the unequal distribution of the pictures per company, the means of the picture variables were analyzed using an unrelated one-way analysis of variance (see Table 5.3). Looking at the four most pictured appliances, the wide screen (F (7, 194) = 1.74, *p* = .10), projection screen (F (3, 171) = .41, *p* = .74), and home control panel (F (2, 144) = 2.72, *p* = .07) did not differ significantly between the companies and the small screen did differ significantly (F (6, 190) = 7.03, p = .00). Consequently, the Scheffé test was used to compare pairs of group means in order to assess where the differences lie. It was found that at the 5% level of significance, IBM (*M* = 1.50, *SD* = 1.73) pictured significantly more (F (6, 190) = 7.03, *p* = .00) small screens than Philips (*M* = .13, *SD* = .34), HP (*M* = .14, *SD* = .35), MIT (*M* = .23, *SD* = .44), LGE (*M* = .18, *SD* = .40), and Orange (*M* = .13, *SD* = .35).

The location of the pictured appliance was also analyzed in the sampled promotional material. The living room (27%) was the most popular place to portray an appliance, followed by a neutral background (26%) (a neutral background means that the appliance was pictured against a color or black and white background), bedroom (10%), 'not clear' (10%), kitchen (5%), bathroom (5%), and study/work room (2%). The 'not clear' category meant that it was not clear in what kind of room the appliances were portrayed. There was no significant effect between the companies considering the pictured locations (F (7, 194) = 1.14, *p* = .34).

The relative size of the pictured humans and appliances was also analyzed to see if there were differences in size in the portrayal of humans and consumer appliances. The mean for relative size (in $cm^2$) of the pictured humans was 13.69 (*SD* = 19.75) and the mean for appliances was 46.49 (*SD* = 37.35). There was no significant difference between the companies on the relative size for humans (F (4, 178) = 1.01, *p* = .41), but there was a significant difference (F (7, 194) = 6.09, *p* = .00) between the companies on relative size of the pictured appliances. It was found that, LGE pictures scored significantly higher (*M* = 96.10, *SD* = 12.93) than Philips (*M* = 44.03, *SD* = 34.81), Orange (*M* = 24.15, *SD* = 32.70), Microsoft (*M* = 7.59, *SD* = 6.88) and Living Tomorrow (*M* = 6.94, *SD* = 7.33).

**Table 5.3** Total count scores, means and standard deviations of appliances per company

| Companies / Devices | Philips (n = 135) | HP (n = 22) | Living Tomorrow (n = 4) | MIT (n = 13) | LGE (n = 11) | Orange (n = 8) | Microsoft (n = 5) | IBM (n = 4) | Total (N = 202) |
|---|---|---|---|---|---|---|---|---|---|
| Wide screen | 26 (.19/.40) | 5 (.23/.43) | 2 (.50/.58) | 1 (.08/.28) | 3 (.27/.47) | 4 (.50/.53) | 3 (.60/.55) | 1 (.25/.50) | 45 (.22/.42) |
| Small screen | 18 (.13/.34) | 3 ( .14/.35) | 2 (.50/1.00) | 3 (.23/.44) | 2 (.18/.40) | 1 (.13/.35) | - | 6 (1.50/1.73)** | 35 (.18/.47) |
| Home control panel | 22 (.16/.39) | - | - | - | - | 4 (.50/.53) | - | 1 (.25/.50) | 27 (.18/.41) |
| Projection screen | 21 (.16/.36) | 2 (.09/.29) | - | 1 (.08/.28) | - | - | 1 (.20/.45) | - | 25 (.14/.35) |
| Micro hifi system | 17 (.13/.58) | 1 (.05/.21) | - | - | 2 (.18/.40) | - | 1 (.20/.45) | 1 (.25/.50) | 22 (.12/.53) |
| Digital pen | 12 (.09/.33) | 2 (.09/.29) | - | 3 (.23/.44) | - | 1 (.13/.35) | - | - | 18 (.10/.34) |
| Remote control | 9 (.07/.28) | - | - | - | 2 (.18/.40) | - | 4 (.80/.84)*** | - | 15 (.10/.34) |
| Ambient lighting | 8 (.06/.24) | 1 (.05/.21) | - | - | - | 2 (.25/.46) | 3 (.60/.55)*** | - | 14 (.08/.28) |
| PDA | - | 5 (.23/.43) | - | 3 (.23/.44) | 2 (.18/.40) | - | - | 1 (.25/.50) | 11 (.22/.42) |
| Intelligent label | 9 (.07/.25) | - | - | - | - | - | - | 1 (.25/.50) | 10 (.07/.26) |
| Total | 142 | 19 | 4 | 11 | 11 | 12 | 12 | 11 | 222 |

*Note.* Values enclosed in parentheses represent mean and standard deviation.

*$p < .05$. **$p < .01$. ***$p < .001$.

## 5.6 Conclusion and Discussion

The study was conducted to get a better understanding of the current representation of ambient intelligence in the home. This was done by a content analysis of promotional material of high-tech companies which are currently developing (prototype) consumer applications for domestic settings. As mentioned in the introduction, smart homes have been around now for some time and the results of this study suggest that many of the features which were stressed then are still being emphasized now. The results showed that “connectedness”, “control”, “easiness” and “personal” were the attributes most frequently mentioned in the promotional material. Two of the four most frequently mentioned attributes, control and connectedness did not differ between the companies’ presentations. This increases the probability that they are considered to be attributes of ambient intelligence applications by all producers at the start of the $21^{st}$ century. However, some significant differences were found between the presentations of the companies. Among the attributes that did differ significantly between the companies, there was not clearly one company that scored significantly higher on all the attributes. More than half of the recording units in the sample and attributes were delivered by Philips. However, as shown by the Scheffé test this makes no difference for the results of the significant attributes.

By a clustering of the attributes, three main groups could be distinguished, namely Convenience, Adaptation and Empowerment. Adaptation was the largest group which consists mainly of technical attributes of ambient intelligence and which also encompasses the most frequently mentioned attribute “Connectedness”. Connectedness can be seen as both a technical and a social attribute of ambient intelligence. The technical attribute connectedness refers to the connecting of all home applications in a network in the ambient intelligence vision. The social side of connectedness refers more to the provision of connections for humans living in the “smart home”, to make them feel “connected” with their family and friends despite geographical distances. Dovey (1985) describes the home as “a series of connections between a person and the world in a way that it connects us with the past, the future, the psychical environment and our social world” (p. 44). The results of this study indicate that in the ambient intelligence vision, a more connected and engaged way of communication between a person and the world awaits us. This finding corresponds with the way ambient intelligence is originally envisioned, namely connecting intelligent devices with each other to adapt to people’s needs.

The convenience cluster mainly encompasses "easiness" and this can be characterized as a social attribute of ambient intelligence. As mentioned in the introduction, the emphasis of ambient intelligence, is among other things, on greater user-friendliness and support for human interactions. Current information and communication technologies are often a source of irritation for users and the promise of ambient intelligence is that it will make information and communication technologies more user-friendly. Although the promise is that this technological vision is human-centered instead of technology centered, the social clusters Convenience and Empowerment were less emphasized in the promotional material than the technical cluster Adaptation. Further research should clarify whether this is caused by marketing preferences or that the developers of ambient intelligence really emphasize the technological aspects during the development of ambient intelligent applications.

The frequently mentioned attributes "control" and "personal" are the main components of the Empowerment cluster. These attributes probably indicate that the high-tech companies want to promote a potential main asset of ambient intelligence, namely more personal control over the information and communication technologies by users and not the other way around, as is the case now with many information and communication technologies.

It is remarkable that words such as privacy and security were mentioned less in the promotional material. These concepts are frequently debated in the literature (Bohn et al., 2004; Langheinrich, 2001; Punie, 2003; Waldrop, 2003) as important factors for the success or failure of ambient intelligence. Perhaps high-tech companies do not want to emphasize critical aspects, such as privacy and security that could deter future users from ambient intelligence. It is understandable that companies will not point out the critical factors in their promotional material about ambient intelligence.

The results from the picture analysis showed that although the aim of ambient intelligence is to be unobtrusive and to work in often invisible ways, a wide screen was the most depicted device in the sample. These findings could imply that although the wish is to make devices that are unobtrusive, this has not been realized yet. However, it could also be that they are harder to picture.

The user is the central focus of ambient intelligence (ISTAG, 2001, 2003), but this was not revealed in the analyzed pictures. In nearly half of the pictures no humans were portrayed and the relative size of the pictured applications was much higher than the size of the pictured humans. Of the humans pictured, males appeared more in the pictures than females and young adults were the frequently pictured human beings. This could mean that although the wish is to emphasize the user in this vision of society and that this vision is meant to be for everyone, this is not what is represented in the promotional material of high-tech companies which develop the applications. The results of this study indicate that in this stage of the development of ambient intelligence, the technical attributes are more emphasized than the user and social attributes. This does not concur with the ambient intelligence vision described above that stresses the user-centeredness of this innovation.

The living room was the place in the home where most applications were portrayed. This could imply that even though manufactures of ambient intelligent applications strive to develop applications which could be used everywhere in the home, in fact they develop applications appropriate for the room packed with most contemporary technology. In most of the Western world this is the living room.

Some caution is needed when drawing conclusions which are only based on promotional material. The marketing department of a company can have different ideas about ambient intelligence than engineers and designers who actually create the ambient intelligent applications. The promotional materials that were used in this study may or may not be created by the same companies that they represent and the visions that are therefore represented do not necessarily reflect their design rationales.

The findings of this empirical study showed that although the aim is to give a central role to the user this is not yet shown, at least not in the promotional material of the high-tech companies. Developers of ambient intelligent applications have to understand that the most frequently mentioned attributes (connectedness, easiness, control and personal) that were found in this study perhaps do not have sufficient appeal to prospective users. Whether this is true will be investigated in an empirical study reported in Chapter 7. In the next chapter, a study will be presented concerning the assumptions of designers with regard to the use and users of domestic ambient intelligent applications.

**End Notes**

[1]For the sake of simplicity only reference to companies is made in the text, recognizing that MIT is a research institution. But because of its progressive role in the development of ambient intelligent applications and its MIT House_n where ambient intelligent applications are designed and tested, it is comparable to the high-tech companies in this respect and therefore also included in this sample.

[2]Attributes in the codebook were: adaptability, ambient, automation, busy, comfort, connectedness, control, convenience, easiness, enjoyment, everyday life, flexibility, freedom, improving quality of life, interactivity, interoperability, mobility, personal, privacy, reliability, safety, save time, smart, user-centered, utility.

# 6

# Ambient Intelligence Designers and How Their Assumptions Shape Our Future

*In this chapter, an empirical study of the implicit assumptions that designers make about ambient intelligent designs and their prospective users will be presented. Twenty-seven ambient intelligence designers at four international high-tech companies were interviewed. First, potential assumptions about ambient intelligence will be discussed, followed by the method and procedures. Next, the findings, the actual assumptions of designers are presented. Finally, conclusions will be drawn at the end of the chapter.*

## 6.1 Introduction

The designers of new technologies are, among other things, important actors who create our future environments, including our public spaces, homes, and work places. Designers have implicit and explicit assumptions about people's use of future information and communication technologies. Due to the increasing possibilities of new technologies, the realization of the original ambient intelligence vision becomes within reach.

The assumptions that designers make regarding the design and user characteristics of ambient intelligent applications play an important role in the realization of ambient intelligence. Ambient intelligent applications encompass certain presumptions about people and their everyday lives. Venkatesh and Mazumbar (1999) ask what considerations enter into the design of these new domestic technologies which offer all kinds of technological possibilities. For one, implicit assumptions are made about the users of ambient intelligent applications, and these assumptions are reflected in the design. An example is the assumption that people want comfort in their daily lives and that ambient intelligent applications will provide this. To fill this need for comfort, users will need to give up some options for action, leaving those actions to be executed by technology.

As far as we know, the explicit assumptions that ambient intelligence designers hold about their designs and their prospective users are unknown. People working in the ambient intelligent community probably have some notion about what these assumptions are; however, these have not been empirically investigated. Furthermore, the potentially irreversible embedding of ambient intelligence into people's everyday lives presents significant challenges (Dourish, 2001). Recently, ethnographic studies (e.g., Rode, Toye, & Blackwell, 2004; Salvador, Bell, & Anderson, 1999) and historical analysis (Wyche, Sengers, & Grinter, 2006) have been used to inform the design of ambient intelligent applications. Defamiliarization of the home has also been used to inspire strategies for the design of domestic technology (Bell, Blythe, & Sengers, 2005).

It is important to study ambient intelligence designers' assumptions at an early stage to determine how these assumptions steer the development of these applications. This study aims to identify the designers' assumptions about the design and user characteristics of ambient intelligent applications for domestic settings. Designers of international high-tech companies were interviewed about their assumptions and the results will be presented in the following sections. Finally, the implications of how these assumptions may affect prospective users' experiences and the further development of ambient intelligence will be discussed.

## 6.2 Assumptions about Ambient Intelligence

As mentioned earlier, in Chapter 3, the mutual shaping of technology and users' perspective includes useful approaches to study the design of a technology and the assumptions of designers of a particular technology. The script-approach (Akrich & Latour, 1992) as outlined in Chapter 3 could shed light on the design of ambient intelligent applications. Innovators construct many different representations of their prospective users, and they objectify these representations in technological choices (Akrich, 1995). In this way, designers 'inscribe' their visions of the prospective users into the technology and specific skills, practices, and responsibilities are attributed to and delegated to the envisioned users of the technology (Akrich & Latour, 1992). This approach emphasizes the inscription of ideas and assumptions that designers have during the development process of products about potential users of these products. The script approach can be used to deconstruct products and to analyze which assumptions designers had about potential users during the development process. As described in Chapter 3, this semiotic approach provides insight on how the ‘scripts’ are read by the users, thus how users actually use the products when they are adopted by them. How users ‘read’ the scripts can be very different from how the designers intended the scripts to be read. When products are adopted and domesticated in people’s environments users can change scripts or adapt scripts to suit the needs of the users not foreseen by the designers.

Designers of ambient intelligent applications will also inscribe their assumptions about prospective users into these applications. They too will implicitly or explicitly inscribe possible practices and restraints for users into ambient intelligent applications. The assumptions designers of ambient intelligent applications inscribe in their products may be based on their knowledge of their target groups, such as specific characteristics and needs their prospective users have.

In the 1990s, Stone observed that computer engineers were ”articulating their own assumptions about bodies and sociality and projecting them onto the codes that define cyberspace systems” (Stone, 1991, p. 103 ). Also, human-computer-interaction (HCI) professionals and system designers rely on their insight into the users’ worlds and on their knowledge of relevant social science theory to create likely hypotheses about relevant user characteristics, such as the users’ identities (Clemmensen, 2004). Clemmensen refers to this as ‘user modeling’, which is the conscious attempt of HCI professionals to learn about the users and to describe them in a way that is useful in the design process.

It is plausible to assume that ambient intelligence designers also use some kind of user modeling in their work and that they articulate assumptions about their prospective users in a way that is reflected in ambient intelligence applications. A study about the role of the user gender in technological development showed that designers of smart homes primarily design for the technically-interested man, and that they pay special attention to the technical gadgets that would interest the future owners of the house (Berg, 1999).

The technical assumptions regarding the underlying infrastructure or applications are more likely to be explicitly mentioned (e.g., Chang et al., 2006; Durmaz Incel, Dulman, & Jansen, 2006) in ambient intelligent designs than the assumptions regarding use and users. Langheinrich (2001) emphasizes that the properties of ambient intelligence, such as ubiquity, invisibility, and sensory and memory amplification, entail social implications that are important to acknowledge from the start and to account for when designing concrete systems. The assumptions that designers have, such as assumptions about how much control the end-user wishes to have over certain ambient intelligent applications, will have a direct effect on which actions will be possible to execute with such an application. Therefore, it is believed that the script approach can provide valuable insights into the underlying assumptions which are used by designers of ambient intelligent applications to inscribe their vision into these applications.

Usually, the script approach is used to deconstruct the scripts of a product once it is in use and thus read by its users. Since, ambient intelligent applications are not available yet and thus not adopted by users the reading of the script by users can not be deconstructed. However, on what assumptions the scripts of designers of ambient intelligent applications are based can be currently studied since designers have started to develop ambient intelligent applications. Knowing these assumptions of designers in an early development phase of ambient intelligence can provide valuable insights into the direction this technology is heading or should be read according to its designers.

## 6.3 Research Questions

According to Thackara (2001), the dilemma is that the designers and the industry do not know and do not even think about which needs the ubiquitous technologies are supposed to meet. He argues that the designers do not know the needs of users or whether these technologies present any added value for users. This lack of knowledge on the part of designers is a serious concern, which may imply that ambient intelligent applications are intended more to create needs than to fulfill existing needs. However, the ambient intelligence community seems to be increasingly sensitive to users' needs and social issues. This is evident, for example, in the increasing number of user and society related articles presented at conferences and in journal articles, although such articles are still relatively few compared to the technical articles.

The ambient intelligence community's growing focus on the incorporation of social issues in their research is an important step forward, but the assumptions of ambient intelligence designers have not yet been empirically investigated in order to ascertain which assumptions are being made about design and user characteristics of ambient intelligent applications when designers try to realize the ambient intelligence vision.

The present research aims to fill in this gap by addressing the following questions:

RQ1: According to their designers, which design characteristics do ambient intelligent applications have in domestic settings?

RQ2: According to their designers, what are the technical and social benefits of ambient intelligent applications in domestic settings?

RQ3: What are the process(es) through which prospective users are assumed to adopt ambient intelligent applications in domestic settings?

RQ4: According to ambient intelligence designers, what are the assumed consequences and implications of ambient intelligent applications for individuals and society?

## 6.4 Methodology

This study employs the interpretative, qualitative methodology of in-depth interviews to examine the assumptions of ambient intelligence designers regarding product use and users. Ambient intelligence designers often work at the research centers of high-tech companies or in academic settings. We chose to focus on designers employed by international high-tech companies, who can be seen as a representative sample of this field. Conducting research inside organizations is complicated by the researchers' need to gain access, which limits the opportunity for random sampling (Bryman, 1989). Twelve international high-tech companies working in the field of ambient intelligence were approached and asked to participate in this study. Four companies, Nokia (a Finnish company), Philips (a Dutch company), Intel (a North-American company) and Siemens (a German company) agreed to participate, and arrangements were made to visit the designers on site.

### 6.4.1 Procedure and Participants

A contact person was assigned to each company to help identify the appropriate respondents. The contact person was someone from the division of the company where (prototype) ambient intelligent applications and systems are designed and who had a good understanding of the different positions in this division. He/she initially filtered the possible respondents according to several selection criteria. A criterion sample (Patton, 2002) was used to select the respondents. This means that only respondents that met these criteria were picked. The criteria for selecting respondents for the interviews were: 1) respondents had to work for companies that had a group of people dedicated to the development of ambient intelligent applications for domestic settings; and 2) respondents had to be involved in the development of ubiquitous applications and systems, although their responsibilities could vary, including technical aspects (such as systems architecture, embedded systems, networks, software, and hardware development); design aspects such as interface and interaction design, usability design, and content design; and managerial aspects including project or research management, strategy and implementation. The respondents were selected because they were information-rich cases with the potential for in-depth analysis (Patton, 2002), a characteristic determined by the researchers, who received a job description in advance for each of the possible respondents from the contact person.

The nonrandom selective sampling procedure consisted of two phases. First, companies were selected, and then individual expert respondents were selected within each company. Descriptions of the job functions of potential respondents were sent to the researchers to check whether the respondents met the abovementioned criteria. After agreement was established, the contact person subsequently approached the potential respondents via e-mail and telephone to ascertain their willingness to participate in interviews. In total, three original respondents were unable to participate, and three new respondents were found to replace them.

The final sample consisted of twenty-seven people, of whom seven worked for Nokia, seven for Philips, seven for Intel, and six for Siemens. The sample was predominantly made up of males, with twenty-two males and five females. The respondents can be divided into two groups: respondents involved in the technical development and realization of ambient intelligent applications (i.e., people who are actually designing the applications or parts of them) and respondents who are involved in the business and user-oriented side of ambient intelligent applications, for example, as project leaders, ethnographers, sociologists, psychologists, or strategists. We refer to these groups as the 'technical respondents' and the 'non-technical respondents', respectively. There were sixteen technical respondents and eleven non-technical respondents, and respondents' ages ranged from the mid-twenties to the late sixties.

### 6.4.2 The Interview Scheme

In order to examine the assumptions of the designers, a semi-structured interview was devised that encompassed topics derived from the literature in the ambient intelligence, human-computer interaction, information systems and new media fields. The interview scheme was tested on site to see whether any modifications were necessary. After the first three interviews, some adjustments were made in the phrasing of the questions. The on-site interviews lasted 1.5 to 2 hours, and respondents were assured of confidentiality. Data were collected from April 2005 through December 2005. The interview began by explaining the selection procedure to the respondents, and permission was asked to record the interview (none of the respondents refused this request). It was agreed that the respondent could refuse to answer any question that fell under the non-disclosure agreement of his or her employer. At the end of the interview, respondents were asked if they had anything to add to the interview. Respondents also received a small gift (a box of chocolates) for their participation.

The interview started with several questions about the respondents' background, such as their age, their educational background, their years of employment with their current employer, and their years of employment in their current function. They were then asked to describe what their work entailed. These questions were asked to make the respondents feel at ease and to stimulate further conversation. After this, the respondents were asked to describe the company's focus within ambient intelligent applications and the respondents' precise role in the development of ambient intelligent applications. The interview scheme consisted of topics which covered the four research questions and which were subdivided as follows:

*RQ1: According to their designers, which design characteristics do ambient intelligent applications have in domestic settings?*

1. The design characteristics of ambient intelligent applications.
2. The presence of factors that influence(d) the development of the ambient intelligent applications.

*RQ2: According to their designers, what are the technical and social benefits of ambient intelligent applications in domestic settings?*

3. A comparison of ambient intelligent applications with existing home technologies (if comparable).
4. The assumptions about the technological and social benefits of designers' own designs for ambient intelligent applications.
5. The fulfillment of users' needs through the development of ambient intelligent applications.

*RQ3: What are the processes through which prospective users are assumed to adopt ambient intelligent applications in domestic settings?*

6. Assumptions about kinds of users (including their social profile, lifestyle, and ICT experience).
7. Assumptions about users' adoption and use.
8. Prospective barriers for user adoption.
9. Representation of critical issues, such as privacy, control, trust, and complexity in ambient intelligent applications.

*RQ4: According to ambient intelligence designers, what are the assumed consequences and implications of ambient intelligent applications for individuals and society?*

10. The potential consequences of ambient intelligent applications in domestic settings for everyday life and for society.

### 6.4.3 Data Analysis

A qualitative approach was used to better understand the assumptions held by the designers of ambient intelligent applications. An interpretative methodology was appropriate to get an in-depth understanding of the designers' views, since pre-existing work in this area was not specific to these research questions (Creswell, 1998). Different ways of looking at the same set of data can lead to important insights (Patton, 2002); therefore, the data analysis consisted of several stages.

First, all recordings of the interviews were transcribed. Two assistants independently went through the data and identified recurring themes and issues that surfaced in the data, paying special attention to the assumptions of the designers regarding ambient intelligent applications, their characteristics and their prospective users, and then the themes were broken down into categories. The preliminary categories were then refined and these categories were continually compared and contrasted during the analysis phase and adjusted according to new insights and discrepant cases (Creswell, 1998). A coding manual was developed with detailed descriptions of the categories. The data was then examined again, and special attention was paid to the similarities and differences between the respondents, both within and across companies.

## 6.5 Findings

There were no systematic differences between the findings from the different companies. While it would be possible for one company to have different views about socio-technical innovation than another company, that was not the case for the companies that we interviewed. However, strong differences were noted between the answers of the technical and non-technical respondents. The views of the technical respondents were much more technology-driven than the views of the non-technical respondents. The latter preferred to look first at serving people, and to identify the kinds of technologies that would fit into their lives, rather than the other way around. This result was striking, since most of the respondents worked in groups with people from various backgrounds. It was expected that the technical respondents' and the non-technical respondents' views would have influenced each other. However, as one respondent remarked, the notion of learning from each other was just beginning:

> *You can't just walk up to your average engineer, or venture capitalist, or marketing person, and say that this is very important. Unless you say it as a result: think about the following investments or here are some implications* [non-technical participant, nr. 10].

### 6.5.1 Background and Characteristics of Ambient Intelligent Applications

In order to provide context for the ambient intelligent applications and to prevent general views about ambient intelligence, the questions focused on specific applications that designers were working on or had recently finished. The designs were often shown to get a better understanding of their characteristics and their development phases (several designs fell under the company's non-disclosure agreement, so respondents were not allowed to reveal anything about the designs). The phases of the designs under discussion varied from research to pre-production to products entering the market.

Most of the designs were in the research phase, and were primarily being used to test possibilities, users' reactions, and commercial potential. If reactions from different actors are positive (e.g., if the product receives positive feedback from users, strategic planners, or upper management), more money and engineering resources are put into the design to develop it further. Four designs were already on the market or were being prepared for the market, and should thus be thought of as precursors to 'real' ambient intelligent applications. The reason for this is that the characteristics attributed to ambient intelligent applications, such as intelligence, an ability to learn certain behaviors of the users in specific contexts, and an ability to adapt to those behaviors, were not incorporated into these designs. The technology is said to be so complex and in such a nascent state that the technology is hardly robust enough to be commercially viable:

> *We did a lot of work on sensor networks and some of the sensor network technology we are really pushing that technology further. It may or may not end up being [company's name] product, but we are working to get it basically to our own robustness…but to say to get the technology half the phase that in order to do any research with it, it has to be a PhD computer scientist which is where things are right now. With a lot of the ubiquitous computing technology actually. You know, to do these ubiquitous*

*computing applications it sounds real good and you can say the technology is mature but really you need a bunch of PhD'ers to do just a little, almost toy application* [non-technical participant, nr. 21].

Designers were working on applications that were mainly related to three areas: entertainment, health, and home control/security. Some examples of the applications are a device that enables users to watch a TV program in different rooms of the home, a device that monitors the movements of elderly people so that they can be prompted if their 'normal' behavior pattern is interrupted, and devices that are able to control home conditions such as lighting, gas, and temperature from a phone or PDA outside the home.

Respondents mentioned several factors that influenced the development of the ambient intelligent applications. Examples include trying to pursue the Weiser vision, feeling that the timing was right, and thinking that the technologies are more or less available and companies do not want to stay behind competitors who are also working in this field. The last reason was illustrated by one respondent:

> *It was predominantly driven out of technology. The reason I think, the time was right at that stage because home networks becoming more common. So it is interesting, anything about digital home it probably goes back in our company about 15 years. As with many of those begin initiatives that sort of get born, they disappear, they beat up, and they get reborn under a different label. At some point in time it actually gains enough momentum and initiative that actually has some sustaining power. Or at the same time, the environments and the industry has changed significant, sufficiently that it really feels like this industry momentum to make something really happen* [technical participant, nr. 6].

### 6.5.2 Benefits of Ambient Intelligent Applications

Designers were asked if ambient intelligent applications for the home could be compared with current domestic technologies. They replied that domestic ambient intelligent applications were not seen as something completely new, but rather as a continuation of existing products with a little bit of 'magic'. This idea of 'magic' refers to the way that the systems and applications operate, meaning that designers want to give users a satisfying experience without requiring users to know how it all works. Furthermore, respondents emphasized that the difference was that the designers tried to 'add' something to the existing technologies to make it easier to use, and that users would have a more comfortable experience at the 'right' price. This view was summarized by one respondent:

> *The technology is no great leap. In a way the technology is relatively old, the key is actually bringing the technologies together in a way that it is easy to use at the right price for the home. Cause one of the issues in the past was how to get it together cheaply* [non-technical participant, nr. 19].

The data obtained in this study revealed that the benefits mentioned by ambient intelligence designers regarding their own applications can be divided into three groups: technical, social, and economic benefits. Among the technical benefits were fewer 'boxes' in people's homes, more intelligent devices, and more connected devices that can 'speak' with each other. However, respondents clarified that at this moment; even the basic underlying technologies have complexities and problems of their own. This drawback of the current technology was listed by more than a third of the respondents as a reason to see ambient intelligent applications as a way of leaving behind the existing problems.

> *You can almost say that what you want to do is to solve the rubbish which is created by the past technology evolution and want to solve this with the power of the current technology evolution* [technical participant, nr. 4].

This notion was echoed by a non-technical respondent, who also saw the development of ambient intelligent applications as a way to avoid dealing with the current problems that people have with technology:

> *There is a whole set of things you could fix without creating a whole new set of technologies. And in fact, in some ways you could argue that our impulse to create new technologies is because we don't want to fix the problems with the stuff that exist right now* [non-technical participant, nr. 22].

The most important social benefit, one that was mentioned by almost all of the respondents, was that ambient intelligent applications would make people's lives easier in one way or the other. This observation was independent of the type of application that the designers were working on. Also, more than half of the respondents mentioned relieving people of certain 'burdens' by making some tasks and routines automatic. This was explained as follows:

> *One of the things is to avoid stress. We want to help people in making their 'to-do' list smaller. We would like to see that such a system would be able to take almost everything over from you. If you will not choose, then everything will go automatically. That would be the most ideal situation. You will have the choice where your attention goes to* [technical participant, nr. 2].

Not only would people have to worry less about 'mundane' things, they would also have more freedom in the sense that they could access their information, music, photos, or videos from anywhere inside or outside the home. Respondents also emphasized that users would have more fun interacting with ambient intelligent applications.

Another benefit for users was that some of the domestic ambient intelligent applications would save time, and that this time could be spent on other, 'better' things, such as quality time with family and friends. More than a third of the respondents worked on applications that would enhance communication between people inside and outside the home. They referred to video walls or video messages where people at different physical locations could see and talk to each other, and could also monitor a family member (for example, an elderly person) to see how the person is doing. This long distance communication would enhance relationships among geographically dispersed families and friends.

More critical feedback was heard regarding the social benefits that ambient intelligent applications would yield, especially from the non-technical respondents. These respondents argued that the complex behavior of human beings is not realistically represented in the development of these applications. They felt that a lot of important habits that people have are not taken into account, even if the designs are serving specific goals. They also noted that these habits and routines are often cherished by people. Furthermore, they mentioned that although ambient intelligent applications fill certain needs, these needs are fabricated. One respondent expressed this as follows:

> *The needs may be somewhat fabricated that after people start to adapt to the device then they say 'how can I possibly lived without it'* [technical participant, nr. 18].

Half of the designers worked on or had previously worked on applications with the aim of improving well-being or health so that people could live independently for a longer time, with the goal often being the economic benefit that this would bring. They mentioned that health care settings are an important area for ambient intelligent applications, since hospitals and governments try to lower the health care costs and support cost savings in health care which could be done through the use of ambient intelligent applications.

### 6.5.3 Future Adoption and Use

A third of the respondents indicated that they build ambient intelligent applications for everyone, including people of all ages and people with different kinds of ICT experiences. In some cases, however, specific groups are targeted, such as the elderly. The results showed that in the initial introduction phase of various applications, the most common target users after the elderly are often upper-middle class people between thirty and sixty years of age; affluent technology users with an active lifestyle, a large social network, busy schedules, and many responsibilities both inside and outside the home. This is clarified as follows:

> *People who are highly interested in technology and with a lot of affinity in that area and with a bit of money* [non-technical participant, nr. 5].

The importance of the economic ability of users to buy ambient intelligent applications is even more explicitly stated by another respondent:

> *If you are living from minimum wage, then you are not going to spend 1000 Euro to try out a new device* [technical participant, nr. 1].

According to designers, the most suitable place in the home for current ambient intelligent applications is the living room, although designers stressed that they are trying to make applications accessible from all places in the home. Half of the ambient intelligent applications were aimed to support an entertainment need and to improve social interaction between families and friends, activities which, it was argued, are often done in the living room. The other half of the applications were control/monitor applications to enhance health care activities and to enhance the feeling of security for users; these functions could also take place in other areas of the home, such as the bedroom and the bathroom.

According to the respondents, the adoption process of ambient intelligent applications will follow a replacement and push strategy. The idea is that at some point, people are going to replace their current home appliances, and the ambient intelligent products for domestic settings will then be available to purchase on a mass-market scale. More than half of the respondents think that people will adopt ambient intelligent applications, because they think that people seem to be ready for these new technologies. It is argued that people will get attached to ambient intelligent applications and that they will not want to live without them anymore, as is the case with home appliances such as the washing machine and the refrigerator. This readiness for ambient intelligent applications is also partly based on current behavior in different consumer segments, such as in the TV, audio, and video markets. As one respondent explained:

> *And now people don't think twice about dishing up 5000 bucks for a big panel TV. So it is real vigorous in people's notion of I now have invested in this big TV screen what*

*else can I put on the TV screen that is worthwhile looking at* [technical participant, nr. 23].

Another strategy mentioned is the push strategy, which means that companies and/or governments will push certain technologies that have to be used by people.

When asked how users will learn how to handle the applications, designers replied that they try to make the devices as intuitive as possible to use. That has not always worked out the way they wanted, because some components of the technology and/or infrastructure are not as developed as they need to be. Until the technology is fully developed, users will have to learn how ambient intelligent applications work, and applications must integrate cues about how to use them. Respondents emphasized that manuals will be unnecessary in the future, although manuals will not disappear entirely, even if only for legal reasons.

*Potential Adoption Barriers.* Designers were asked if they foresaw any barriers for users with regard to the adoption of ambient intelligent applications. Thirteen respondents mentioned the complexity of the applications, and several respondents also cited the lack of privacy and the price of the applications. Other barriers include fear of the technology, lack of trust, unfamiliarity with the kind of technology that does things for you and therefore can seem to take away human control, and 'nonsense' ambient intelligent applications. Nonsense applications are applications that are possible to build with current technologies but that have no added value for users.

Respondents were asked how they deal with the mentioned barriers and in what ways they take the barriers into account in their own applications. All respondents emphasized that they attempted to design their ambient intelligent applications to be as simple as possible and to make sure that the level of complexity is as low as possible within the given context and current possibilities. The complexity of ambient intelligent applications was often related to privacy issues in the sense that designers wondered how to make certain actions visible to users without making things more complex.

Personalization of the ambient intelligent applications is also related to privacy issues. The goal of making ambient intelligent applications as personal as possible for users was mentioned as a barrier to handling privacy issues well. Some respondents mentioned that they only provided, for example, four settings from which the user could choose; this was an effort to keep both the privacy risks and the level of complexity low. Respondents also mentioned that privacy issues were more complex if the applications were also mobile, or if they could be used from both inside and outside the house. Respondents mentioned that the home was a private setting; people usually only live with or invite into their home the people that they trust. It was stressed that people with whom you already live can get to your personal belongings, and can see them by entering your room or opening your closet. Therefore, respondents stated that privacy is less of an issue in applications for domestic settings:

> *We have always said that our point of view is that the social context must assure that it is safeguarded against violation of privacy. That you have to treat each other [the members of the household] on a basis of trust so we didn't put any mechanism in that regarding privacy* [technical participant, nr. 3].

However, some respondents tried to prevent sensitive private data from being seen by outsiders or hackers or from becoming otherwise available to others. They did this by recognizing the potential threat, taking it into account, and choosing to incorporate more secure systems or preventive measures into the applications. For example, some applications avoid using cameras to monitor people's behavior, or they require the user to make deliberate choices to be able to perform certain tasks.

The respondents handled the difficult issue of privacy in different ways throughout the design of ambient intelligent applications. There was a clear difference between the technical and the non-technical respondents in the way that they perceived and handled privacy. One technical respondent stated:

> *Privacy is something that I'm not that much concerned about, you're already using online applications today and you do telebanking from home and you're not that much concerned about your privacy anymore. And we used a very safe security means for our applications, so I don't expect on that side major problems and our concept of the home gateway is more safe than any other competitive concept about using pc's that could be hacked* [technical participant, nr. 21].

The non-technical respondents, on the other hand, saw users' privacy as a very complex issue that was not sufficiently taken into account during the design phase. They claimed that users are unaware of the potential misuse when using certain applications. They also stated that almost every designer of ambient intelligent applications is aware of the privacy problems, but that they are not tackled often enough. This is also partly due to the fact that not all of the applications will become products. Additionally, privacy legislation is currently unclear. One respondent said:

> *We try to fulfill the existing legislation at least when possible related to data privacy. However, the legislation is not very much and not very good at the moment. There are very few guidelines. We try to; it is users who have to be in control of their own data. So we are trying not to risk privacy. We try to avoid risking privacy at all possible ways when designing products. But the problem is that that will lead to more configurations. So more security less usability and more usability, less security. So*

> *that is a balance you have to deal with and in our case it happens on a case by case basis* [technical participant, nr. 11].

The designers often see the concepts of trust and privacy as intertwined. Designers were asked how they deal with the issue of trust in their ambient intelligent applications, and some designers responded that they were surprised how easily people trusted their applications during user tests:

> *It is funny how people seem to trust the system far more than I did as the engineer, that's why I am an engineer. People had high expectations that it would work. Like the display, people expected that that would accurately reflect how much time they spend talking with various relatives and their friends and in fact there were a lot of complex issues around figuring out who is making the phone call. We know the phone number, but we would not necessarily know who it was. And also they use things like calling cards at times where we get this number and we had no idea who it was but yet the respondents trusted it. I would say we didn't spend a lot of energy thinking about how to convince people to trust the system* [technical participant, nr. 15].

More than a third of the respondents mentioned branding as a strategy for creating trust. They argued that if people trust a certain brand, they will also trust its ambient intelligent applications.

> *Product brand is an important factor. If it comes from a distinguishable manufacturer such as Sony, Nokia or Philips or whoever is making the application then it is more reputable. It is expected to be more reliable and trustworthy. We have this slogan … which is the label of our products. We feel the products are sufficiently reliable and trustworthy. It is expected to be more reliable, more trustworthy* [technical participant, nr. 25].

Other respondents mentioned that trust was gained slowly and that users made rational considerations regarding the benefits and potential risks of ambient intelligent applications. Respondents also emphasized that whenever possible, designers had tried to use accepted underlying networks and infrastructures to show users that they are already using the infrastructure and therefore should not be afraid.

### 6.5.4 The Assumed Consequences and Implications for Individuals and Society

Designers were asked about the direction in which ambient intelligent applications for domestic settings are heading. They replied that ambient intelligent applications will make our lives easier and more convenient, that people will have more time for themselves and their families, and that people will have closer social networks (again). One respondent talked about the renewed sense of community:

> *A renewed sense of community with your family, also with your friends. The virtual family can have a sense of still being together. Better quality communication devices. The experience will be of a better quality in the future* [non-technical participant, nr. 19].

Six of the twenty-seven respondents were more skeptical about the future. Their view was that ambient intelligent applications may not be the revolution that they are sometimes presented as being. They emphasized that the applications may enhance the experience of certain tasks, but that they will not bring a revolution like those brought by the television and the personal computer. Technology's larger role in our lives was also mentioned; it was not always seen as a bad thing, but respondents acknowledged that it could lead to side effects that cannot be foreseen. In addition, one foreseeable effect is the increased confusion among people:

> *Increased confusion, well people are going to be scared about living room technology. Can I configure this card? They don't know how it works, how it can be configured. People are already scared about very simple devices, like video recorders. We of course try to make the new things very simple but that is more and more impossible, because to be able to go to the market with new things means new features. New features mean more learning for the people. The market requires more features and that increases the difficulty for the user which is really sad* [technical participant, nr. 11].

Furthermore, it is suggested that people could become more apathetic because systems are making choices for people, and they may be inclined to think that the choice the system makes is 'fine, too'. The gap between rich, highly-educated people and poor, less-educated people has been increasing; one potential reason is the high income and skills that are needed to own and to understand ambient intelligent applications. Respondents stressed that the focus on only the technological side of ambient intelligent applications was something that they hoped could be avoided, and that people should be the central issue in the development of these applications. This view was clarified by one of the respondents who stated:

> *I hope that our company is heading to be much more acutely aware of the home part of that equation than of the digital part of the equation. And that unlike for instance the paperless office, a great fantasy, we actually imagine people live in these homes* [non-technical participant, nr. 10].

## 6.6 Conclusions

The aim of this research was to explore the assumptions of designers and to answer the research questions presented in Section 6.3. In answer to RQ1, concerning the design characteristics of domestic ambient intelligent applications, it can be concluded that designers primarily characterize ambient intelligent applications by their connectivity and their built-in intelligence, so that they can anticipate user behavior. However, due to technological barriers, these characteristics are not yet present in all ambient intelligent designs. Moreover, the pursuit of ambient intelligent applications is partly perceived as a way to avoid having to fix current technology problems.

The most important technical benefits perceived by designers (RQ2) were the reduction in the number of boxes in people's homes and the presence of more intelligent devices and more connected devices that can 'speak' with each other. The most important perceived social benefit was that ambient intelligent applications could make people's everyday lives easier. Designers aim to satisfy the presumed needs of users for a more convenient and less hassled life. Simultaneously "user needs" are also being fabricated because new technologies are available to create (precursors of) ambient intelligent applications and these are expected to be adopted by people because of their current lifestyles.

Designers presume that the adoption process of ambient intelligent applications will happen either gradually through the replacement of current domestic applications by ambient intelligent applications, or more abruptly via governmental and corporate technology pushes, such as introducing compulsory new standards (RQ3). It is assumed that *certain* users will adopt the technology first, that is, technologically advanced users who have sufficient wealth. These groups are the target groups of the ambient intelligent designs. Moreover, designers want to make the adoption process of ambient intelligence as smooth as possible by trying to make the applications less complex. Whether this is possible remains to be seen, since the market demands more features, which will increase complexity.

The last research question (RQ4), concerning the presumed consequences and implications of domestic ambient intelligent applications for individuals and society compromises both positive and negative consequences. It can be concluded that the most positive consequence of ambient intelligence according to the designers will be the increase in quality time that people will have with family members and friends. Furthermore, the conclusion is drawn that ambient intelligent applications will support the maintenance or improvement of existing social relationships. The increase in quality time is suggested to be a direct consequence of the use of ambient intelligent applications. Because these applications are aimed to make tasks and activities around and in the house more efficient, people are supposed to have more time left. The efficiency notion of domestic ambient intelligent applications is very similar to the efficiency factor related to "common" domestic technologies (Bell & Kaye, 2002).

In addition to the potential positive consequence of ambient intelligence as brought forward by designers, negative consequences are also foreseen. A first one is a growing apathy among users because ambient intelligent applications will make choices for them. A second negative consequence anticipated by designers is that people will become more confused about how to handle complex technology in their lives.

The implications of the assumptions found in this research will be discussed in more detail in Chapter 9. Ambient intelligence will not only be shaped by its designers but also by its prospective users. In the following chapter, the perceptions of prospective users of domestic ambient intelligent applications will be presented.

# 7

# The Anticipated Adoption of Ambient Intelligent Appliances in Domestic Settings

*In the previous chapter, designers' assumptions about the design and user characteristics of ambient intelligent applications for domestic settings were identified. In this chapter, the central focus is on how prospective users perceive ambient intelligent appliances in domestic settings. A large-scale quantitative survey was used to provide an overall picture and understanding of the anticipated adoption by prospective users. First, a model will be presented which was constructed to study the anticipated adoption of ambient intelligent applications. Next, the method and procedures are discussed in more detail, followed by the findings. Finally, conclusions will be drawn at the end of the chapter.*

## 7.1 Introduction

Ambient intelligence is a growing interdisciplinary area in which the focus is shifting towards users instead of merely emphasizing the technological opportunities of ambient intelligence (see Chapter 2). Different methods are employed to understand the potential adoption of ambient intelligent applications by users in a wide range of settings. For example, ethnographic studies (Hughes, O'Brien, Rodden, Rouncefield, & Viller, 2000), scenarios and risk assessment (Hilty, Som, & Kohler, 2004), historical analysis (Wyche, Sengers, & Grinter, 2006), and interviews combined with diary studies (Ellis, 2004) have been used to gain a better understanding of ambient intelligence and its possible consequences in different domains.

A large number of studies has focused on the needs and support of older persons in the home and how technology can assist their independent living (Baillie & Benyon, 2001; Blythe, Monk, & Doughty, 2005; Consolvo et al., 2004; Mynatt, Melenhorst, Fisk, & Rogers, 2004). On a smaller scale, both in the US and in Europe, studies have been undertaken which focus not only on health care for seniors but also on the general needs and expectations of people regarding intelligent domestic technologies (Eggen, Hollemans, & Van de Sluis, 2003; Ellis, 2004; Venkatesh, Stolzoff, Shih, & Mazumdar, 2001). In the next section, these studies will be briefly reviewed to show that there is a multitude of different methods used to investigate the potential use of ambient intelligent applications and what they have learned us so far.

## 7.2 Understanding the Potential Adoption of Ambient Intelligent Applications

Researchers from different backgrounds try to gain understanding of ambient intelligent applications in domestic settings to inform future design and to evaluate what kind of implications these applications can have for prospective users.

Health care is seen as a potential area where ambient intelligence could provide many benefits for both the patient and the care giver (in terms of health monitoring, cost savings, and efficiency, see Greenfield, 2006) and where different methods are used to explore this area. Interviews were used in the study by Mynatt et al. (2004) to address the physical and cognitive needs of elderly to support their daily activities. Different devices were shown to elderly during a tour in the Aware Home. The Aware Home is a normal home embedded with sensors and facilities to support ubiquitous interactions between the residents and the house (see Abowd et al., 2002). One such device was the Gesture Pendant (a wireless device) which enables the residents to give commands in the form of hand movements. Activities such as closing the blinds, dimming of lights and raising the thermostat temperature could be executed by using different gestures. After the tour participants were asked about their opinions regarding the devices.

Semi-structured interviews and a two-week phone diary study were methods used by Consolvo et al. (2004) to explore the needs and implications of these kinds of information systems. A technology-probe named the "Carenet Display" was used here to understand current practices, needs, and privacy concerns of eldercare technologies. The Carenet Display was an interactive ambient picture frame which provided local-network members of the older person with updates throughout the day about the elder's calendar and information about the elder's meals, medications and activities (see Consolvo et al., 2004). Blythe, Monk and Doughty (2005) used interviews with medical and care professionals and elderly to investigate the needs of technologies for elderly.

As mentioned earlier, studies have also been undertaken which focus not only on health care for elderly but on the general needs and expectations of people regarding ambient intelligence. Venkatesh et al. (2001) used photographs and illustrations of smart homes and appliances during interviews to gain insight into the attitude and potential interest of American household members towards the home of the future. Workshops were used by Baillie and Benyon (2001) in five homes in Scotland to explore the requirements that people have for ambient intelligent technologies in domestic settings. Pictures of emerging technologies were shown and discussed with the families and scenarios were used to imagine activities which could be possible in the near future (see Baillie & Benyon, 2001). In the Netherlands, Eggen, Hollemans and Van de Sluis (2003) used multiple interactive family sessions with ten families to answer the following three questions: 1) what does 'home' mean to people 2) what do people expect from a 'smart home' and 3) how do people specify their ideal 'future home'? The sessions involved interviews, showing prototypes of future technologies to stimulate the imagination and picture drawing. In the study of Ellis (2004) a total of 47 people from different European countries (Norway, Finland, Hungary, and UK) were interviewed to gain insight into user receptions of ambient intelligence. The respondents also used dairies and disposable cameras to deliver data on work/ home boundary issues. The respondents were mainly recruited through the researchers' social networks and therefore white collar workers were over-represented.

This brief overview of studies shows that different methods such as small-scale questionnaires, focus groups, interviews, diary studies, and cultural probes studies are the most frequently used methods to elicit responses from users regarding domestic ambient intelligent applications. However, these are often small-scale methods that focus on specific subgroups. As ambient intelligent appliances will ultimately be woven into society and into the everyday lives of many people (Dourish, 2001), large scale quantitative studies can be a valuable addition to current methods to provide an overall picture and understanding of the anticipated adoption of ambient intelligent appliances by a large, diverse group of people. Therefore, in this research a large scale survey will be adopted to examine the anticipated adoption of ambient intelligent appliances.

## 7.3 Research Questions

Precursors of ambient intelligent appliances are entering the public domain and research activities worldwide have been employed to realize the ambient intelligence vision. However, not enough knowledge is available about people's perceptions of domestic ambient intelligent appliances to understand and inform the future development of ambient intelligence. Therefore, the following research questions are addressed:

> RQ1: How are the benefits and disadvantages of domestic ambient intelligent appliances perceived by potential users?
>
> RQ2: What are the attitudes and intentions of potential users regarding ambient intelligent appliances?

We would also like to go one step further and focus on the variables which could explain and predict the anticipated adoption of ambient intelligent appliances. Therefore, a third research question is proposed:

> RQ3: Which variables explain and predict the attitudes and intentions for adopting ambient intelligent appliances in domestic settings, and what are their relationships?

In Chapter 3, it has been identified that the existing user acceptance theories and models of technology such as the technology acceptance model (TAM) or the unified model of acceptance and use of technology (UTAUT) could offer insight into the adoption process of ambient intelligent applications. Only, they are usually applied to technologies which are fully developed and already in use. Therefore applying these models to a technology which is in its development phase means that only the anticipation of adoption and use can be investigated. For this purpose a new model has to be constructed. From the existing user acceptance theories and models of technology a number of relevant constructs are selected to investigate the anticipated adoption of domestic ambient intelligent appliances by prospective users. These constructs and their hypothesized relations form the basis of a conceptual model which will be used to explore the anticipated adoption of ambient intelligent appliances. This model will be tested in the user survey. In the next section, the conceptual model will be discussed in more detail.

## 7.4 Adoption of Ambient Intelligent Appliances: A Conceptual Model

Several factors influence the adoption of new technologies. As mentioned earlier in Chapter 3, previous research on user acceptance of technologies has shown that factors such as attitudes, behavioral intentions, (Ajzen & Fishbein, 1980) and outcome expectancies (LaRose & Eastin, 2004) play an important role in the adoption process of new technologies. Fishbein and Ajzen's theory of reasoned action (TRA) postulates that behavioral intentions are the most immediate determinant of behavior. Thus, people's intentions precede their actual behavior. It is hypothesized that the anticipated intention to adopt ambient intelligent appliances will also precede actual behavior to adopt these technologies and therefore intention will be included in the conceptual model.

It is hypothesized that the specific characteristics of ambient intelligence will also play an important role in the adoption process. As outlined in Chapter 4, the specific characteristics of ambient intelligence such as its unobtrusiveness, invisibility, adaptability and pro-active anticipation of user behavior, are supposed to bring ease and convenience to everyday domestic life (Punie, 2003). However, next to these potential positive benefits negative outcomes are also related to ambient intelligence, such as loss of privacy, loss of control, less reliability, and a low social acceptance of these technologies (Langheinrich, 2001, 2002; Nguyen & Mynatt, 2002; Punie, 2003; Bohn et al., 2004). Loss of privacy and loss of control are often mentioned as potential negative outcomes of ambient intelligence in daily life or, in other words, as the "dark side" of ambient intelligence (Stone, 2003). If users also have these concerns, this will probably have a negative effect on the adoption process of ambient intelligent appliances. McCullough (2004) argues that we should pay considerable attention to privacy aspects in the development process of ambient intelligence. The loss of privacy and control are included in the conceptual model as perceived disadvantages because they can be seen as important potential barriers to the widespread adoption of ambient intelligent appliances. The potential positive benefits of ambient intelligence such as convenience, easiness, and personalization will be included in the model as perceived advantages of ambient intelligent appliances.

In addition to the perceived benefits and perceived disadvantages of ambient intelligent applications, it is hypothesized that attitude towards ambient intelligent appliances will also play an important role in the adoption process. Attitude towards a behavior is defined as "the degree to which performance of the behavior is positively or negatively valued" (Fishbein & Ajzen, 1975). It refers to the desirability of the behavior, which is considered to be a function of the sum of the perceived values of the expected consequences of the behavior. It is hypothesized that perceived benefits and perceived disadvantages of ambient intelligent appliances can influence people's attitude and therefore in the conceptual model perceived benefits and perceived disadvantages of ambient intelligent appliances will precede the attitude towards ambient intelligent appliances. Furthermore, it is hypothesized that attitude precedes outcome expectancies because outcome expectancies are more specifically presented to future users (e.g., "I expect this technology to make everyday life easier") than the more general attitude concept (specified in general items such as "I think that using ambient intelligent appliances is good vs. bad"). It is also hypothesized that the more specific outcome expectancies will have a direct influence on users' intentions to adopt ambient intelligent applications. Thus, it is hypothesized that attitude towards ambient intelligent appliances will influence the outcome expectancies of people and these expectancies will probably have a direct effect on intentions to adopt ambient intelligent appliances.

The variables of the conceptual model are not independent of each other. It is hypothesized that if people have a negative attitude towards ambient intelligent appliances, they will probably perceive fewer benefits of ambient intelligent appliances, and vice versa. Therefore, a reciprocal relationship is expected between the perceived benefits and the perceived disadvantages concerning attitudes towards ambient intelligent appliances. Figure 7.1 shows the proposed conceptual model, including its proposed relationships among predictive variables.

## 7.5 Method

### 7.5.1. Sample and procedure

Members of a national panel ($N = 1539$) which is supposed to represent the Dutch population and is administrated by a research and consultancy company were invited via email to participate voluntarily in the online survey. For vocabulary, understanding of sentences, irregularities, and length of time, the survey was pre-tested by 25 people with ages ranging from 18 to 63 years. Textual adjustments to the survey were made accordingly.

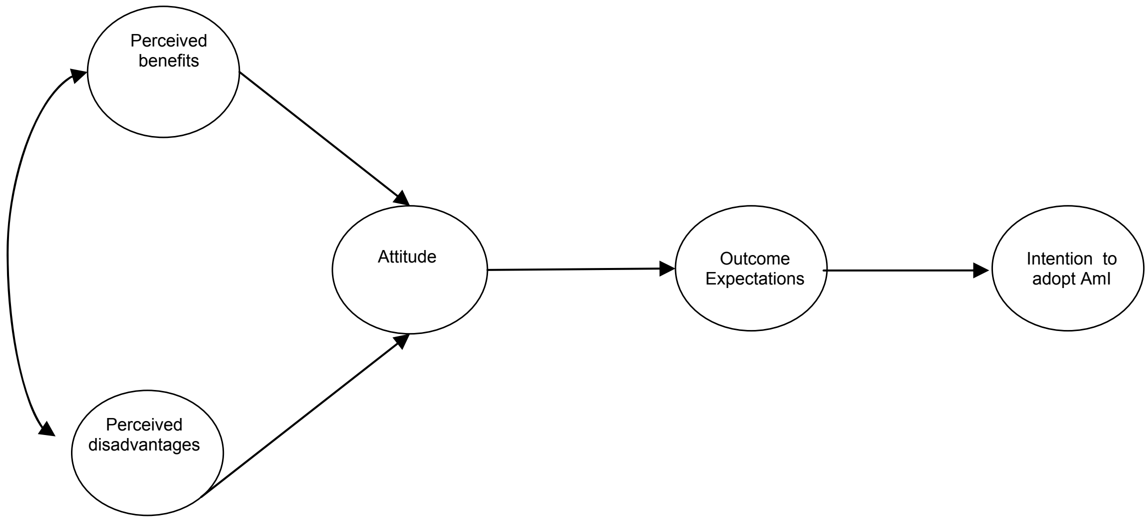


**Figure 7.1** Conceptual model of the intention to adopt ambient intelligent appliances

To increase participation, respondents could win three electronic products (i.e., I-pod, digital camera, and DVD-player) if they returned a completed questionnaire. The 1221 panel members (79.3% response rate) who responded to the invitation were included in the sample. Pearson's chi-square test was used to test for differences in demographics between the respondents and the non-respondents. There was no significant difference between the non-respondents and the respondents in terms of gender ($\chi^2$ (1, $N$ = 1539) = .01, $p$ > .05); age ($\chi^2$ (4, $N$ = 1539) = 4.57, $p$ > .05); education ($\chi^2$ (8, $N$ = 1522) = 12.73, $p$ > .05) or income ($\chi^2$ (6, $N$ = 1539) = 4.06, $p$ > .05).

Although, the national panel - from which the respondents were selected - is representative of the Dutch population, this unfortunately does not always result in a representative sample of the Dutch population. In comparison with the Dutch population (CBS, 2006a) gender was almost equally distributed (48% males compared to 49% of the adult Dutch population, and 52% females compared to 51% of the adult Dutch population). Respondents younger than 25 years (7% compared to 12% of the Dutch population) and respondents 65 years and older (5% compared to 17.4% of the Dutch population) were underrepresented in our sample. The other age groups were all slightly overrepresented, namely respondents aged 26 to 35 years (18% compared to 16.5% of the Dutch population), the group of 36 to 50 years (39% compared to 30% of the Dutch population) and the group of 51 to 65 years (31% compared to 24.1% of the

Dutch population). Respondents with higher education levels were also overrepresented in our sample. There were more respondents with bachelor degrees (32% compared to 16% of the Dutch population) and with master's degrees (11% compared to 9% of the Dutch population); respondents with only primary educational levels or less were underrepresented (1.3% compared to 9% of the Dutch population). The sampling result of this study is thus not completely comparable to the Dutch population. As social demographics were not a part of the hypothesized model to be tested, the sampling result was satisfactory to continue with the testing of the model.

### 7.5.2 Measures

A questionnaire was designed to examine how people perceive ambient intelligent appliances in domestic settings. The questionnaire consisted of two parts. The first part of the questionnaire was dedicated to current possession of information and communication technologies in the home, past experience with computers, and attitude towards information and communication technologies.

To assess whether respondents with a positive attitude towards current information and communication technologies hold a more positive attitude towards ambient intelligent appliances, respondents' attitudes towards current issues related to information and communication technologies were measured with a scale consisting of six positive judgments (scaled 1 to 5, where '1' was totally disagree and '5' was totally agree) following Punie (2000). Punie distinguishes three different attitudes using this scale, namely: the tech-phobic, the tech-nuanced and the tech-savvy. A tech-phobic attitude is characterized by a negative attitude towards technological development; a tech-nuanced attitude corresponds with a position between the tech-phobic and the tech-savvy; and a tech-savvy attitude is a positive attitude towards technology. Some judgments were rephrased to Netherlands-Dutch (Punie's was Belgian-Dutch) and some ICT examples were adjusted to suit current practice in the Netherlands (e.g., telephone was adjusted to internet).

Cronbach's alpha ($\alpha$) is used as an indication of how well a set of items measures a latent construct. A scale is regarded as reliable when Cronbach's $\alpha$ is at least .70 (Nunnally, 1978). Here, the internal consistency (Cronbach's $\alpha$) of the ICT-attitude scale was .72.

The second part of the questionnaire started with a short description of ambient intelligence (i.e., *'a vision of the future which includes intelligent appliances that know what you want and can automatically do things for you. These intelligent appliances will also be* *available for the home'*). After the general introduction of ambient intelligence, four specific, currently existing ambient intelligent appliances were described in detail. After each description of an ambient intelligent appliance, questions followed; then, the next application was described and questions followed. The ambient intelligent appliances were an intelligent fridge, an intelligent mirror, an intelligent TV and a set of intelligent appliances, labeled as intelligent appliances for the home, which consisted of blinds automatically closing, lights automatically turning on when entering a room, and the room temperature automatically adjusting to a person's specific temperature preference when that person enters a room in the house. Except for the intelligent appliances, each application was accompanied by a photo to give respondents a better idea of the specific application.

*Perceived benefits.* Perceived benefits of ambient intelligent appliances were measured with five items including: more or less perceived enjoyment, making usage more or less easy/complex, having more or less convenience, having more or less personalization, and perceiving more or less utility through usage of the particular ambient intelligent appliance (all were scaled 1 to 5 where '1' was not at all enjoyable and '5' was very enjoyable, etc.). A Cronbach's $\alpha$ of .88 for the intelligent fridge; $\alpha$ = .89 for the intelligent mirror; $\alpha$ = .83 for the intelligent television and $\alpha$ = .88 for the intelligent appliances indicated reliable scales to measure perceived benefits of the four ambient intelligent appliances.

*Perceived disadvantages.* Privacy and loss of control were used as the two variables to measure the perceived disadvantages of ambient intelligent appliances. For each of the four appliances, two privacy items and two control items were used to assess how respondents perceive privacy and control aspects accompanying the ambient intelligent appliances (scaled 1 to 5 where '1' was very unattractive and '5' very attractive). We recoded this scale so that the higher the score, the less attractive the capacity of the ambient intelligent appliances to know and store private information, or the less attractive the idea that the ambient intelligent appliances are in control over certain functions in the home. The items for the intelligent fridge are given as examples; the items for the other three appliances were similar, but adapted to the specific characteristics of each appliance. The privacy items were *'this intelligent fridge can order foods and give you cooking tips if you give the fridge permission to keep track of what you are keeping in your fridge'* and *'when and how you use the intelligent fridge is being recorded by an internal system so that the intelligent fridge can better suit your wishes'*. The control items consisted of '*this intelligent fridge can automatically take over a couple of tasks from you, such as keeping track of which foods are out of stock'* and *'this intelligent fridge can automatically* *take over a couple of decisions from you, such as ordering foods at the grocery store if you have programmed the fridge to do this'.*

The privacy items of the four ambient intelligent appliances were summed up to form one overall privacy construct (two items per appliance makes 8 items in total) and the control items (also 8 in total) were also summed up to form one control construct. The internal consistency of the privacy scale was $\alpha$ = .88 and $\alpha$ = .85 for the control scale.

*Attitude.* As a measure of attitude towards the four ambient intelligent appliances, respondents rated the use of the four appliances on six five-point bipolar scales. The scale endpoints were defined as good/bad, wise/unwise, beneficial/harmful, pleasant/unpleasant, valuable/worthless and enjoyable/unenjoyable. The internal consistencies of the attitude scales were $\alpha$ = .94 for the intelligent fridge; $\alpha$ = .95 for the intelligent mirror; $\alpha$ = .94 for the intelligent TV and $\alpha$ = .95 for the intelligent appliances.

*Outcome expectations*. Expected outcomes (i.e., "using the ambient intelligent appliances, how likely are you to ____") were measured in a Likert-type scale that ranged from 1 (very unlikely) to 5 (very likely). We used monetary outcomes ($\alpha$ = .92), activity outcomes ($\alpha$ = .89), social outcomes ($\alpha$ = .85), self-reactive outcomes ($\alpha$ = .89), novelty outcomes ($\alpha$ = .80) and fashion/status outcomes ($\alpha$ = .86).

*Intention.* Three intention measures asked the respondents to rate their intention to use each specific ambient intelligent appliance as it becomes available, using a five-point bipolar scale ranging from 'extremely unlikely' to 'extremely likely'. The three intention measures were: 'I intend to use this intelligent fridge if it becomes available'; 'I plan to buy this intelligent fridge as soon as it becomes available' and 'I will use this intelligent fridge if it becomes available'. Cronbach's $\alpha$ was .95 for the intelligent fridge; $\alpha$ = .95 for the intelligent mirror; $\alpha$ = .95 for the intelligent TV and $\alpha$ = .93 for the intelligent appliances.

The questionnaire ended with socio-economic questions about age, gender, education level, income and household situation.

### 7.5.3 Data analysis

SPSS v12 was used to analyze the data. Statistical comparisons between groups used chi-square tests for categorical data and Mann-Whitney tests for ordinal data.

Structural Equation Modelling using Amos 6.0 (Arbuckle, 2005) with maximum likelihood estimation was used to test the hypothesized model predicting the intent to adopt ambient intelligent appliances in domestic settings. As suggested by Holbert and Stephensen (2002), certain model fit indices were used, particularly the $\chi^2$ estimate with degrees of freedom that are most commonly used to make comparisons across models (Hoyle & Panter, 1995). Additionally, the standardized root-mean-squared residual (SRMR) is reported as a second absolute fit statistic (Hu & Bentler, 1999) in combination with the Tucker-Lewis index (TLI) as an incremental index and the root-mean-squared error of approximation (RMSEA) (Browne & Cudeck, 1993). Hu and Bentler (1999) recommend using a cut-off value close to .95 for TLI in combination with a cut-off value close to .09 for SRMR to evaluate model fit, and the RMSEA close to .06 or less. Fit indices are relative to progress in the field (Garson, 2006). Although there are rules of thumb for acceptance of a model fit (e.g., that TLI should be at least .95), Bollen (1989) observed that these cut-offs are arbitrary. A more salient criterion may be simply to compare the fit of one's model to the fit of previous models of the same phenomenon.

## 7.6 Findings

The questionnaire on ambient intelligent appliances was designed to examine the perceptions of future users regarding ambient intelligence. It was also designed to get a better understanding of how specific ambient intelligent appliances are perceived and what respondents' attitudes are towards these appliances. However, since respondents already have certain attitudes towards today's existing information and communication technologies, we wanted to compare the results of the perceptions of ambient intelligent appliances with current attitudes towards information and communication technologies and therefore we also present these findings. Finally, we test which variables are strong predictors for the anticipated adoption of ambient intelligent appliances.

### 7.6.1 Attitude towards information and communication technologies

Respondents' overall attitudes towards information and communication technologies were measured with a scale consisting of six positive judgments regarding information and communication technology issues (Cronbach's $\alpha$ = .72). Overall, the respondents had positive attitudes towards information and communication technologies. The item *'the disadvantages which some technical appliances can cause just belong to this kind of appliance'* scored the lowest ($M$ = 3.42, $SD$ = .96) and the item *'I find it good that when I want to know something, I can also get that information via technical appliances'* was the highest ($M$ = 4.50, $SD$ = .70).

There was no significant difference for gender and education regarding ICT attitudes. Respondents aged 26 to 35 years (mean rank = 664.64) and people older than 65 years (mean rank = 700.16) had a significantly more positive ICT attitude ($\chi^2$ (4, $n$ = 1221) = 11.72, $p < .05$) than other age groups. The group of respondents who did not provide answers about their incomes (mean rank = 557.18) and people who have an income of 1.5 times the average (mean rank = 584.65) had a significantly less positive attitude ($\chi^2$ (6, $n$ = 1221) = 21.13, $p < .01$) towards information and communication technologies than the other income groups. People who earned three times the average income or more had the most positive ICT attitude (mean rank = 753.79). There was a significant correlation between age and income level ($r$ = .70, $n$ = 1221, $p < .05$), which indicates that people who are older have a higher income.

Generally, the respondents had a positive attitude towards information and communication technologies. The overall score of the ICT-attitude scale ranging from 6 to 30 is the product of the six items on a five point scale ranging from 1 = totally disagree to 5 = totally agree. Thus, although the overall attitude towards information and communication technologies was high, based on the mean score of the ICT-attitude scale ($M$ = 23.88, $SD$ = 3.48), three ICT groups were formed to assess differences in their attitudes towards ambient intelligent appliances. The first group (range 6 to 23) had the most negative attitude towards information and communication technologies (labeled the tech-phobic) and consisted of 42.8% of the sample. The second group (range 24 to 25) was labeled the tech-nuanced group and consisted of 24.2%. The last group, the tech-savvy (range 26 to 30) consisted of 33% of the respondents.

### 7.6.2 Perceived benefits and disadvantages of domestic ambient intelligent appliances

To answer the first research question concerning the perceived benefits and disadvantages of ambient intelligent appliances, the perceived benefits were measured separately for all four ambient intelligent appliances. The perceived benefits of the intelligent fridge and intelligent mirror were regarded as low by the respondents. The mean value *(SD*) for the intelligent fridge ranged from 2.20 *(1.14*) to 3.23 (*.99*) and the mean for the intelligent mirror ranged from 2.35 (*1.18*) to 2.97 (*.90*). Respondents perceived the intelligent TV, with a mean ranging from 2.34 (*1.04*) to 3.61 (*.98*), and intelligent appliances, with a mean ranging from 3.00 (*1.16*) to 3.62 (*.89*), as having slightly greater benefits. See Table 7.1 for the exact means and standard deviations of the perceived benefits of the four ambient intelligent appliances.

Among the three groups with different attitudes towards information and communication technologies, significant differences were found in how they perceive the benefits of ambient intelligent appliances. The tech-savvy group perceived all four ambient intelligent appliances as having more benefits, followed by the tech-nuanced and the tech-phobes. Consider intelligent applications as an example. The tech-savvy group (mean rank = 717.45) perceived intelligent applications as having significantly greater benefits ($\chi^2$ (2, $n$ = 1221) = 92.31, $p$ < .001) than the tech-nuanced (mean rank = 658.26) and the tech-phobic groups (502.32).

The disadvantages of the ambient intelligent appliances were in general perceived as varying from not very attractive to neutral to the respondents (see Table 7.1). With regard to privacy aspects of ambient intelligent appliances, the intelligent mirror's sending private information (such as weight and blood pressure) to the doctor was least appealing to the respondents (*M* = 3.60, *SD* = 1.19). Respondents seemed to have fewer privacy concerns with the intelligent TV's keeping a record of programs the user watches and, based on this recorded list, suggesting a list of interesting programs for the user (*M* = 2.48, *SD* = 1.08). A similar response was seen when intelligent applications keep track of temperatures in the home and adjust the temperature based on the recorded list of previous temperatures (*M* = 2.53, *SD* = 1.05). Respondents did not find it very attractive that ambient intelligent appliances could do things for them when this caused a loss of control over tasks typically done by the user. The intelligent fridge ordering food (*M* = 3.63, *SD* = 1.19) and the intelligent TV ordering products (*M* = 3.63, *SD* = 1.07) were found to be the least attractive. The intelligent TV taking over the selection and recording of movies seemed to be a little bit more attractive to the respondents (*M* = 2.32, *SD* = .99).

How privacy and control aspects of ambient intelligent appliances were perceived differed significantly among the three ICT groups. The tech-savvy group (mean rank = 506.30) significantly had the fewest problems ($\chi^2$ (2, $n$ = 1221) = 77.92, $p$ < .001) with the privacy aspects, followed by the tech-nuanced (mean rank = 581.03) and the tech-phobic groups (mean rank = 708.58). The tech-savvy people (mean rank = 502.87) were also significantly more positive $\chi^2$ (2, $n$ = 1221) = 76.70, $p$ <.001) towards the idea that ambient intelligent appliances could take over some control tasks, as compared to the tech-nuanced (mean rank = 591.03) and the tech-phobic (mean rank = 705.59).

**Table 7.1** Descriptive statistics and Cronbach's α of perceived benefits and perceived disadvantages of ambient intelligent appliances

| | M | SD |
|---|---|---|
| Perceived benefits intelligent fridge (α = .88) | | |
| Enjoyment | 3.03 | 1.28 |
| Ease | 2.20 | 1.14 |
| Convenience | 3.23 | .99 |
| Personalization | 2.92 | 1.13 |
| Usefulness | 2.40 | 1.17 |
| Perceived benefits intelligent mirror (α = .89) | | |
| Enjoyment | 2.83 | 1.22 |
| Ease | 2.69 | 1.03 |
| Convenience | 2.97 | .90 |
| Personalization | 2.76 | 1.10 |
| Usefulness | 2.35 | 1.18 |
| Perceived benefits intelligent TV (α = .83) | | |
| Enjoyment | 3.61 | .98 |
| Ease | 2.82 | 1.12 |
| Convenience | 3.57 | .92 |
| Personalization | 3.37 | 1.06 |
| Usefulness | 2.34 | 1.04 |
| Perceived benefits intelligent appliances (α = .88) | | |
| Enjoyment | 3.45 | .97 |
| Ease | 3.00 | 1.16 |
| Convenience | 3.62 | .89 |
| Personalization | 3.46 | .98 |
| Usefulness | 3.34 | 1.16 |
| Perceived disadvantages: Loss of privacy (α = .88) | | |
| P1 intelligent fridge | 2.96 | 1.20 |
| P2 intelligent fridge | 3.19 | 1.16 |
| P1 intelligent mirror | 3.23 | 1.11 |
| P2 intelligent mirror | 3.60 | 1.19 |
| P1 intelligent TV | 2.48 | 1.08 |
| P2 intelligent TV | 2.94 | 1.08 |
| P1 automatic applications | 2.80 | 1.08 |
| P2 automatic applications | 2.53 | 1.05 |
| Perceived disadvantages: Loss of control (α = .85) | | |
| C1 intelligent fridge | 2.85 | 1.14 |
| C2 intelligent fridge | 3.63 | 1.19 |
| C1 intelligent mirror | 2.90 | 1.09 |
| C2 intelligent mirror | 2.83 | 1.20 |
| C1 intelligent TV | 2.32 | .99 |
| C2 intelligent TV | 3.63 | 1.07 |
| C1 automatic applications | 2.74 | 1.07 |
| C2 automatic applications | 2.63 | 1.07 |

### 7.6.3 Attitude, outcome expectations and intention to adopt ambient intelligent appliances

The results for research question two concerning the attitudes and intentions to adopt ambient intelligent appliances showed that respondents did not have a pronounced attitude towards ambient intelligent appliances. The attitude towards all four ambient intelligent appliances varied from a neutral to a slightly positive attitude. People seemed to have a more positive attitude towards the intelligent TV and towards the intelligent appliances than towards the intelligent fridge and intelligent mirror (see Table 7.2).

**Table 7.2** Descriptive statistics and Cronbach's α of attitudes towards ambient intelligent appliances

| | M | SD |
|---|---|---|
| Attitude intelligent fridge (α = .94) | | |
| Good/bad | 3.00 | 1.09 |
| Wise/unwise | 2.89 | 1.07 |
| Beneficial/harmful | 2.88 | 1.04 |
| Pleasant/unpleasant | 2.91 | 1.22 |
| Valuable/worthless | 2.71 | 1.09 |
| Enjoyable/unenjoyable | 3.07 | 1.36 |
| Attitude intelligent mirror (α = .95) | | |
| Good/bad | 2.89 | 1.10 |
| Wise/unwise | 2.91 | 1.13 |
| Beneficial/harmful | 2.74 | 1.00 |
| Pleasant/unpleasant | 2.68 | 1.19 |
| Valuable/worthless | 2.75 | 1.15 |
| Enjoyable/unenjoyable | 2.86 | 1.32 |
| Attitude intelligent TV (α = .94) | | |
| Good/bad | 3.35 | .98 |
| Wise/unwise | 3.08 | .92 |
| Beneficial/harmful | 3.06 | .96 |
| Pleasant/unpleasant | 3.48 | 1.09 |
| Valuable/worthless | 3.15 | .94 |
| Enjoyable/unenjoyable | 3.58 | 1.15 |
| Attitude intelligent applications (α = .95) | | |
| Good/bad | 3.45 | 1.02 |
| Wise/unwise | 3.38 | 1.02 |
| Beneficial/harmful | 3.37 | 1.01 |
| Pleasant/unpleasant | 3.60 | 1.08 |
| Valuable/worthless | 3.28 | 1.02 |
| Enjoyable/unenjoyable | 3.51 | 1.14 |

The attitude towards ambient intelligent appliances differed significantly among the three ICT groups. The tech-savvy group had the most positive attitude towards all four ambient intelligent appliances. The intelligent TV is taken as an example. The tech-savvy group (mean rank = 692.17) had a significantly more positive attitude ($\chi^2$ (2, *n* = 1221) = 49.15, *p* <.001) towards the intelligent TV than the tech-nuanced (mean rank = 638.48) and the tech-phobic (mean rank = 532.96).

Respondents seemed to expect the most from ambient intelligent appliances in terms of activity and monetary outcome. These outcome expectancies are more focused on making daily life easier (e.g., "to make your everyday life easier", *M* = 3.19, *SD* = 1.11) and bringing more enjoyment (e.g. "to make daily domestic activities more pleasant" *M* = 3.22 *SD* = 1.13). Social outcomes which focus on the enhancement of social relations or the building of social relations through ambient intelligent appliances scored the lowest of all outcome expectations (see Table 7.3).

For all four ambient intelligent appliances (intelligent fridge, intelligent mirror, intelligent TV, and intelligent home appliances), the behavioral intention to adopt the appliances was measured in order to answer research question two. Respondents' intentions to adopt the four appliances were generally low (see Table 7.4). The intention to adopt the intelligent mirror was the lowest and the intention to adopt the intelligent home applications (e.g., blinds automatically closing) was the highest.

The intention to adopt ambient intelligent appliances differed significantly among the three ICT groups. The tech-savvy group had a higher intention to adopt all four ambient intelligent appliances than the tech-nuanced and the tech-phobes. For example, the tech-savvy (mean rank = 685.09) had the highest intention ($\chi^2$ (2, *n* = 1221) = 45.62, *p* <.001) to adopt the intelligent mirror compared to the tech-nuanced (mean rank = 637.63) and the tech-phobic (mean rank = 538.89).

### 7.6.4. Explaining and predicting adoption of ambient intelligent appliances

Prior to the analyses, data were checked for normality; no significant deviation from normality was found (skewness and curtosis Z < 1.96). The variables (e.g., intention, attitude, perceived benefits, and privacy) used for each of the four ambient intelligent appliances were summarized to construct 'overall' variables regarding adoption of ambient intelligent appliances. In other words, the intention scales of the four ambient intelligent appliances were summed up in one overall scale to measure intentions to adopt ambient intelligent appliances, the four attitude scales were summed up to

**Table 7.3** Descriptive statistics and Cronbach's α of outcome expectations of ambient intelligent appliances

| | M | SD |
|---|---|---|
| Activity outcomes (α = .89) | | |
| To make it easier for you | 3.38 | 1.07 |
| Because it offers you more freedom | 3.07 | 1.07 |
| Because it makes the tasks in the home more pleasant | 3.25 | 1.07 |
| To make daily domestic activities more pleasant | 3.22 | 1.13 |
| Because you like to use such appliances | 2.85 | 1.25 |
| To be entertained | 2.46 | 1.20 |
| Monetary outcomes (α = .92) | | |
| To be able to do different things at once | 3.07 | 1.09 |
| To have more control over your daily life | 2.88 | 1.08 |
| Not to have to do everything yourself | 2.94 | 1.12 |
| To make your everyday life easier | 3.19 | 1.11 |
| Because it is convenient that you do not have to carry out certain tasks yourself | 3.03 | 1.14 |
| To save time | 3.06 | 1.21 |
| Social outcomes (α = .85) | | |
| To strengthen my relationship with family and friends | 1.98 | 1.07 |
| To be able to communicate with family and friends | 1.95 | 1.08 |
| To maintain valuable contact with others | 2.33 | 1.17 |
| To belong to a particular group | 1.61 | .85 |
| To have something to talk about with others | 1.74 | .95 |
| Self-reactive outcomes (α = .89) | | |
| To have something to do | 1.97 | 1.07 |
| When you are bored | 2.02 | 1.16 |
| To relax | 2.66 | 1.23 |
| When you do not have anything to do | 2.10 | 1.10 |
| To feel less lonely | 1.79 | .96 |
| As a way to pass time | 1.68 | .94 |
| Novelty (α = .80) | | |
| Because it is something new | 2.28 | 1.11 |
| To be able to use the internet via the intelligent fridge | 1.68 | .96 |
| To be able to order products via the intelligent TV | 1.86 | 1.01 |
| To actively monitor your health through the intelligent mirror | 2.55 | 1.29 |
| To discover new possibilities | 2.97 | 1.17 |
| Fashion/Status (α = .86) | | |
| Because these appliances are modern appliances | 2.21 | 1.16 |
| To keep up with the newest technology | 2.54 | 1.19 |
| Because it belongs to your lifestyle | 2.10 | 1.12 |
| Because it increases your status | 1.60 | .86 |

**Table 7.4** Descriptive statistics and Cronbach's α of intention to adopt ambient intelligent appliances

| | M | SD |
|---|---|---|
| Intention to adopt intelligent fridge (α = .95) | | |
| I intend to use this intelligent fridge if it is available | 2.14 | 1.25 |
| I plan to buy this intelligent fridge as soon as it is available | 1.93 | 1.08 |
| I will use this intelligent fridge if it is available | 1.98 | 1.14 |
| Intention to adopt intelligent mirror (α = .95) | | |
| I intend to use this intelligent mirror if it is available | 1.93 | 1.08 |
| I plan to buy this intelligent mirror as soon as it is available | 1.79 | 1.01 |
| I will use this intelligent mirror if it is available | 1.83 | 1.06 |
| Intention to adopt intelligent TV (α = .95) | | |
| I intend to use this intelligent TV if it is available | 2.76 | 1.18 |
| I plan to buy this intelligent TV as soon as it is available | 2.50 | 1.13 |
| I will use this intelligent TV if it is available | 2.56 | 1.20 |
| Intention to adopt intelligent appliances (α = .93) | | |
| I intend to use these intelligent appliances if they are available | 2.78 | 1.13 |
| I plan to buy these intelligent appliances as soon as they are available | 2.67 | 1.14 |
| I will use these intelligent appliances if they are available | 2.72 | 1.21 |

measure overall attitudes towards ambient intelligent appliances, et cetera.

*Measurement model.* The initial measurement model generated a poor fit, $\chi^2(1035) = 8472.06$, $\chi^2/df = 8.19$, SRMR = .0649, TLI = .864 , RMSEA = .077 (CI: .075, .078). Items with highly correlated error variances identified by post-hoc modification indices were removed. Although the Cronbach's alpha of the indicators of novelty was above the aspiration level ($\alpha > .70$), the error variances co-varied with various indicators of other constructs and were, therefore, excluded from further analysis. The observed items of monetary outcomes and activity outcomes were loaded on both latent variables. This was also the case for the observed items of social outcomes and self-reactive outcomes. With regard to the content of their items, the four constructs were indeed closely related and were, therefore, reconstructed into two new constructs. The new construct of monetary outcomes and activity outcomes was labeled instrumental outcomes; the combination of the constructs social outcomes and self-reactive outcomes was labeled personal outcomes. This procedure resulted in a reduced number of observed indicators of the latent constructs. The internal consistency of the measures to predict adoption of ambient intelligent appliances was above the aspiration level ($\alpha > .70$). The modified measurement model generated a good fit, $\chi^2(209) = 779.32$ , $\chi^2/df = 3.73$, SRMR = .026, TLI = .976, RMSEA = .047 (CI: .044, .051).

*Structural model.* The results obtained from testing the validity of a causal structure of the hypothesized model showed a reasonable fit $\chi^2(222) =1271.44$ , $\chi^2/df = 5.73$ ,

SRMR = .0597, TLI = .959, RMSEA = .062 (CI: .059, .066). Post-hoc modification indices suggested an improved fit by correlating the error terms of personal outcomes and fashion outcomes ($r = .67$, $p < .001$). The respecified model generated a good fit $\chi^2(221) = 930.31$, $\chi^2/df = 4.21$ , SRMR = .0355, TLI = .972, RMSEA = .051 (CI: .048, .055). Table 5 summarizes the mean and standard deviation, Cronbach's $\alpha$, the factor loading (β), and the squared multiple correlation ($R^2$) of the observed indicators to predict adoption of ambient intelligent appliances. The path model with standardized path coefficients is featured in Figure 7.2.

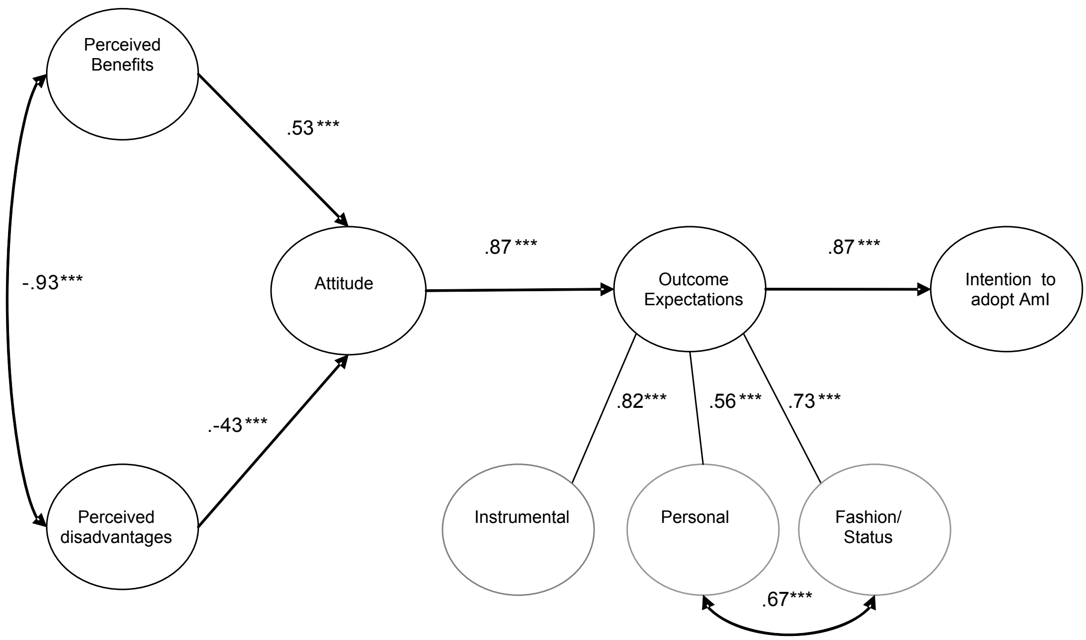


**Figure 7.2** Standardized path coefficients for the model to predict intentions to adopt ambient intelligent appliances.
*Note* .The observed indicators of the latent constructs are not shown (see Table 7.5). ***$p < .001$.
The error terms of the double-headed arrows are correlated.

As shown in Figure 7.2, there was a significant direct effect of outcome expectations on the intention to adopt ambient intelligent appliances. Perceived benefits and perceived disadvantages had a significant direct effect on attitude. The attitude-outcome expectancies path, as well as the outcome expectancies-intention path, appeared to be significant. A correlation was found between perceived benefits and perceived disadvantages of ambient intelligent appliances, $r = -.93$, $p < .001$. This indicates that the error terms of the two constructs are very closely related.

Squared multiple correlations (Table 7.5) showed that the intention to adopt ambient intelligent appliances was accounted for 75%, the attitude towards ambient intelligent appliances was accounted for 89%, and the outcome expectancies of ambient intelligent appliances were accounted for 76%.

**Table 7.5** Descriptive statistics, factor loadings, squared multiple correlations and Cronbach's α of the observed indicators to predict intention to adopt ambient intelligent appliances

| | M | SD | B | $R^2$ |
|---|---|---|---|---|
| Intention (α = .97) | | | | .75 |
| I intend to use this AmI appliance if it is available | 2.40 | .90 | .92 | .85 |
| I plan to buy this AmI appliance as soon as it is available | 2.22 | .85 | .98 | .95 |
| I will use this AmI appliance if it is available | 2.27 | .89 | .98 | .96 |
| Attitude (α = .95) | | | | .89 |
| ATT 1 (good/bad) | 3.17 | .81 | .93 | .86 |
| ATT2 (beneficial/harmful) | 3.01 | .76 | .85 | .73 |
| ATT3 (pleasant/unpleasant) | 3.17 | .88 | .95 | .90 |
| ATT4 (valuable/worthless) | 2.97 | .81 | .92 | .85 |
| Perceived benefits (α = .85) | | | | |
| Enjoyment | 3.23 | .84 | .89 | .79 |
| Easy | 2.68 | .82 | .62 | .38 |
| Personalization | 3.13 | .83 | .91 | .83 |
| Perceived disadvantage (α = .95) | | | | |
| Privacy | 2.97 | .83 | .94 | .88 |
| Control | 2.94 | .77 | .96 | .92 |
| Personal outcomes (α = .86) | | | | .32 |
| To have something to talk about with others | 1.74 | .95 | .78 | .60 |
| When you do not have anything to do | 2.10 | 1.10 | .78 | .61 |
| As a way to pass time | 1.68 | .94 | .82 | .67 |
| To feel less lonely | 1.79 | . 96 | .74 | .54 |
| Instrumental outcomes (α = .90) | | | | .68 |
| Because it makes the tasks that you perform in the home more pleasant | 3.25 | 1.07 | .87 | .76 |
| To make your everyday life easier | 3.19 | 1.11 | .84 | .71 |
| To make daily domestic activities in the home more pleasant | 3.22 | 1.13 | .84 | .70 |
| To not have to do everything yourself | 2.94 | 1.12 | .80 | .65 |
| Fashion/status outcomes (α = .87) | | | | .53 |
| To keep up with the newest technology | 2.54 | 1.19 | .83 | .70 |
| Because it belongs to your lifestyle | 2.10 | 1.12 | .80 | .64 |
| Because they are modern appliances | 2.31 | 1.16 | .85 | .73 |

## 7.7 Conclusions and Discussion

In this study, people's perceptions of ambient intelligent appliances in domestic settings and the variables that explain and predict future adoption of ambient intelligent appliances were explored. This study showed that the respondents perceived the benefits of the four ambient intelligent appliances as varying from low to neutral. Enjoyment and convenience often scored the highest of all the measured perceived benefits for all four ambient intelligent appliances (other perceived benefits were ease of use, personalization, and usefulness). Attitudes towards ambient intelligent appliances varied from negative to neutral and the intention to adopt ambient intelligent appliances was low.

The results of the structural equation analysis showed that outcome expectancies of ambient intelligent appliances could largely predict the intention to adopt domestic ambient intelligent appliances. This finding indicates that people's expectations about a new technology play a very important role in anticipating the adoption of a new technology. More specifically, instrumental, personal and fashion outcomes have a large influence on the intention of prospective users to adopt ambient intelligent appliances.

The perceived disadvantages of ambient intelligent appliances in this study included the loss of privacy and the loss of control. The findings show that there is statistical evidence for a relationship between perceived benefits and perceived disadvantages of ambient intelligent appliances. However, on the basis of the results of this study, the exact nature of this relationship is unclear. It could be that benefits and disadvantages of ambient intelligent appliances act simultaneously, or that one of the constructs has a stronger influence on the other. If the nature of this relationship is known, designers of ambient intelligent appliances can keep this in mind when developing these technologies. For example, when it appears that people are willing to accept and use ambient intelligent appliances in domestic settings because they derive enough personal benefits from them, then some of the disadvantages of these appliances could be accepted by the majority. Or, if people are not willing to lose their privacy and control and thus perceive the disadvantages of ambient intelligent appliances as being stronger than the benefits, the adoption of ambient intelligent appliances will probably be lower. Further research could bring more insight into this reciprocal relationship.

The findings of this study show that the intention to adopt ambient intelligent appliances is largely explained by outcome expectancies. This suggests that this construct also is a strong predictor of the intention to adopt ambient intelligent appliances, just as attitude appears to be. Attitude was defined in this study as a general judgment that precedes more specific outcome expectancies of ambient intelligent appliances. The findings indicate that outcome expectancies have a direct effect on the intention to adopt ambient intelligent appliances, according to the path model that was tested. Attitude had a direct significant effect on outcome expectancies. UTAUT argues that attitude is not significant in the presence of other concepts. Instead, UTAUT proposes performance and effort expectancy as the most significant predictors. This study shows that attitudes do influence the intention to adopt new technologies via outcome expectancies which in their turn can explain a large part of the intention to adopt new technologies in their early development phase. Further research should clarify the precise relationship between attitude and outcome expectancies, and whether our proposed attitude-outcome expectancies-intention path is also applicable to technologies that are in later stages of development or for technologies that are already available.

The descriptive results show that people have a negative to neutral attitude towards ambient intelligent appliances. An explanation for this finding could be that the ambient intelligent appliances we used in this study are “cold” appliances. These are not appliances you have a ”close relationship” with, as for example some people have with their mobile phones. Perhaps such a pronounced attitude towards ambient intelligent appliances has yet to be widely generated by the public.

The sample of respondents was marked by a high penetration of internet access and the possession of many information and communication technologies on average. In general, respondents had a very positive attitude towards current information and communication technologies. However, in general, the descriptive results show that the attitude towards ambient intelligent appliances is not positive. This could be explained by the fact that people do not know exactly what this future technology comprises and have not seen the physical appliances or experienced them first-hand in their own domestic settings. This makes it especially hard for the respondents to make qualified judgments about these appliances and to have a well pronounced attitude towards them.

As the findings showed, people with the most positive attitude towards information and communication technologies also had a more positive attitude towards the ambient intelligent appliances. The exact reasons behind the negative attitude towards information and communication technologies of the tech-phobic respondents are not known, but if people reject information and communication technologies because they think and maybe have experienced that information and communication technologies were difficult to use, this could imply that this group of people will not adopt ambient intelligent appliances based on their earlier experiences with information and communication technologies. Since ISTAG (2001, 2003) proposes the influence of ambient intelligence in everybody's life in the near future, it is important to pay attention to this finding to ensure that ambient intelligent appliances will be adopted by everybody and not just by a certain group of people.

Bouwman and De Jong (1996) argue that consumers are influenced by the marketing of expectations of consumer companies of information and communication technologies who make consumers think they need to use the latest technologies. The results of this study indicate that expectations of new technologies play a very important role in the adoption of new technologies. Therefore, this marketing of expectations should be done in a very careful way to avoid misleading consumer expectations of ambient intelligent appliances. The findings suggest that perceived disadvantages, in this case the loss of privacy and loss of control, did have a direct effect on attitudes towards ambient intelligence. When the disadvantages with regard to ambient intelligent appliances were perceived to be high, the attitude towards ambient intelligent was low and thus more negative. From the start of the development of ambient intelligent appliances, loss of privacy and loss of control has been recognized as important concerns for the future success of the adoption of ambient intelligent technologies. We suggest that future users should be clearly informed about the possible disadvantages which ambient intelligent technologies incorporate, so that they can make well-informed decisions about adopting ambient intelligent appliances in their domestic settings. Even though the specific features of ambient intelligent, such as being able to anticipate owner behavior by constantly using data about user behavior and personal routines, make it difficult to exclude all potential privacy and control disadvantages, designers should make the effort to minimize the loss of privacy and control for users from the start of the design process.

The development of ambient intelligent appliances is at full pace. More and more appliances are becoming context-aware and connected to other appliances and networks. However, only separate appliances were taken as examples in this study, and we did not focus on interrelations between appliances. Therefore, results may vary when another set of appliances is used. However, the appliances that we presented to the respondents are regularly used in ambient intelligence research as examples of ambient intelligent appliances of the future.

This study was done in a Western-European country with a high penetration and use of both the mobile phone and the internet (European Commission, 2006). Bell, Blythe, Sengers, and Wright (2003) argue that there are cultural differences in technology behavior and that we have to take these into consideration when designing technologies for domestic settings. Even among European countries, differences were found in the use of mobile ambient intelligent services (Forest & Arhippainen, 2005). Therefore, the results cannot automatically be translated to other countries and cultures. Furthermore, the sample was relatively ICT-minded, which could lead to two different conclusions. First, if ICT-minded people are not very positive about ambient intelligent appliances, the population at large would be even less positive. Second, and opposite, less-ICT-minded people would embrace ambient intelligent appliances because they are supposed to be relatively easy to use and can be smoothly integrated into everyday environments. More research is needed to find out whether ambient intelligent applications are more appropriate for less ICT-minded groups in society.

Ambient intelligence is cheered and criticized for its possible influential role in people's everyday lives. Obviously, more research is needed to assess the variables and their interrelationships as ambient intelligent appliances become more widespread in societies. Most importantly, variables such as real user experience should be incorporated into future studies. Overall, this study showed evidence that people's current attitudes and outcome expectations of ambient intelligent appliances are important factors to consider when anticipating the future adoption of ambient intelligent appliances in domestic settings.

# PART III

## Conclusions and Discussion

# 8

# Conclusions

*The aim of this thesis was to examine the interplay of design and use of ambient intelligent applications. In this chapter overall conclusions will be drawn from the findings of the empirical studies investigating this issue and thereby answering the central research questions as described in Chapter 1. The next chapter will be dedicated to the implications of the conclusions drawn in this chapter and future directions.*

## 8.1 Characteristics and Representation of Ambient Intelligence

Rice (1987) argued that we have the opportunity to assess how new technologies will affect our lives. Only, different assessments can be made by the designers and the users of new technologies. In this thesis, assessments made by designers of ambient intelligent applications and assessments made by prospective users have been investigated to determine whether they are in agreement. In the following paragraphs, answers to the research questions will be given based on the empirical studies presented in the previous chapters.

The characteristics of ambient intelligence and the representation of ambient intelligence to the general public were central to the first research question and were stated in Chapter 1 as follows:

RQ1: What are the characteristics of ambient intelligence and how is ambient intelligence in the home represented to the general public by its producers?

The key technology characteristics of ambient intelligence are embeddedness, context-awareness, personalization, adaptivity, and anticipation (Aarts & Marzano, 2003). There are few ambient intelligent appliances which possess all these characteristics and are commercially available to date. As described in Chapter 2, ambient intelligence is still in a development and research phase and therefore still emerging. Currently, many ambient intelligent appliances could better be seen as precursors of "real" ambient intelligent appliances and not (yet) as fully developed ambient intelligent appliances as envisioned by their spiritual fathers.

The idea behind ambient intelligence is that it will provide intelligent, efficient, intuitive, seamless and user-friendly appliances that will make people's everyday lives more convenient and easier. To investigate how ambient intelligence and its characteristics are presented to the general public a content analysis of promotional material of domestic ambient intelligent applications was performed.

As presented in Chapter 5, the analysed text of the promotional material shows that the features "connectedness", "control", "easiness" and "personal" are most often used when sketching an image of ambient intelligence. Three main clusters of features could be distinguished on the basis of the textual analysis, namely Convenience, Adaptation and Empowerment. Adaptation was the largest cluster of features and consisted of mainly technical features such as the physical connection of diverse appliances with each other. The Convenience cluster and the Empowerment cluster encompass more human-oriented attributes and refer to how everyday live will become easier for ordinary people and that users of ambient intelligent applications will have more control over their lives than at present. Furthermore, the findings show that critical policy issues such as privacy and security were underexposed in the promotional material illustrating that the material focused primarily on the potential benefits ambient intelligence could bring to domestic life.

Based on the findings of the analysis of the pictures in the promotional material it can be concluded that almost half of the pictures contained no persons but only devices and that more space was reserved for the pictured applications than for the pictured humans. Furthermore, males and young adults were most visible on the pictures to present ambient intelligence to a general public.

In sum, based on the empirical analysis of promotional material of producers of ambient intelligent applications it can be concluded that although the aim of ambient intelligence is that people should be the centre of attention when realizing this emerging technology, on a closer look, the technological characteristics are nevertheless at the forefront when ambient intelligence is presented to the general public.

## 8.2 Designers of Ambient Intelligence

The second key research question to be answered in this thesis concerns the assumptions of the designers with regard to users and how they shape domestic ambient intelligent appliances. In Chapter 1, the research question was stated as follows:

> RQ2: What are the key assumptions of designers of domestic ambient intelligent applications regarding prospective users and their needs?

The empirical study presented in Chapter 6, shows that in general the view of the different designers from the four different companies, who develop domestic ambient intelligent applications, did not differ much. The interviewed designers were rather concord in their views about the technical and social benefits of ambient intelligent appliances for domestic settings and their assumptions about prospective users. Based on the findings (see Chapter 6) it can be concluded that according to the designers, domestic ambient intelligent appliances above all provide benefits for prospective users. The technical benefits were the reduction in the number of boxes in people's homes and the presence of more intelligent devices and more connected devices that can 'communicate' with each other. The most important social benefit of domestic ambient intelligent applications according to the designers was that these applications make people's everyday lives easier. However, in the process of making everyday life easier designers sometimes fabricate user 'needs' rather than designing applications to fulfill people's existing needs. The implications of this conclusion will be discussed in more detail in the next chapter.

Another conclusion that can be drawn from this qualitative study is that important adoption barriers such as privacy and trust are not always dealt with by the designers during the design process of domestic ambient intelligent applications. The cause of this appears to be the aspiration to design user-friendly appliances which is more difficult to attain when holding account with privacy design issues. After all, building privacy rules into the applications could make ambient intelligent appliances for users less user-friendly by requiring more user input.

In conclusion, designers are very positive about the benefits domestic ambient intelligent applications will bring to future everyday life, while also acknowledging some of the potential disadvantages. Designers seem to be puzzled about how to handle these disadvantages in a satisfactory way which sometimes leads to designs where the disadvantages for users such as loss of privacy and loss of control are not taken care of.

Furthermore, designers assume that domestic ambient intelligent appliances will increase quality time so that more time can be spent with family members and friends (see paragraph 6.5). This quality time does not necessarily have to be spent face-to face but can also be spent via mediated communication. This indicates that domestic ambient intelligent appliances promote human to human relationships that are mediated by technological systems.

The domestic ambient intelligent appliances are assumed by the designers to be adopted by a specific group of people, namely affluent, technologically advanced people. This finding is not in agreement with the aim of the creators of the vision of ambient intelligence, namely to serve everybody (see Chapter 1).

In sum, designers of ambient intelligent appliances for domestic settings are trying to shape our future homes and the activities that can be performed there with assumptions that are, at least partly, questionable.

## 8.3 Prospective Users of Ambient Intelligent Applications

The third research question to be answered in this thesis concerns the anticipated intention to adopt domestic ambient intelligent appliances by prospective users. In Chapter 1, the research question was stated as follows:

> RQ3: What are users' attitudes and intentions anticipating the adoption of domestic ambient intelligent applications?

In Chapter 7, users' perceptions of domestic ambient intelligent applications and the variables that anticipate the intention to adopt these appliances were explored. The descriptive findings indicated that, in general, prospective users have a neutral to slightly positive attitude towards domestic ambient intelligent applications and that the intentions to adopt these applications varied from low to neutral. In addition, the findings also indicate that prospective users do not perceive that the domestic ambient intelligent applications would provide many benefits to them. Enjoyment and convenience were benefits which were slightly more positively perceived than ease of use, personalization, and usefulness.

In addition, the perceived disadvantages of domestic ambient intelligent appliances, the loss of privacy and loss of control in this case, were evaluated as varying from not very attractive to neutral. It can be concluded that prospective users find the ability of the appliances to collect private information about them and send this information to official representatives (e.g., family doctors) much less appealing than an intelligent TV keeping record of their viewing behaviour. Users apparently make a distinction in how much private information they allow the different ambient intelligent appliances to collect and use. Apparently they make an evaluation in which situations they are willing to lose some of their privacy and in turn receive some benefits. The same can be concluded for loss of control. The findings (see paragraph 7.6) indicate that users seem willing to hand over some control to ambient intelligent appliances, but not all control even if it will make their lives in certain aspects more convenient. In the next chapter the implications of this conclusion will be discussed in more detail.

In Chapter 7, a conceptual model was proposed to test which constructs are of influence on the intention to adopt domestic ambient intelligent appliances. It was hypothesized that perceived benefits and perceived disadvantages of ambient intelligent appliances would influence attitude towards these appliances and that the general attitude construct precedes the more specific expected outcomes. Expected outcomes in turn would directly influence the intention to adopt ambient intelligent appliances. The findings of testing the conceptual model in the context of domestic ambient intelligent appliances adoption showed that the percentage explained variance accounted for by the model was 75%.

Furthermore, the findings indicate that perceived benefits and perceived disadvantages of domestic ambient intelligent appliances both had a significant direct effect on attitude. The findings indicate that perceived benefits have slightly more influence on the attitude of prospective users than perceived disadvantages (see Figure 7.2). Furthermore, it can be concluded that there is statistical evidence for a strong relationship between perceived benefits and perceived disadvantages of ambient intelligent appliances. This makes sense, because if prospective users perceive ambient intelligent appliances as providing more benefits to them, they will probably perceive fewer disadvantages or will at least be more willing to take (some of) the disadvantages for granted and vice versa. This conclusion will be discussed in more detail in paragraph 9.1.

Finally, attitude was hypothesized to precede expected outcomes and the attitude-expected outcomes path appeared to be significant. The findings indicate that the expected outcomes-intention path was also significant and that specifically the expected outcomes that users will develop with regard to domestic ambient intelligent appliances when they become available on the market strongly contribute to the intention to adopt this emerging technology.

In conclusion, expected outcomes appear to be a strong predictor of the intention to adopt domestic ambient intelligent appliances. This conclusion is supported by Peters (2007) who argues that expected outcomes are very suitable to predict the adoption of new innovative technologies that are not yet experienced and which people are thus unfamiliar with. This thesis showed that people's current attitudes to and expected outcomes of ambient intelligent appliances are important to consider when anticipating the intention to adopt ambient intelligent appliances in domestic settings. Implications of this conclusion will be discussed in more detail in the next chapter.

## 8.4 Confrontation between Design(ers) and Use(rs)

The last key research question to be answered in this thesis concerns the confrontation between the design and use of ambient intelligent appliances for domestic settings. In Chapter 1, the fourth research question was stated as follow:

> RQ4: What agreements and differences between the assumptions and attitudes and intentions appear when design and use of domestic ambient intelligent applications are confronted?

On the basis of the empirical studies (see Chapters 5, 6, and 7) several conclusions can be drawn with regard to the confrontation between design and use.

Based on both the qualitative (see Chapter 6) and quantitative findings (see Chapter 7) it appears that the benefits that are assumed by the designers are less sustained by prospective users. The interviewed designers reasoned that bringing more convenience and easiness to people's daily lives was the greatest social benefit of domestic ambient intelligent appliances. The findings in paragraph 7.6 show that, in general, prospective users do not share this view and regard different domestic ambient intelligent appliances as having only marginal benefits. However, although the prospective users in general did not perceive that these appliances would provide many benefits for them, enjoyment and convenience were the particular benefits that were slightly more positively perceived than ease of use, personalization, and usefulness. So, only a modest positive benefit of convenience is similarly assessed by designers and users.

As presented in Chapter 6 and concluded in paragraph 8.2, according to the designers domestic ambient intelligent appliances primarily provide benefits for users. Potential disadvantages of ambient intelligent applications are also acknowledged by designers but they are assumed to be of less influence on the future adoption of domestic ambient intelligent appliances because it is argued that prospective users will take them for granted to a certain degree. From the early inception of ambient intelligence, loss of privacy and loss of control have been recognized by observers as important concerns for the future success of the adoption of ambient intelligence. The findings of the research presented in Chapter 7, show that when the disadvantages, in this case the loss of privacy and loss of control, with regard to domestic ambient intelligent appliances were perceived by prospective users to be high, the attitude towards the acceptance of the appliances was low and thus more negative. Therefore, it can be concluded that designers of ambient intelligent appliances should not take the potential disadvantages of this technology for granted because the findings show that the disadvantages perceived by prospective users have a direct, negative effect on users' attitudes towards domestic ambient intelligent appliances. The implications of this conclusion will be discussed in more detail in the next chapter.

Finally, the theoretical exertion to explore the combination of the general perspective of mutual shaping of technology and users and the specific perspective of particular user acceptance models of technology (see Chapter 3) turned out to be fruitful. The mutual shaping approach inspired the search for the assumptions that are held by designers of domestic ambient intelligent applications regarding prospective users of these applications. The findings provided useful insights into the way designers perceive future users of ambient intelligent applications. The user acceptance models of technology were used to get a better understanding of the variables that may play a role in the prediction of intention to adopt domestic ambient intelligent appliances by prospective users. A combination of constructs of these acceptance models was used to build a new model that proved to fit to the survey data. The multidisciplinary use of different theoretical perspectives used in this thesis showed that it can add to our understanding of social processes, which take place in a world where technological innovations are rapidly entering our everyday lives. Therefore, insights from different fields are needed to enlarge our understanding of the processes which take place in that social world.

# 9

# Discussion

*In this final chapter, first the general relevance for the design practice of the conclusions drawn from the findings of the empirical studies in the previous chapter will be discussed. Then, the limitations of the study will be acknowledged, followed by a discussion of the implications for the design and use of domestic ambient intelligent applications. Finally, this thesis concludes with recommendations for future research directions.*

## 9.1 General Insights

This thesis focused on the interplay of design and adoption of ambient intelligent applications for domestic settings. More specifically, the aim of this thesis was to better understand the assumptions held by designers of domestic ambient intelligent applications and the anticipated adoption of these applications by prospective users. To get more insight into the interplay of technology design in an early stage of development and its anticipated adoption an interdisciplinary approach was chosen. The main approach of this thesis to reach this insight is to use different methods to investigate the multi-facetted, complex interplay between design and adoption of domestic ambient intelligent applications. These different methods consisted of a content analysis of the presentation of an emerging technology, in-depth interviews to uncover the assumptions of designers and a large scale survey to identify the perceptions of prospective users towards this new technology. This approach is able to deliver the following general practical insights considering the interplay of design and use.

*Designers' assumptions about ambient intelligent applications.* The qualitative findings regarding the assumptions of designers indicated that the aim of designers is to make the lives of users of ambient intelligent applications more convenient and less hassled (see Chapter 6). The findings also support the notion that simultaneously "user needs" are being fabricated. Designers stated that new technological possibilities are used to create applications which are not primarily designed to fulfill people's existing needs, but rather because it is currently possible to make these applications and that the market demands new products and companies need to be the first to introduce new products to keep their leading positions. Miles, Cawson, and Haddon (1992) found in their study of innovative household technologies that consumer companies first look at their "improved" new technologies and then go on to search an existing market gap which can be filled. It seems that some ambient intelligent applications also follow this strategy.

Furthermore, the findings indicate that not much attention is paid to people's habits and routines. Tolmie, Pycock, Diggins, MacLean, and Karsenty (2003) stress that everyday routines in the home are subtle and complex and that these routines have to be recognized and taken into consideration when designing ambient intelligent applications, because it is difficult to alter or change people's routines. It seems that the non-technical respondents are aware of the importance of routines and habits, especially in people's private settings. However, the technical respondents seem less aware of these subtle details that exist in domestic settings than their non-technical colleagues. It is therefore necessary for the future success of ambient intelligent applications that technical and non-technical experts work closely together. The technical and non-technical respondents in the companies where the interviews were held already worked together in teams. They tried to share their expertise about technical possibilities of ambient intelligence on the one hand and human and social aspects on the other hand. However, it was acknowledged that it is still difficult to "speak each other's language". The findings of the qualitative study show that this kind of teamwork is of vital importance to be able to learn from each others' work and backgrounds and to design ambient intelligent applications that people will find not only ease to use but also useful in their everyday life.

How do the assumptions found in the designers' study actually impact the design of ambient intelligent applications? Some of the findings are very close to what Weiser (1991) originally envisioned in ubiquitous computing, such as the applications that provide convenience and improve communication. Rogers (2006) indicated that designers are trying to realize the "original" ubiquitous computing vision and that many of these research projects have been disappointing. She calls for ambient intelligent technologies that are not designed to do things for people, but to engage people more actively in what they currently do. The findings of the qualitative study affirm that designers' current assumptions about ambient intelligent applications are very much inspired by Weiser's thoughts about ubiquitous computing, and that no "new" set of ideas about ambient intelligence in everyday life has emerged. We agree with Rogers that it is time for ambient intelligent designers to pursue a new set of ideas and goals and to focus on more than the original vision of ambient intelligence. However, before designers adopt a new set of ideas, they should first try to understand their current assumptions about users. When designers recognize the assumptions that they hold, they can take a step forward and recognize potential pitfalls in the design process.

Important social issues such as loss of privacy and loss of control have been recognized as potential barriers to adoption since the start of ambient intelligence. The findings in Chapter 6 indicate that privacy and control are not always given the attention they deserve during the design of ambient intelligent applications by designers. Privacy threats are, among other things, a consequence of the complexity and personalization built into ambient intelligent designs. Privacy threats are often neglected as designers try to reduce the complexity of the applications. Weiser (1991) indicated that there are different ways to deal with privacy issues in ubiquitous systems. He noted that "if designed into systems from the outset, these techniques can ensure that private data do not become public" (p. 75). The findings of the qualitative study showed that this is only occasionally being done during the design phase of ambient intelligent applications.

Designers do not always adequately try to solve potential privacy threats for users because they work on prototypes and therefore privacy is not a necessary requirement that must be achieved. Privacy is also regarded as "less of an important" issue within domestic settings than in public settings by designers because they argue that household members already live with each other on a basis of trust. Designers seem to hand over the privacy issue to be partly resolved within the household setting. Recently, research has showed that people in a household setting find their privacy very important and use different strategies to obtain their privacy in the home (Janse, Vink, Soute, & Boland, 2007). Designers should be much more critical and offer users (more) choices to be able to protect their privacy. Designers should also make the effort to minimize the loss of privacy and control for users from the start of the design process by trying to incorporate them as much as possible into the designs themselves as suggested by Weiser (1991). Even though the specific features of ambient intelligence, such as being able to anticipate user behaviour by constantly using personal data and personal routines, make it difficult to exclude all potential privacy and control disadvantages designers should feel socially responsible (cf. McQuail, 1984) for addressing and working at proper solutions because they do not only affect the acceptance of ambient intelligence but also the potentially widespread influence of this emerging technology on people's daily lives.

We strongly believe that designers should carefully consider the assumptions they hold with regard to prospective users when designing new technologies and simultaneously we do acknowledge that this is a rather cognitive approach of the design process. Creativity plays a very important role in the design process and is an important aspect for many designers regardless of the specific products they design. Ergo, it is not proposed here that the design process should loose her creative touch, but that a thorough understanding of the assumptions held by designers can allow for more informed decisions to be made in the development process which could increase the acceptance of new technologies by a wider audience.

*Prospective users of ambient intelligent appliances.* The findings of the prospective users' study presented in Chapter 7 indicate that prospective users seem willing to hand over some control to the domestic ambient intelligent appliances, but not all control, even if it will make their lives in certain aspects more convenient. Spiekermann's (2007) study on the acceptance of RFID tags in a retail environment showed that people did not like the idea that RFID tags have a pro-active initiator role and even favor the killing of RFID tags when leaving a shop. RFID tags are used to collect information in an automated way and are thus very important for the realization of ambient intelligence.

In contrast to Spiekermann's study, the users' study in this thesis showed that in the context of domestic ambient intelligent applications prospective users seem willing to hand over some control to particular domestic ambient intelligent appliances such as the intelligent home applications (e.g., blinds automatically closing, lights automatically turning on or off when one enters a room, or the room temperature automatically adjusting to a person's specific temperature). Although, it was not specifically asked of the prospective users in the survey study why they were willing to pass some control to one domestic ambient intelligent appliance and not to the other it can be assumed that freedom of choice plays an important role here. For example, people seemed less willing to pass control to the intelligent TV. An explanation for this could be that people are used to switch between different TV channels and want to see what is on so that they are able to choose themselves what they want to see. Leaving this habit to an intelligent application and thus giving the TV the control over what is viewed, can give people the feeling of a loss of control over something they like to do.

The loss of control is one of the perceived disadvantages studied in this thesis. The test of the conceptual model (see Chapter 7) that makes an inventory of variables influencing the intention to adopt domestic ambient intelligent applications indicated that a relationship exists between perceived benefits and perceived disadvantages of domestic ambient intelligent appliances. Thus, if prospective users perceive that ambient intelligent appliances provide them with benefits, they perceive less disadvantages and vice versa. The findings indicate that apparently they are not independent of each other; there seems to be a strong mutual influence, which is not totally peculiar in this situation. It seems logical that, considering potential use of a new technology, both perceived benefits and disadvantages will play an important role. Although, it is not clear from the findings whether one construct precedes the other, or if one of the constructs has a stronger influence than the other. It could also be that benefits and disadvantages of domestic ambient intelligent appliances act simultaneously. Prospective users will probably make some sort of judgment based on how many disadvantages of an ambient intelligent application they are willing to "cope" with in return for the benefits it delivers.

The introduction, acceptance, and use of innovations have always gone together with some aspects getting more research attention than others. Qualitative aspects such as the influence of new technologies on the quality of life, especially, are underemphasized (Rice, 1987; Rogers, 1976). The aim of ambient intelligence is to increase the quality of life of ordinary people. Based on the findings presented in this thesis, it can be argued that we are not yet that far. However, we are in a development phase of ambient intelligence where different directions can still be followed. If designers of this emerging technology step away from the technological possibilities and incorporate more realistic assumptions about their prospective users, maybe then ambient intelligence will be able to support people's needs and wishes so that they themselves can decide if and how they want to increase their quality of life.

## 9.2 Limitations of the Study

Some limitations of the empirical studies presented in this thesis should be acknowledged. The promotional material which was used to analyze how ambient intelligence is represented to a general public included mainly promotional material from large, well-known, high-tech, Western companies and institutions. Although, we tried to include the promotional material of Asian companies as well, due to practical reasons this was not possible. This might have influenced the findings of the representation of ambient intelligence and future research is encouraged to also include the view of a more diverse range of companies large and small and from different continents.

In the final sample of the interviewed designers, only designers working at large, Western companies were included. However, we tried many times to also include designers from Asian companies such as LG (South Korea) and Matsushita Electric Industrial Co., Ltd. (Japan). Unfortunately, they were not able to or willing to participate and/or practical reasons such as limited knowledge of the English language to be able to respond to the interviewer prevented their participation.

Although, the aim of the users' study was to obtain a representative sample of Dutch citizens to study the anticipated use of prospective users of domestic ambient intelligent appliances, this was unfortunately not completely attained. The sample of respondents in the prospective users' study was marked by a high penetration of internet access and the possession of many information and communication technologies on average. A large group of respondents had a very positive attitude towards current information and communication technologies. This might have influenced the findings and future research should attempt to include a completely representative sample of respondents. However, in general, the descriptive results showed that the attitudes towards domestic ambient intelligent appliances varied from neutral to only slightly positive even within this ICT-minded sample. Future research should investigate more in depth why prospective users have less pronounced attitudes towards ambient intelligent appliances. Research should investigate whether this is caused by the lack of visibility of the physical appliances or the lack of first hand experience with the appliances in people's own domestic settings or that other reasons play a role in this process.

In addition, more insight is needed to understand the impact of the findings of this thesis for the future success of ambient intelligence. The findings from the study presented in Chapter 6 indicate that designers in this stage of the development process of ambient intelligence mainly target their designs at the more technologically advanced users. If even ICT-minded people do not have a pronounced positive attitude towards domestic ambient intelligent appliances this implies that designers have to carefully reconsider their assumptions about the user groups they are currently targeting.

Emotions and aesthetics were not taken into account in the model predicting the intention to adopt domestic ambient intelligent applications. It is more and more recognized that hedonic outcomes, emotions, and aesthetics play an important role in the acceptance of new devices and technologies (Jordan, 2000; Norman, 2005; Venkatesh & Brown, 2001) and, since recently, also in the field of ambient intelligence (Spiekermann, 2007; Zhou, Yu, Riekki, & Kärkkäinen, 2007). Future research is needed to investigate how these aspects could add to the findings of this study.

Finally, to improve the fit of the model to predict the intention to adopt domestic ambient intelligent appliances, post hoc modification indices suggested correlating the error terms of personal outcomes with fashion/status outcomes. Personal outcomes consisted of a combination of social outcomes and self-reactive outcomes. Although, fashion/status, social outcomes and self-reactive outcomes are theoretically distinct, they are strongly related concepts and it is likely that these measures have something specific in common.

Despite the limitations of the empirical studies, which to some extent are intrinsic to the challenge of studying future technologies and their prospective users, this thesis contributes in revealing existing assumptions of designers of domestic ambient intelligent appliances and the perceptions of these appliances by prospective users.

## 9.3 Implications for the Design and Use of Ambient Intelligence

To this point in time the interplay of design and use of ambient intelligent applications for domestic settings has not received much attention in the research community. From the initiation of ambient intelligence it is mentioned that not only technological characteristics but also human-oriented, social, and cultural characteristics are important for the acceptance of ambient intelligence by ordinary people (Bohn et al., 2004; Friedewald et al., 2005; ISTAG, 2003).

The designers' study identified some concerns about the assumptions designers of domestic ambient intelligent appliances have with regard to prospective users. The findings showed that designers mainly target one group of users, namely technology advanced users. It is almost counter-intuitive for designers to primarily target one group of people instead of everybody. Ambient intelligence is supposed to be for everyone and to enter every domain of our daily lives and thus diverse groups of people would naturally come in contact with ambient intelligent applications and thus not only one specific group of people. The strategy of the designers seems to be that they specifically focus on the early adopters, thus the technologically advanced users, and they assume that other groups will follow later. Recently, research investigating the more technical infrastructure of home networking enabling ambient intelligence showed that only a small group of people could install and maintain such infrastructures (Chetty, Sung, & Grinter, 2007). Concerns about another digital divide caused by ambient intelligence have been expressed before (e.g., Punie, 2005). The insights gained from this study clearly show that these concerns are not unjustified, because it appears that designers do target a specific group of people in society, namely the technologically advanced users. This implies that producers of ambient intelligence should do everything they can to prevent new divides in societies, especially since ambient intelligence is no longer in its infancy. It is to be expected that the designers who focus on more human and social aspects of this emerging technology will fulfill this task.

In addition, although an important aspect of ambient intelligence is to make everyday life more convenient for ordinary people, the insights gained in this study clearly showed that designers sometimes fabricate user needs rather than design applications to fulfill people's existing needs. This could imply that potentially important user needs are overlooked in the process by going after technological opportunities and that the supposed central aim of ambient intelligence, namely people's needs and wishes being the central focus of this emerging technology is not realized.

Recently, a book entitled *Safeguards of Ambient Intelligence* (Wright, Gutwirth, Friedewald, Vildjiounaite, & Punie, 2008) came out. It contained one clear message, namely to be aware of the potential threats ambient intelligence might bring, such as loss of privacy and loss of control. An important implication that can be derived from the findings of this thesis is that designers of domestic ambient intelligent appliances should gain better insight in their assumptions about prospective users and should re-evaluate their assumptions about prospective users. Loss of privacy and loss of control are not only identified by scholars as potential threats of ambient intelligence. The findings of this study show that they influence prospective users' attitudes in a negative way and negative attitudes towards a new technology could decrease the potential acceptance of ambient intelligent applications. This implies that although sometimes designers strive to find a solution for these barriers of acceptance when designing ambient intelligent applications, they should try to incorporate them into their designs right from the start.

Another important implication that can be derived from the findings of this thesis is that the current development phase of ambient intelligence requires producers and designers of ambient intelligence applications to focus on different user aspects. As the findings of the tested conceptual model in Chapter 8 show, prospective users' attitudes towards domestic ambient intelligent applications play an important role in the anticipated adoption process of this emerging technology. When presenting ambient intelligence to the general public, for example via promotional material, producers of ambient intelligent applications have to specifically focus on people's attitudes. As mentioned in Chapter 7, the characteristics of ambient intelligence are currently generally described and it is not yet clear how environments and applications in an ambient intelligent world will crystallize. However, the potential disadvantages of ambient intelligence appear to have a negative influence on people's attitudes. This implies that when, at present, ambient intelligence is presented to the general public, producers and their marketing departments should focus on the more general attitude of prospective users to inform them correctly about ambient intelligence.

One step further, in the adoption process, expected outcomes appear to have a large influence on the intention to adopt ambient intelligent applications. This implies that designers should specifically focus on these concrete expected outcomes which people have with regard to domestic ambient intelligent applications when designing these applications. Designers should also understand that in the first phase of diffusion of ambient intelligent applications people's current expected outcomes appear to be important to consider when anticipating the intention to adopt ambient intelligent appliances in domestic settings. Expected outcomes already have a significant influence on the intention to adopt new technologies when they are in an early stage of development and not experienced yet by users (cf. Peters, 2007). However, when users become familiar with technologies, habit strength becomes an even stronger predictor to explain current use of new technologies (Peters & Ben Allouch, 2005). Time is required for new habits to develop, but this implies that designers of domestic ambient intelligent applications should take account of people's current domestic habits. It is known that habits strongly influence the use of media and information and communication technologies (Atkin & LaRose, 1994). Atkin and LaRose refer to the (dis)continuity factor to argue that if people have to radically change their current habits, the chance is small that a medium will be adopted by a large group of people.

Domestic ambient intelligent appliances are not yet domesticated by people, but precursors of ambient intelligent applications are starting to enter our daily lives. The television (Sigel, 1992), mobile phone (Ling & Yttri, 2002), and the internet (Kraut et al., 1998) have all influenced social structures and cultural and social norms. For example, Spigel (1992), O'Sullivan (1991), and Yoshimi (1999) showed that the television played a very important symbolic role in post war consumer cultures. Domestic ambient intelligent applications could also become important symbols in postmodern cultures and future research could investigate whether these patterns will repeat themselves and how the social structures and cultural and social norms of behavior influence the use of ambient intelligent applications and vice versa.

The implications of this thesis probably stretch beyond domestic ambient intelligent appliances. Ambient intelligence is supposed to touch every aspect in our future everyday life both inside and outside the home. Hence, when entering other places, such as public domains, designers should carefully consider their assumptions about people and their behavior in such places and their social and cultural values and routines. Although, ambient intelligence may turn out to be something different than presently foreseen, academics should at least anticipate this future since the assumptions' of designers about users and users' perceptions will keep playing an important role in the acceptance and use of technological innovations in various environments. After all, both designers and users will shape our future everyday life.

# References


Aarts, E. (2003). Technological Issues in Ambient Intelligence. In E. Aarts & S. Marzano (Eds.), *The New Everyday: Views on Ambient Intelligence* (pp. 12-16). Rotterdam: 010 Publishers.

Aarts, E. (2004). Ambient Intelligence: A Multimedia Perspective. *IEEE Multimedia, 11*(1), 12-19.

Aarts, E., & Encarnacao, J. L. (2006). *True Visions. The emergence of Ambient Intelligence.* Berlin: Springer.

Aarts, E., & Marzano, S. (Eds.). (2003). *The New Everyday: Views on Ambient Intelligence.* Rotterdam: 010 Publishers.

Abowd, G. D., Bobick, A. F., Essa, I. A., Mynatt, E. D., & Rogers, W. A. (2002). The aware home: developing technologies for successful aging. *Proceedings of the American Association of Artificial Intelligence (AAAI) Conference and Workshop and Automation as a Care Giver, Canada*.

Abowd, G. D., & Mynatt, E. D. (2000). Charting past, present, and future research in ubiquitous computing. *ACM Transactions on Computer-Human Interaction, 7*(1), 29-58.

Abowd, G. D., & Sterbenz, J. P. G. (2000). Final report on the inter-agency workshop on research issues for smart environments. *IEEE Personal Communications, 7*(5), 36-40.

Ackerman, M. S. (2004). Privacy in pervasive environments: next generation labeling protocols. *Personal, Ubiquitous Computing, 8*(1), 430-439.

Adamowsky, N. (2000). *Kulturelle Relevanz.* Retrieved, May 16, 2006, from www.vs.inf.ethz.ch/events/slides/adamowldbg.pdf.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior.* Englewood-Cliffs, NJ: Prentice-Hall.

Akrich, M. (1992). The de-scription of technical objects. In W. Bijker & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 205-224). Cambridge, MA: MIT Press.

Akrich, M. (1995). User representations: Practices, methods and sociology. In A. Rip, T. J. Misa, & J. Schot (Eds.), *Managing technology in society, the approach of constructive technology assessment (*pp. 167-184). New York: Printer.

Akrich, M., & Latour, B. (1992). A summary of a convenient vocabulary for the semiotics of human and nonhuman assemblies. In W. Bijker, & J. Law (Eds.), *Shaping technology/building society: studies in sociotechnical change* (pp. 259-264). Cambridge, MA: MIT Press.

Aldrich, F. (2003). Smart Homes: Past, Present and Future. In R. Harper (Ed.), *Inside the Smart Home* (pp. 17-39). London: Springer.

Andriessen, J. H. T. H. (1989). 'Nieuwe media in organisaties: gebruikt of niet?', [New media in organizations: used or non-used?]. In H. Bouwman & N. Jankowski (Eds.), *Interactieve media op komst* [The rise of interactive media], (pp. 17-28). Amsterdam: Otto Cramwinckel.

Araya, A. (1995). Questioning ubiquitous computing. *Proceedings of the ACM 23rd annual conference on computer science, Nashville, Tennessee, United States,* 230–237.

Arbuckle, J. L. (2005). *Amos 6.0 User's Guide.* Chicago, IL: SPSS Inc.

Arnbak, J. C., Cuilenburg, van J. J., & Dommering, E. J. ( 1990). V*erbinding en ontvlechting in de communicatie: een studie naar toekomstig overheidsbeleid voor de openbare elektronische informatievoorziening.* Amsterdam: Otto Cramwinckel.

Atkin, D., & LaRose, R. (1994). A meta-analysis of the information services adoption literature: lessons to be learned from cable and telephony. In J. Hanson (Ed.), *Advances in Telematics* (Vol. 2, pp. 91-110). Norwood, NJ: Ablex Publishing.

Baillie, L., & Benyon, D. (2001). Investigating ubiquitous computing in the home. *Proceedings of the 1st Equator IRC Workshop on Ubiquitous Computing in Domestic Environments, Nottingham, UK,* 16-33.

Bandura, A. (1986). *Social foundations of thought and action: a social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1997). *Self-efficacy: the exercise of control*. New York: Freeman.

Barkhuus, L., & Dey, A. K. (2003). Is context-aware computing taking control away from the user? Three levels of interactivity examined. *Proceedings of the Ubicomp conference, Seattle, Washington,* 159-166.

Barlow, J., & Gann, D. (1998). *A changing sense of place: are integrated IT systems reshaping the home?* Paper presented at the Technological Futures, Urban Futures Conference, Durham, UK.

Bell, P. (2001). Content analysis of visual images. In T. Van Leeuwen & C. Jewitt (Eds.), *Handbook of Visual Analysis* (pp. 10-34). London: Sage.

Bell, G., & Kaye, J. (2002). Designing technology for domestic spaces: a kitchen manifesto. *Gastronomica, 2*(2), 46-62.

Bell, G., Blythe, M., & Sengers, P. (2005). Making by making strange: defamiliarization and the design of domestic technologies. *ACM Transactions on Computer-Human Interaction, 12*(2), 149-173.

Bell, G., Blythe, M., Sengers, P., & Wright, P. (2003). Designing culturally situated technologies for the home. *Proceedings of CHI 2003, Human Factors in Computing Systems, Ft. Lauderdale, Florida, USA*, 1062- 1063.

Belloti, V., & Sellen, A. (1993). Design for privacy in ubiquitous computing environments. *Proceedings ECSCW '93. Kluwer, Dordrecht, The Netherlands.*

Bellotti, V., Back, M., Edwards, W. K., Grinter, R. E., Henderson, A., & Lopes, C. (2002). Making sense of sensing systems: five questions for designers and researchers. *Proceedings of CHI' 2002, ACM Conference on Human Factors in Computing Systems. Minneapolis, Minnesota, USA*, 415-422.

Bellotti, V., & Edwards, K. (2001). Intelligibility and accountability: human considerations in context-aware systems. *Human-Computer Interaction, 6*, 193–212.

Ben Allouch, S., Van Dijk, J. A. G. M., & Peters, O. (2006). *Our future home: A content analysis of ambient intelligence promotional material.* Paper presented at the annual meeting of the International Communication Association, Dresden, Germany.

Berg, A-J. (1990). He, She and I.T. Designing the home of the future. In K. Sorensen & A. Berg (Eds.), *Technology and everyday life: trajectories and transformations*. Trondheim: Norwegian Research Council for Sciences and Humanities.

Berg, A-J. (1999). A gendered socio-technical construction: the smart house. In D. MacKenzie & J. Wajcman (Eds.), *The Social Shaping of Technology* (pp. 301-313). Philadelphia: Open University Press.

Berker, T., Hartmann, M., Punie, Y., & Ward, K. J. (2006). *Domestication of media and technology.* Open University Press.

Bies, R. J. (1993). Privacy and procedural justice in organizations. *Social Justice Research, 6*(1), 69-86.

Bijker, W. E. (1995). *Of bicycles, bakelites, and bulbs: toward a theory of sociotechnical change.* Cambridge, MA: MIT Press.

Bijker, W. E., Hughes, T. P., & Pinch, T. (Eds.). (1987). *The social construction of technological systems: new directions in the sociology and history of technology.* Cambridge, MA: MIT Press.

Birnbaum, J. (1997). Pervasive information systems. *Communications of the ACM, 40*(2), 40- 41.

Blythe, M. A., Monk, A. F., & Doughty, K. (2005). Socially dependable design: the challenge of ageing populations for HCI. *Interacting with Computers, 17*(6), 672-689.

Boczkowski, P. J. (1999). Mutual shaping of users and technologies in a national virtual community. *Journal of Communication, 49*(2), 86-108.

Bohn, J., Coroamã, V., Langheinrich, M., Mattern, F., & Rohs, M. (2004). Living in a world of smart everyday objects - social, economic, and ethical implications. *Human and Ecological Risk Assessment, 10*(5), 763-785.

Bollen, K.A. (1989). *Structural equations with latent variables*. New York: Wiley.

Bouwman, H., & Jong, de A. (1996). Predicting consumer adoption of information technologies. In N. Jankowski & L. Hanssen (Eds.), *The contours of multimedia. Recent technological, theoretical and empirical developments* (pp. 160–172). Luton: University of Luton Press.

Bowden, S., & Offer, A. (1994). Household appliances and the use of time: the United States and Britain since the 1920s. *Economic History Review, XLVII*(4), 725-748.

Brey, P. (2005). Freedom and privacy in ambient intelligence. *Ethics and Information Technology, 7*(3), 157–166.

Brown, H. G., Poole, M. S., Rodgers, T. L., & Van Walsum, K. (2003). Trust, trait theory, and collaboration in telemedicine: A circumplex perspective. *Proceedings of the Thirty-Sixth Hawaii International Conference on System Sciences, IEEE Computer Society, Los Alamitos, CA.*

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162). Thousand Oaks, CA: Sage.

Brumitt, B., Meyers, B., Krumm, J., Kern, A., & Shafer, S. A. (2000). EasyLiving: technologies for intelligent environments. In P. J. Thomas & H-W. Gellersen (Eds.), *Handheld and Ubiquitous Computing, Second International Symposium, HUC 2000, LNCS 1927* (pp. 12-29). Berlin: Springer.

Bryman, A. (1989). *Research Methods and Organization Studies* (Vol. 20). London: Routledge.

Castells, M. (1996). *The rise of the network society.* Oxford: Blackwell.

Cawson, A., Haddon, L., & Miles, I. (1989). *Delivering IT into the home: Interim Report.* Paper presented at DTI/ESRC Research Initiative on New Technologies and the Firm, Workshop at Warwick University.

Cawson, A., Haddon, L., & Miles, I. (1995). *The shape of things to consume: Delivering information technology into the home.* London: Avebury.

Central Bureau of Statistics (CBS). (2006a). *Population: core figures*. Retrieved May 19, 2007, from <http://statline.cbs.nl/.

Central Bureau of Statistics (CBS). (2006b). *ICT and media use.* Retrieved May 19, 2007, from <http://statline.cbs.nl/.

Chang, K-H., Liu, S-Y., Chu, H-H., Hsu, J. Y-J., Chen, C., Lin, T-Y., Chen, C-Y., & Huang, P. (2006). The diet-aware dining table: Observing dietary behaviors over a tabletop surface. *Proceedings of the 4th International Conference of Pervasive Computing*, 366-382.

Chetty, M., Sung, J-Y., & Grinter, R. E. (2007). How smart homes learn: The evolution of the networked home and household. *Proceedings of 9th International Conference on Ubiquitous Computing (UbiComp 07), Innsbrück, Austria*, 127-144.

Clemmensen, T. (2004). Four approaches to user modeling – a qualitative research interview study of HCI professionals' practice. *Interacting with Computers, 16*(4), 799-829.

Cockburn, C. (1997). Domestic technologies: Cinderella and the engineers. *Women's Studies International Forum, 20*(3), 361-371.

Cockburn, C., & Ormrod, S. (1993). *Gender and technology in the making.* London: Sage.

Coleman, R., & Wasike, B. (2004). Visual elements in public journalism newspapers in an election: A content analysis of the photographs and graphics in campaign 2000. *Journal of Communication, 54*(3), 456-73.

Consolvo, S., Roesller, P., Shelton, B. E., LaMarca, A., Schilit, B., Bly, S. Dourish, P., 2004. Technology for Care Networks and Elders. *Pervasive Computing, 3*(2), 22-29.

Cooper, G., & Woolgar, S. (1994). Software quality as community performance. In R. Mansell (Ed.), *The management of information and communication technologies: Emerging patterns of control* (pp. 54-68). London: ASLIB.

Corritore, C. L., Kracher, B., & Wiedenbeck, S. (2003). Online trust: concepts, evolving themes, a model. *International Journal of Human Computer Studies, 58*, 737-758.

Cowan, R. S. (1976). The 'industrial revolution' in the home: household technology and social change in the 20th century. *Technology and Culture*, *17*(1), 1-23.

Cowan, R. S. (1983). *More work for mother: the ironies of household technologies form the open hearth to the microwave.* New York: Basic Books.

Cozijnsen, A. J., & Vrakking, W. J. (1986). *Handboek voor Strategisch Innoveren. Een internationale balans [Handbook for Strategic Innovations: An international Balance].* Deventer: Kluwer.

Crabtree, A., Rodden, T., Hemmings, T., & Benford, S. (2003). Finding a place for UbiComp in the home. *Proceedings of the 5th International Conference on Ubiquitous Computing, Seattle, USA,* 208-226.

Cranor, L. F., Reagle, J., & Ackerman, M. S. (1999). Beyond concern: understanding net users' attitudes about online privacy. In I. Vogelsang & B. Compaine (Eds.), *The Internet upheaval: raising questions, seeking answers in communications Policy* (pp. 47-60). Cambridge: MIT Press.

Creswell, J. W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.

Culnan, M. J., & Armstrong, P. K. (1999). Information privacy concerns, procedural fairness, and impersonal trust: An empirical investigation. O*rganization Science, 10*(1), 104-115.

Davidoff, S., Lee, M. K., Yiu, C., Zimmerman, J., & Dey, A. K. (2006). Principles of smart home control. *Proceedings of Ubicomp 2006, LNCS 4206,* 19-34.

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly, 13*(3), 319-340.

Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioural impacts. *International Journal Man-Machine Studies, 38*(3), 475-487.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

DeCew, J. (1997). *In Pursuit of Privacy. Law, Ethics, and the Rise of Technology.* Ithaca: Cornell University Press.

Deleuze, G. (1992). *Postscript on the societies of control, 59,* 3–7. Retrieved 2006, from ftp://etext.archive.umich.edu/pub/Politics/Spunk/anarchy_texts/isc/Spunk962.txt.

Denning, P. J., & Metcalfe, R. M. (Eds.). (1997). *Beyond Calculation: The Next Fifty Years of Computing*. New York: Copernicus Springer.

Dertouzos, M. L. (1999). The future of computing. *Scientific American, 281,* (2), 52-55.

DeSanctis, G., & Poole, M. S. (1994). Capturing the complexity in advanced technology use: adaptive structuration theory. *Organization Science, 5*, 121-147.

Dijk, J. A. G. M. van (2006). *The network society* (2nd ed.). Londen: Sage.

Dourish, P. (2001). *Where the action is*. Cambridge, MA: MIT Press.

Dovey, K. (1985). Home and Homelessness. In I. Altman & C. M. Werner (Eds.), *Home Environments* (pp. 33-64). New York: Plenum.

Dritsas, S., Gritzalis, D., & Lambrinoudakis, C. (2006). Protecting privacy and anonymity in pervasive computing: trends and perspectives. *Telematics and Informatics, 23*(3), 196-210.

DuGay, P., Hall, S., Janes, L., Mackay, H., & Negus, K. (1997). *Doing Cultural Studies. The Story of the Sony Walkman.* London: Sage.

Durmaz Incel, O., Dulman, S., & Jansen, P. (2006). Multi-channel support for dense wireless sensor networking. In P. Havinga, M. Lijding, N. Meratnia & M. Wegdam (Eds.), *Smart Sensing and Context, LNCS 4272* (pp. 1-14). Berlin: Springer.

Edwards, W. K., & Grinter, R. E. (2001). At home with ubiquitous computing: seven challenges. In G. D. Abowd, B. Brummit & S. A. Shafer (Eds.), *Proceedings of UbiComp 2001, LNCS 2201 (*256-272). Berlin: Springer.

Eggen, B., Hollemans, G., & van de Sluis, R. (2003). Exploring and enhancing the home experience. *Cognition, Technology & Work, 5*(1), 44-54.

Ellis, R. (2004). Challenges of work/home boundaries and user perceptions for Ambient Intelligence. In P. Cunningham & M. Cunningham (Eds.), *E-adoption and the Knowledge Economy: Issues, Appliances, Case Studies* (pp. 1395-1402). Amsterdam: IOS Press.

Esrock, S., & Leichty, G. B. (2000). Organization of Corporate Web Pages: Publics and Functions. *Public Relations Review, 26*(3), 327-44.

European Commission, (2006). *Special Eurobarometer: E-communications household survey.* Retreived October, 2006, from http://ec.europa.eu/ information_society/ policy/ecomm/doc/info_centre/studies_ext_consult/ecomm_household_study/eb_jul06_main_report_en.pdf.

Fersch, A., & Mattern, F. (Eds.). (2004). *Proceedings of the Second International Conference Pervasive Computing, Vienna, Austria, LNCS 3001, XVII.* Berlin: Springer.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: an introduction to theory and research.* Reading, MA: Addison-Wesley.

Fiske, J. (1990). *Introduction to Communication Studies* (2nd ed.). London: Routledge.

Forest, F., & Arhippainen, L. (2005). Social acceptance of proactive mobile services: observing and anticipating cultural aspects by a Sociology of User Experience method. *Proceedings of Joint sOc-EUSAI conference, Grenoble, France.*

Friedewald, M., Da Costa, O., Punie, Y., Alahuhta, P., & Heinonen, S. (2005). Perspectives of ambient intelligence in the home environment. *Telematics and Informatics, 22*(3), 221-238.

Friedewald, M., Vildjiounaite, E., Punie, Y., & Wright, D. (2006). Privacy, identity and security in ambient intelligence: A scenario analysis. *Telematics and Informatics, 24*(1), 15-29.

Frissen, V. (2000). ICTs in the rush hour of life. *The Information Society, 16,* 65-75.

Fulk, J. (1993). Social Construction of Communication Technology. *Academy of Management Journal, 36*(5), 921-950.

Fulk, J., Steinfield, C., Schmitz, J., & Power, J. G. (1987). A social information processing model of media use in organizations. *Communication Research, 14,* 529-552.

Gajos K., Fox, H., & Shrobe, H. (2002). End user empowerment in human centered pervasive computing. *Proceedings Pervasive 2002, Zurich, Switzerland*, 134-140.

Gann, D., Barlow, J. & Venables, T. (1999). *Digital Futures: Making Homes Smarter*. Coventry: Chartered Institute of Housing.

Garcia, M. R., & Stark, P. (1991). *Eyes on the news.* St. Petersburg, FL: Poynter Institute.

Garson, G.D. (2006). *Statnotes: Topics in multivariate analysis.* Retrieved May, 2007, from http://www2.chass.ncsu.edu/garson/ pa765/ structur.htm.

Gaver, W. (2001). Designing for ludic aspects of everyday life. *ERCIM News*. Retrieved March, 2007, from www.ercim.org/publication/Ercim_News/enw47/gaver.html.

Gibson, R., & Zillmann, D. (2000). Reading between the photographs: The influence of incidental pictorial information on issue perception. *Journalism and Mass Communication Quarterly, 77*(2), 355-366.

Giddens, A. (1984). *The Constitution of Society: Outline of the Theory of Structuration.* Cambridge: Polity Press.

Greenfield, A. (2006). *Everyware: The dawning age of ubiquitous computing.* Berkely, CA: New Riders.

Grinter, R. E., & Edwards, W. K. (2001). At home with ubiquitous computing: seven challenges. *Proceedings of Ubicomp 2001, LNCS 2201,* 256-272.

Haddon, L. (1995). *Home Automation: Research Issues*. Paper presented at the second EMTEL Workshop: The European Telecom User, November 10-11th, Amsterdam, The Netherlands.

Haddon, L., & Silverstone, R. (1994). The Careers of Information and Communication Technologies in the Home. In K. Bjerg & K. Borreby (Eds.), *Proceedings of the International Working Conference on Home Orientated Informatics, Telematics and Automation.* Copenhagen: University of Copenhagen.

Hamill, L. (2006). Controlling smart devices in the home. *The Information Society, 22*(4), 241-249.

Hansell, S. (2006). TiVo is watching when you don't watch, and it tattles. *New York Times.* Retrieved July 26, 2006, from http://www.nytimes.com/2006/07/ 26/ technology/26adco.html.

Hansen, T. R., Bardram, J. E., & Soegard, M. (2006). Moving out of the lab: deploying pervasive technologies in a hospital. *IEEE Pervasive Computing, 5*(3), 24–31.

Harper, R. (Ed.). (2003). *Inside the Smart Home.* London: Springer.

Heimer, T. (1995). The Genesis of Intelligent Home Technology. In J. Esser, G. Fleischmann & T. Heimer (Eds.), *Soziale und ökonomische Konflikte in Standardisierungsprozessen [Social and Economic Conflicts in Standardising processes]* (pp. 105-37). Frankfurt/Main: Campus.

Hilty, L. M., Som, C., & Kohler, A. (2004). Assessing the human, social, and environmental risks of pervasive computing. *Human and Ecological Risk Assessment, 10*(5), 853-874.

Hindus, D. (1999). The Importance of Homes in Technology Research. *Proceedings of the Second International Workshop on Cooperative Buildings (CoBuild'99), LNCS 1670,* 199-207.

Holbert, R. L., & Stephensen, M. T. (2002). Structural Equation Modeling in the Communication Sciences, 1995-2000. *Human Communication Research, 28(*4), 531-551.

Hoyle, R. H., & Panter, A. T. (1995). Writing about structural equation models. In R. H. Hoyle (Ed.), *Structural equation modeling: Comments, issues, and applications* (pp. 158-176). Thousand Oaks, CA: Sage.

Hu, L.,& Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1-55.

Hughes, T. P. (1983). *Networks of power: electrification in western society, 1880-1930.* Baltimore: John Hopkins University Press.

Hughes, T. P. (1994). Technological Momentum. In M. R. Smith & L. Marx (Eds.), *Does Technology Drive History? The Dilemma of Technological Determinism* (pp. 101-113). Cambridge: MIT Press.

Hughes, J., O'Brien, J., Rodden, T., Rouncefield, M., & Viller, S. (2000). Patterns of home life: informing design for domestic environments. *Personal Technologies, 4*(1), 25-38.

Iachello, G., Smith, I., Consolvo, S., Chen, M., & Abowd, G. D. (2005). *Developing Privacy Guidelines for Social Location Disclosure Applications and Services.* Paper presented at the Symposium on Usable Privacy and Security (SOUPS), July 6-8, Pittsburgh, PA, USA.

Information Society Technologies Advisory Group (ISTAG) (2001). *Scenarios for ambient intelligence in 2010*. Seville, Spain: Institute for Prospective Technological Studies (IPTS). Retrieved May, 2003, from http://www.cordis.lu/ist/istag.htm.

Information Society Technologies Advisory Group (ISTAG). (2003). *Ambient intelligence: from vision to reality for participation in society and business.* Retrieved November, 20, 2005, from http://europa.eu.int/information_society/programmes/evaluation/pdf/5_y_a/interim_report_final_30-06-04.pdf.

Intille, S. (2002). Designing a home of the future. *IEEE Pervasive Computing, 1*(2), 76–82.

Intille, S. S., Larson, K., Beaudin, J. S., Nawyn, J., Tapia, E. M., & Kaushik, P. (2005). A living laboratory for the design and evaluation of ubiquitus computing technologies. *Proceedings of CHI'05 conference on human factors in computing systems*, 1941-1944.

Ishii, H., & Ullmer, B. (1997). Tangible bits: Towards seamless interfaces between people, bits and atoms. *Proceedings of CHI '97, Atlanta, Georgia, USA,* 1-8.

Janse, M. D., Vink, P., Soute, I., & Boland, H. Perceived privacy in ambient intelligent environments. *Proceedings of Context Awareness and Trust 2007 (CAT07), First International Workshop on Combining Context with Trust, Security and Privacy,* 1-12.

Jarvenpaa, S. L., Knoll, K., & Leidner, D. E. (1998). Is anybody out there? Antecedents of trust in global virtual teams. *Journal of Management Information Systems*, *14*(4), 29-64.

Jordan, P. W. (2000). *Designing Pleasurable Products: an introduction to the new human factors.* London: Taylor & Francis.

Kidd, C., Orr, R. J., Abowd, G. D., Atkeson, C. G., Essa, I. A., MacIntyre, B., Mynatt, E. D., Starner, T. E., & Newstetter, W. (1999). The Aware Home: A living laboratory for ubiquitous computing research. *Proceedings of the Second International Workshop on Cooperative Buildings (CoBuild'99), Pittsburgh, PA.*

Kleinrock, L. (2001). Breaking loose. *Communications of the ACM, 44*(9), 41–45.

Kline, R., & Pinch, T. (1996). Users as agents of change: the social construction of the automobile in the rural United States. *Technology and Culture, 37,* 763-795.

Kling, R., & Scacchi, W. (1982). The web of computing: computer technology as social organization. *Advances in Computers, 21,* 1-90.

Kobsa, A. (2003). A component architecture for dynamically managing privacy constraints in personalized web-based systems. *Proceedings of the third workshop on privacy enabling technology, Dresden, Germany.*

Kraut, R., Patterson, M., Lundmark, V., Kiesler, S., Mukophadhyay, T., & Scherlis, W. (1998). Internet paradox. A social technology that reduces social involvement and psychological well-being. *American Psychologist, 53*(9), 1017-1031.

Krippendorff, K. (1980). *Content analysis: An introduction to its methodology.* Thousand Oaks, CA: Sage.

Kun, A., Miller, T. W., & Lenharth, W. (2004). Computers in police cruisers. *IEEE Pervasive Computing, 3*(4), 34–41.

Langheinrich, M. (2001). Privacy by design - Principles for privacy-aware ubiquitous systems. *Proceedings of Ubicomp 2001, LNCS 2201*, 273-291.

Langheinrich, M. (2002). A privacy awareness system for ubiquitous computing environments. *Proceedings of Ubicomp 2002, LNCS 2498,* 237-245.

Langheinrich, M., Coroama, V., Bohn, J., & Rohs, M. (2002). As we may live – Real-world implications of ubiquitous computing. Retrieved, 2003, from

http://www.vs.inf.ethz.ch/publ/papers/uc-implications.pdf.
Latour, B. (1988). Mixing humans and non-humans together: the sociology of a door-closer. *Social Problems, 35*(3), 298-310.
LaRose, R., & Eastin, M. S. (2004). A social cognitive theory of Internet uses and gratifications: Toward a new model of media attendance. *Journal of Broadcasting and Electronic Media, 48*(3), 358- 377.
LaRose, R., Mastro, D. A., & Eastin, M. S. (2001). Understanding Internet usage: a social cognitive approach to uses and gratifications. *Social Science Computer Review, 19,* 395-413.
Lederer, S., Hong, J., Dey, A. K., & Landay, A. (2004). Personal privacy through understanding and action: five pitfalls for designers. *Personal and Ubiquitous Computing, 8*(6), 440-454.
Lee, M. K. O., & Turban, E. (2001). A trust model for consumer Internet shopping. *International Journal of Electronic Commerce, 6*(1), 75-91.
Lessig, L. (1999). *Code and Other Laws of Cyberspace.* New York: Basic Books.
Lievrouw, L. A. & Silverstone, S. (2002). *The handbook of new media: social shaping and consequences of ICTs*. London: Sage.
Ling, R., & Yttri, B. (2002). Hyper-coordination via mobile phones in Norway. In J. E. Katz & M. A. Aakhus (Eds.), *Perpetual contact: Mobile communication, private talk, public performance* (pp. 139-169). Cambridge: Cambridge University Press.
Little, L., Briggs, P., & Coventry, L. (2005). Public space systems: designing for privacy? *International Journal Human-Computer Studies, 63*, 254-268.
Little, L., Marsh, S., & Briggs, P. (2007). Trust and privacy permission for an ambient world. In R. Song, L. Korba, & G. Yee (Eds.), *Trust in eservices: technologies, practices and challenges* (pp. 259-292). Hershey, PA.: Idea Group Publishing.
Living Tomorrow. (2006). *The home of the future.* Retrieved May, 2006, from http://www.livingtomorrow.nl/.
Lucky, R. (1999). *Everything will be connected to everything else.* Retrieved, 2003, from www.argreenhouse.com/ papers/rlucky/spectrum/connect.shtml.
Lyytinen, K., & Yoo, Y. (2002). Research commentary: the next wave of nomadic computing. *Information Systems Research, 13*(4), 377-388.
Mackay, H., Crane, C., Benyon-Davies, P., & Tudhope, D. (2000). Reconfiguring the user: using rapid application development. *Social Studies of Science, 30*(5), 737-759.
Mackay, H., & Gillespie, G. (1992). Extending the social shaping of technology approach: ideology and appropriation. *Social Studies of Science, 22*(4), 685-716.
MacKenzie, D., & Wajcman, J. (1985). *The Social Shaping of Technology: how the*

*refrigerator got its hum.* Milton Keynes – Philadelphia: Open University Press.
Mansell, R., & Silverstone, R. (Eds.). (1996). *Communication by design. The politics of information and communication technologies.* Oxford: Oxford University Press.
McCullough, M., (2004). *Digital ground: Architecture, pervasive computing, and environmental knowing.* Cambridge, MA: MIT Press.
McFarland, D. J., & Hamilton, D. (2006). Adding contextual specificity to the technology acceptance model. *Computers in Human Behavior, 22*(3), 427-447.
McQuail, D. (1984). *Mass Communication Theory: an introduction*. (3rd ed.). London: Sage.
McQuail, D. (1987). Research on new communication technologies: barren terrain or promising arena? In W. H. Dutton, J. G. Blumler, & K. L. Kraemer (Eds.), *Wired Cities: shaping the future of communications* (pp. 431-446). London: Cassell.
Metzger, M. J., & Docter, S. (2003). Public opinion and policy initiatives for online privacy protection. *Journal of Broadcasting & Electronic Media, 47*(3), 350-374.
Meyer, S., & Rakotonirainy, A. (2003). A survey of research on context-aware homes. *Proceedings of Workshop on Wearable, Invisible, Context-Aware, Ambient, Pervasive and Ubiquitous Computing: ACS Conferences in Research and Practice in Information Technology, 21,* 159-68. Australian Computer Society.
Miles, I., Cawson, A., & Haddon, L. (1992). The shape of things to consume. In R. Silverstone & E. Hirsch (Eds.), *Consuming Technologies: Media and information in domestic spaces* (67-81). London: Routledge.
Milne, G. R., & Gordon, M. E. (1993). Direct mail privacy-efficiency trade-offs within an implied social contract framework. *Journal of Public Policy & Marketing, 12*(2), 206-215.
Misker, J. M. V., Lindenberg, J., & Neerincx, M. A. (2005). Users want simple control over device selection. *Proceedings of the 2005 Joint Conference on Smart objects and Ambient Intelligence,* 129 – 134.
MIT Project Oxygen, (2000). Pervasive, human centered computing. Retrieved, June, 2004, from http://oxygen.csail.mit.edu/Overview.html.
Mynatt, E. D., Melenhorst, A-S., Fisk, A. D., & Rogers, W. A. (2004). Aware technologies for ageing in place: understanding user needs and attitudes. *Pervasive Computing, 3*(2), 36-41.
Nguyen, D. H., & Mynatt, E. D. (2002). *Privacy mirrors: understanding and shaping socio-technical ubiquitous computing systems.* Technical Report GIT-GVU-02-16, Georgia Institute of Technology. Retrieved October 16, 2007 http://smartech. gatech.edu/handle/1853/3268.
Norman, D. A. (1998). *The invisible computer: Why good products can fail, the personal computer is so complex, and information appliances are the solution.* Cambridge, MA:

MIT Press.
Norman, D. A. (2005). *Emotional design: why we love (or hate) everyday things*. New York: Basic Books.
Nunnally, J.C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw-Hill.
Orlikowski, W., & Iacono, C. S. (2001). Research commentary: desperately seeking the "IT" in IT research - A call to theorizing the IT artefact. *Information Systems Research, 12*(2), 121-134.
O'Sullivan, T. (1991). Television memoires and cultures of viewing 1950-65. In J. Corner (Ed.), *Popular Television in Britain*, London: British Film Institute.
Oudshoorn, N., & Pinch, T. (Eds.). (2003). *How users and Non-users matter. The co-construction of users and technologies*. Cambridge: MIT Press.
Paivio, A., & Csapo, K. (1973). Picture superiority in free recall: Imagery or dual coding? *Cognitive Psychology 5*(2), 176-206.
Patton, M. Q. (2002). *Qualitative evaluation and research methods (*3rd ed.). Thousand Oaks, CA: Sage.
Pedersen, D. M. (1999). Model for types of privacy by privacy functions. *Journal of Environmental Psychology, 19*, 397-405.
Pedersen, P. E. (2005). Adoption of mobile Internet services: An exploratory study of mobile commerce early adopters. *Journal of Organizational Computing and Electronic Commerce, 15*(2), 203-222.
Peters, O. (2007). *Social psychological determinants of mobile communication technology and use and adoption. A comparison of three models to explain and predict communication technology behavior.* Doctoral dissertation, University of Twente, The Netherlands.
Peters, O., & Ben Allouch, S. (2005). Always connected: a longitudinal field study of mobile communication. *Telematics and Informatics, 22*(3), 239-256.
Petriu, E. M., Georganas, N. D., Petriu, D. C., Makrakis, D., & Groza, V.Z. (2000). Sensor-based information appliances. *IEEE Instrumentation and Measurement Magazine, 3*(4), 31-35.
Philips Research. (2002). *Ambient Intelligence in HomeLab*. Eindhoven, The Netherlands: Royal Philips Electronics.
Philips Research. (2005). *What is Ambient Intelligence?* Retrieved, 2006, from, http://www.research.philips.com/technologies/syst_softw/ami/index.html.
Philips Research. (2007). *Ambilight - the new TV experience.* Retrieved, September, 2007, from http://www.research.philips.com/technologies/ syst_softw/ami/ ambilight.html.

Pinch, T. J., & Bijker, W. E. (1984). The social construction of facts and artefacts: or how the sociology of science and the sociology of technology might benefit each other. *Social Studies of Science, 14*(3), 399-441.

Poole, M. S., & DeSanctis, G. (1990). Understanding the use of group decision support systems: the theory of adaptive structuration. In J. Fulk & C. Steinfield (Eds.), *Organizations and communication technology* (pp. 173-193). Newsbury Park, CA: Sage.

Punie, Y. (2000). *Adoption, use and meaning of media in daily life: continuous limitation or discontinuous liberation?* Doctoral dissertation, Free University of Brussels, Belgium.

Punie, Y. (2003). *A social and technological view on Ambient Intelligence in Everyday Life: What bends the trend?* European Media, Technology and Everyday Life Research Network, (EMTEL2) Key Deliverable Work Package 2, EC DG-JRC. Sevilla, Spain: Institute for Prospective technological Studies (IPTS).

Punie, Y. (2005). The future of Ambient Intelligence in Europe: the need for more everyday life. *Communications & Strategies, 57,* 141-165.

Putman, T. (1999). Postmodern home life. In I. Cieraad (Ed.), *At home: An anthropology of domestic space* (pp. 144-152). Syracuse, NY: Syracuse University Press.

Reeves, B., & Nass, C. (1996). *The media equation: how people treat computers, televisions and new media like real people and places.* Cambridge, UK: Cambridge University Press.

Rice, R. E. (1987). Challenges facing research on wired cities. In W. H. Dutton & J. G. Blumler & K. L. Kraemer, K. L. (Eds.), *Wired cities: shaping the future of communications* (pp. 446-455). London: Cassell.

Rice, R. E., & Rogers, E. M. (1980). Reinvention in the innovation process. *Knowledge: creation, diffusion, utilization, 1*(4), 499-514.

Rice, R. (1999). Multiple theories, issues, data and methods for understanding the implementation of an information system. *Trends in Communication, 5*, 39-52.

Rode, J. A., Toye, E. F., & Blackwell, A. F. (2004). The fuzzy felt ethnography - understanding the programming patterns of domestic appliances. *Personal and Ubiquitous Computing,* 8(3/4), 161-176.

Rogers, E. M. (1976). Communication and development: the passing of the dominant paradigm. *Communication Research, 3*(2), 213-240.

Rogers, E. M., Collins-Jarvis, L., & Schmitz, J. (1994). The PEN Project in Santa Monica: Interactive communication, equality and political action. *Journal of the American Society for Information Science, 45*(6), 401-140.

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press.

Rogers, Y. (2006). Moving on from Weiser's vision of calm computing: engaging

ubicomp experiences. *Proceedings of Ubicomp 2006, LNCS 4206,* 404-421.
Rohs, M. (2002). *Ubiquitous computing criticism*. Seminar Ubiquitous Computing Information. Presentation at the Department of Computer Science, ETH Zurich. Retrieved December, 2004, from http://www.vs.inf.ethz.ch/ edu/WS0102/UI/ slides/ui_10critique.pdf.
Rommes, E. (2002). *Gender scripts and the Internet. The design and use of Amsterdam's digital city.* Doctoral dissertation, University of Twente, Enschede: Twente University Press.
Rosen, L. D., & Weil, M. M. (1995). Adult teenage use of consumer, business, and entertainment technology: Potholes on the Information Superhighway? *Journal of Consumer Affairs, 29*(1), 55-84.
Roussos, G., & Moussouri, T. (2004). Consumer perceptions of privacy, security and trust in ubiquitous commerce. *Personal Ubiquitous Computing, 8,* 416–429.
Salvador, T., Bell, G., & Anderson, K. (1999). Design Ethnography. *Design Management Journal, 10*(4), 35-41.
Satyanarayanan, M. (2001). Pervasive computing: vision and challenges. *IEEE Personal Communications, 8*(4), 10−17.
Siegel, S., & Castellan, N. J. (1988). *Nonparametric statistics for the behavioral sciences*. New York: McGraw-Hill.
Silverstone, R. (1994). *Television and Everyday Life.* London: Routledge.
Silverstone, R., & Haddon, L. (1996). Design and the domestication of information and communication technologies: Technical change and everyday life. In R. Mansell & R. Silverstone, (Eds.), *Communication by design. The politics of information and communication technologies,* (pp. 45-74). Oxford: Oxford University Press.
Silverstone, R., & Hirsch, E. (Eds.). (1992). *Consuming technologies. Media and information in domestic spaces*. London: Routledge.
Silverstone, R., Hirsch, E., & Morley, D. (1992). Information and communication technologies and the moral economy of the household. In R. Silverstone & E. Hirsch (Eds.), *Consuming technologies. Media and information in domestic spaces* (pp. 15-31). London: Routledge.
Singh, R., Sycara, K., & Payne, T. (2002). Distributed AI, schedules and the semantic Web. *The XML Journal , 3*(11), 40-44.
Singleton, L. A., & Schement, J. R. (2003). *The home as a borderland: An information policy perspective*. Paper presented at the Annual International Communication Association, San Diego, CA.

Skinner, D. (1994). Computerized homes: visions and realities. *Proceedings of the International Working Conference on Home Orientated Informatics, Telematics and Automation, Copenhagen.*

Smith, M. R. (1994). Technological determinism in American culture. In M. R. Smith & L. Marx (Eds.), *Does Technology Drive History? The Dilemma of Technological Determinism* (pp. 1-35). Cambridge: MIT Press.

Soliman, K. S., & Janz, B. D. (2004). An exploratory study to identify the critical factors affecting the decision to establish Internet-based interorganizational information systems. *Information and Management, 41*(6), 697–706.

Spiekermann, S. (2007). *User control in ubiquitous computing: Design alternatives and user acceptance*. Doctoral dissertation, Humboldt-University, Berlin.

Spigel, L. (1992). *Make room for your TV: Television and the family ideal in postwar America.* Chicago: University of Chicago Press.

Stanford, V. (2002). Using pervasive computing to deliver elder care. *IEEE Pervasive Computing, 1*(1), 10–13.

Stewart, J. (2003). The social consumption of information and communication technologies (ICTs): insights from the research on the appropriation and consumption of new ICTs in the domestic environment. *Cognition, Technology and Work, 5*(1), 4-14.

Stone, A. R. (1991). Will the real body please stand up? Boundary stories about virtual cultures. In M. Benedikt (Ed.), *Cyberspace: First Steps* (pp. 81-118). Cambridge, MA: MIT Press.

Stone, A. (2003). The dark side of pervasive computing. *Pervasive Computing, 2*(1), 4-8.

Stone, E. F., & Stone, D. L. (1990). Privacy in organizations: theoretical issues, research findings, and protection mechanism. In K. M. Rowland & G. R. Ferris (Eds.), *Research in personnel and human resource management*, vol. 8 (pp. 349-411). Greenwich, CT: JAI Press.

Suchman, L. A. (1987). *Plans and Situated Actions: The problem of human-machine communication.* Cambridge: Cambridge University Press.

Thackara, J. (2001). The design challenge of pervasive computing. *Interactions, 8*(3), 46-52.

Tolmie, P., Pycock, J., Diggins, T., MacLean, A., & Karsenty, A. (2003). Towards the unremarkable computer: making technology at home in domestic routines. In R. Harper (Ed.), *Inside the Smart Home* (pp. 183-206). London: Springer.

Tyre, M., & Orlikowski, W. (1994). Windows of opportunity: temporal patterns of technological adaptations in organizations. *Organization Science, 5,* 98-118.

Udo, G. J. (2001). Privacy and security issues as major barriers for e-commerce. *Information Management and Computer Security, 9*(4), 165-174.

Van Oost, E. (1995). Over 'vrouwelijke' en 'mannelijke' dingen. [About 'female' and 'male' things]. In M. Brouns, M. Verloo, & M. Grunell (Eds.), *Vrouwenstudies in de jaren negentig: een kennismaking vanuit verschillende disciplines [Female studies in the nineties: an introduction from different disciplines]* (pp. 287-310). Coutinho.

Venkatesh, A. (1985). A conceptualization of the household/technology interaction. *Advances in Consumer Research, 12*(1), 189-194.

Venkatesh, A. (1996). Computers and other interactive technologies for the home. *Communications of the ACM, 39*(12), 47-54.

Venkatesh, V., & Brown, S. (2001). A longitudinal investigation of personal computers in homes: adoption determinants and emerging challenges. *MIS Quarterly, 25*(1), 71-102.

Venkatesh, A., Kruse, E., & Shih, E. C-F. (2003). The networked home: an analysis of current developments and future trends. *Cognition, Technology and Work 5*(1), 23-32.

Venkatesh, A., & Mazumbar, S. (1999). Near information technologies in the home: a study of the use, impacts and design strategies. *Proceedings of the 30th Annual Conference of the Environmental Design Research Association (EDRA) "The Power of Imagination"*, 216-220.

Venkatesh, A., Stolzoff, N., Shih, E., & Mazumdar, S. (2001). The home of the future: An ethnographic study of new information technologies in the home. In M. Gilly & J. Meyers-Levy (Eds.), *Advances in Consumer Research Volume XXVIII* (pp. 88-96). Valdosta, Georgia: Association for Consumer Research.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly, 27*(3), 425-478.

Von Hippel, E. (1986). Lead users: A source of novel product concepts. *Management Science, 32*(7), 791-805.

Von Hippel, E. (1988). *Sources of innovation*. New York: Oxford University Press.

Wajcman, J. (1991). *Feminism confronts technology*. Cambridge: Polity Press.

Waldrop, M. M. (2003). *Pervasive computing. An overview of the concept and an exploration of the public policy implications.* Retrieved January 7, 2004, from http://www.foresightandgovernance.org/images/Pervasi5.pdf.

Wanta, W. (1988). The effects of dominant picture graphs: An agenda-setting experiment. *Journalism Quarterly, 65*(1), 107-111.

Weiser, M. (1988). *Ubiquitous Computing*. Originally published at Xerox PARC. Retrieved December 2005, from http://www.ubiq.com/hypertext/weiser/UbiHome.html.

Weiser, M. (1991). The computer for the 21st century. *Scientific American, 265*(3), 66-75.

Weiser, M. (1993). Some computer science issues in ubiquitous computing. *Communications of the ACM, 36*(7), 75–85.

Weiser, M., & Brown, J. S. (1997). The coming age of calm technology. In P. J. Denning & R. M. Metcalfe (Eds.), *Beyond calculation: The next fifty years of computing*. New York: Copernicus.

Westin, A. (1967). *Privacy and Freedom*. New York: Atheneum.

Williams, R., & Edge, D. (1996). The Social Shaping of Technology. *Research Policy, 25*(6), 856-899.

Williams, F., Rice, R., & Rogers, E. (1988). *Research methods and the new media.* New York: Free Press.

Winner, L. (1977). *Autonomous technology: technics-out-of-control in political thought.* Cambridge, Mass.: MIT Press.

Winner, L. (1980). Do Artifacts Have Politics? *Daedalus, 109,* 121-136.

Winner, L. (1999). *The voluntary complexity movement*. NETFUTURE: Technology and Human Responsibility. Retrieved December 2006, from http://www. netfuture.org/ 1999/Sep1499_94.html.

Woolgar, S. (1991a). The turn to technology in social studies of science. *Science, Technology, & Human Values, 16*(1), 20-50.

Woolgar, S. (1991b). Configuring the user: the case of usability trails. In J. Law (Ed.), *A Sociology of Monsters* (pp. 57-103). London: Routledge.

Wright, D., Gutwirth, S., Friedewald, M., Vildjiounaite, E., & Punie, Y. (Eds.). (2008). *Safeguards in a world of Ambient Intelligence*. Berlin: Springer.

Wyche, S., Sengers, S., & Grinter, R. E. (2006). Historical analysis: Using the past to design the future. *Proceedings of Ubicomp 2006, LNCS 4206*, 35-51.

Yoshimi, S. (1999). 'Made in Japan': the cultural politics of 'home electrification' in postwar Japan. *Media, Culture & Society, 21*(2), 149-171.

Zhou, J., Yu, C., Riekki, J., & Kärkkäinen, E. (2007). AmE framework: a model for emotion-aware ambient intelligence. *Proceedings of the second International Conference on Affective Computing and Intelligent Interaction (ACII2007*), 163 - 169.

# Samenvatting (Summary in Dutch)

Technologische innovaties vormen een belangrijk onderdeel van moderne samenlevingen. In de afgelopen decennia hebben innovaties zoals het internet en de mobiele telefoon het dagelijkse leven van velen op verschillende manieren beïnvloed en steeds meer mensen maken gebruik van deze informatie- en communicatietechnologieën. Het internet en de mobiele telefoon zullen voorlopig een belangrijke rol blijven spelen in ons dagelijkse leven, maar nieuwe technologische innovaties, zoals ambient intelligence, zijn in de maak om ons dagelijkse leven te betreden.

Ambient intelligence kan omschreven worden als een technologische innovatie waarbij informatie- en communicatietechnologieën steeds meer verbonden zullen zijn in netwerken en waarvan de technologische infrastructuur verworven zal zijn in de fysieke omgevingen van mensen zodat deze onopvallend en overal en altijd aanwezig zal zijn (Weiser, 1991). Ambient intelligence toepassingen anticiperen op het gedrag van mensen die, zonder dat mensen expliciet hoeven aan te geven wat hun behoeften en wensen zijn op een bepaald moment, bepaalde taken van hen kunnen overnemen.

Hierdoor zouden de ervaringen die mensen hebben in verschillende omgevingen (zowel in publieke als privéomgevingen) aangenamer worden. Ambient intelligence is niet gebonden aan één specifieke, fysieke omgeving, maar zou in principe in alle omgevingen het dagelijkse leven van mensen kunnen beïnvloeden. De verwachting is dan ook dat deze technologische innovatie een belangrijke rol zal gaan spelen in het toekomstige, dagelijkse leven van velen. Ambient intelligence toepassingen zijn op dit moment nog niet wijd verspreid, maar bevinden zich voornamelijk nog in de ontwikkelingsfase. Voorlopers van ambient intelligence toepassingen (zoals de Ambilight TV; de kleuren die op het scherm van deze televisie verschijnen, worden ook op de muur geprojecteerd) bevinden zich al wel in de verspreidings- en adoptiefase.

In dit proefschrift staan zowel de ontwerpers als de potentiële gebruikers van ambient intelligence toepassingen centraal. De doelstelling van dit proefschrift is om inzicht te verkrijgen in de veronderstellingen van ontwerpers van ambient intelligence toepassingen en in het adoptieproces van potentiële gebruikers van ambient intelligence toepassingen. In het uitgevoerde onderzoek naar het ontwerp en de geanticipeerde adoptie van ambient intelligence toepassingen is de nadruk gelegd op toepassingen voor in huis.

Inzicht in de veronderstellingen die ontwerpers hebben ten opzichte van een technologische innovatie die zich nog in een vroeg stadium van ontwikkeling bevindt en in het adoptieproces door potentiële gebruikers, is noodzakelijk om een accuraat beeld te krijgen van de mogelijke gevolgen voor zowel individuen als de gehele maatschappij. Vanuit een wetenschappelijk perspectief is het van belang om beter inzicht te krijgen in het ontwikkelingsproces van technologische innovaties die zich nog in een vroeg ontwikkelingsstadium bevinden voordat deze zich op de markt gebracht worden en er nog geanticipeerd kan worden op het adoptieproces.

Ambient intelligence kenmerkt zich door een aantal technologische kenmerken, deze zijn: integratie van genetwerkte toepassingen in de fysieke omgeving, herkenning van de locatie en de situatie van gebruikers, personalisering door het aanpassen van toepassingen aan specifieke wensen van individuele gebruikers, en anticipatie op gebruikerswensen. De kenmerken adaptatie en anticipatie spelen in op de behoeften van gebruikers. Adaptatie houdt hier in dat ambient intelligence toepassingen patronen van gebruikers kunnen leren onderscheiden op basis van verzamelde en opgeslagen gegevens over de herhaalde handelingen van gebruikers. Daarnaast anticiperen ambient intelligence toepassingen op het gedrag van mensen. Toepassingen kunnen bijvoorbeeld bepaalde handelingen voor de gebruiker uitvoeren, zonder dat de gebruiker daar zelf expliciet om heeft gevraagd, waardoor mensen zelf minder hoeven aan te geven wat hun behoeften en wensen zijn.

De relatie tussen technologie en haar gebruik en adoptie wordt in verschillende wetenschappelijke disciplines onderzocht, zoals in de communicatiewetenschap, sociale en feministische studies van wetenschap en technologie, organisatie- en innovatiestudies en psychologie. Binnen deze verschillende disciplines vestigen sociaal constructivistische theorieën de aandacht op de wederzijdse relatie tussen gebruikers en technologie. Deze theorieën stellen dat betekenissen van technologieën niet in de technologie zelf zitten, maar gevormd worden door de interacties van o.a. ontwerpers, gebruikers, beleidsmakers en sociale groepen. Een centraal perspectief in sociaal constructivistische theorieën is het 'mutual shaping of technologies and users' perspectief: technologie en haar gebruikers beïnvloeden elkaar op diverse manieren. Het is gebaseerd op de assumptie dat technologieën zowel 'agents' van verandering zijn die hun gebruikscontext vormen en tegelijkertijd 'objecten van verandering' zijn die hervormd en herontworpen worden door ontwerpers en gebruikers.

Het 'mutual shaping of technology and users' perspectief kan beschouwd worden als een breed, algemeen perspectief op de relatie tussen technologie en gebruik, waarbij ook veel aandacht wordt geschonken aan het ontwikkelingsproces van technologische innovaties en de rol die verschillende groepen zoals producenten, sociale groepen en uiteindelijke gebruikers daarin spelen. Daarentegen houdt het ‘mutual shaping’ perspectief zich veel minder bezig met het empirisch toetsen van verklarende of voorspellende hypothesen met betrekking tot gebruik en adoptie van technologieën.

In disciplines zoals de communicatiewetenschap en psychologie wordt het meer specifieke ’diffusie en adoptie van technologie’ perspectief aangehangen. In dit perspectief wordt technologiegebruik en -adoptie meer benaderd als een lineair proces dat gaat van technologisch ontwerp naar adoptie en gebruik, in tegenstelling tot het ‘mutual shaping’ perspectief waar een dialectisch proces wordt verondersteld tussen ontwerp en herontwerp na gebruik en tussen verschillende actoren, zoals tussen ontwerpers en gebruikers van technologieën.

Gedragstheorieën en -modellen die technologiegebruik en –adoptie kunnen verklaren en voorspellen spelen in het ’diffusie en adoptie van technologie’ perspectief een belangrijke rol. Prominente voorbeelden hiervan zijn onder andere, de diffusie van innovatiestheorie (Rogers, 1995), ‘the technology acceptance model’ (TAM) (Davis, Bagozzi, & Warshaw, 1989; Davis, 1993) en ‘the unified theory of acceptance and use of technology’ (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003). In dit proefschrift vormen zowel het ‘mutual shaping of technologies and users’ perspectief als het 'diffusie en adoptie van technologie' perspectief de theoretische basis voor de empirische studies die zijn uitgevoerd.

In de eerste studie van dit promotieonderzoek, beschreven in hoofdstuk 5, is de centrale vraag hoe ambient intelligence gerepresenteerd wordt door producenten naar potentiële gebruikers. Om een antwoord te kunnen geven op deze vraag is gebruik gemaakt van een inhoudsanalyse. Promotiemateriaal (brochures en websites) van acht internationale producenten van ambient intelligence toepassingen voor in huis (Philips, Microsoft, MIT, LGE, HP, Living Tomorrow, IBM en Orange) is geanalyseerd. Zowel de tekst als de afbeeldingen van het promotiemateriaal zijn geanalyseerd om te achterhalen welke kenmerken en welke toepassingen gebruikt worden om ambient intelligence te representeren. In totaal zijn er 2400 zinnen en 202 afbeeldingen geanalyseerd.

Op basis van de verkregen resultaten werden kenmerken van ambient intelligence toepassingen geclusterd in drie groepen, namelijk ‘convenience’, ‘adaptation’ en ‘empowerment’. Adaptation was de grootste cluster en deze bestond voornamelijk uit technologische kenmerken van ambient intelligence. De cluster ‘empowerment’ bevat kenmerken die betrekking hebben op het verkrijgen van meer controle in het dagelijkse leven van mensen door het gebruik van ambient intelligence toepassingen. De derde cluster ‘convenience’ bestond uit kenmerken die benadrukken dat het dagelijkse leven gemakkelijker en comfortabeler zou kunnen zijn door het gebruik van ambient intelligence toepassingen voor in huis. De resultaten van de geanalyseerde afbeeldingen laten zien dat een groot scherm het vaakst voorkwam in het promotiemateriaal als een toepassing om ambient intelligence te representeren.

De ontwerpers van ambient intelligence toepassingen stonden centraal in de tweede studie van dit promotieonderzoek. Deze kwalitatieve studie wordt beschreven in hoofdstuk 6. Door middel van diepte-interviews met ontwerpers ($n = 27$) die ambient intelligence toepassingen voor in huis ontwikkelen, zijn de veronderstellingen die ontwerpers van ambient intelligence toepassingen hebben onderzocht. De geïnterviewde ontwerpers waren werkzaam bij vier technologiebedrijven namelijk: Philips (Nederland), Siemens (Duitsland), Nokia (Finland) en Intel (Verenigde Staten).

De resultaten illustreren dat ontwerpers van ambient intelligence toepassingen voor in huis zowel technische als sociale voordelen toeschrijven aan het gebruik van deze toepassingen. De technische voordelen zijn vooral de vermindering van het aantal 'dozen' in huis en de aanwezigheid van 'intelligente' toepassingen die met elkaar kunnen communiceren. Ontwerpers zien het gemakkelijker en comfortabeler maken van het dagelijkse leven van mensen als het belangrijkste sociale voordeel dat het gebruik van ambient intelligence toepassingen zou kunnen opleveren. Doordat het leven van mensen gemakkelijk zou moeten worden door het gebruik van ambient intelligence toepassingen, voorzien de ontwerpers dat mensen meer 'quality time' zullen hebben. Het potentiële verlies van privacy voor gebruikers en het vooruitzicht dat individuen waarschijnlijk minder controle zullen hebben over het maken van eigen beslissingen, omdat deze voor een deel door de toepassingen worden overgenomen, worden lang niet door alle ontwerpers onderkend. Daarnaast is het zo dat er tijdens het ontwerpproces over het algemeen relatief weinig aandacht geschonken wordt aan potentiële oplossingen om verlies van privacy en controle tegen te gaan door ze al in het ontwerp te integreren. Ontwerpers geven aan dat ze streven naar gebruiksvriendelijke toepassingen. Om potentieel privacy- en controleverlies te beperken is het vaak nodig om aan gebruikers extra input te vragen wanneer zij de toepassingen gaan gebruiken, zoals het ondernemen van extra stappen om bijvoorbeeld privacy- instellingen aan te passen of te veranderen. De ontwerpers geven aan dat het gebruik van ambient intelligence toepassingen hierdoor ingewikkelder zou kunnen worden. Daarnaast is het zo dat de ontwerpers ook aangeven dat gebruikers wellicht weinig aanstoot zullen nemen aan het potentiële privacy- en controleverlies als gevolg van het gebruiken van ambient intelligence toepassingen, zolang de toepassingen maar genoeg voordeel voor mensen opleveren.

Naast ontwerpers van ambient intelligence toepassingen staan ook potentiële gebruikers van deze toepassingen centraal in dit promotieonderzoek. In de derde studie, die wordt beschreven in hoofdstuk 7, staan de houdingen en intenties van potentiële gebruikers van ambient intelligence toepassingen centraal. Daarnaast is er in deze kwantitatieve studie ook onderzocht welke variabelen de intentie om ambient intelligence toepassingen te adopteren kunnen verklaren en voorspellen. Respondenten uit een bestaand landelijk panel ($N = 1539$) beheerd door een commercieel onderzoeks- en consultancybureau zijn via email uitgenodigd om deel te nemen aan een online survey. De steekproef ($n = 1221$) was deels representatief voor de Nederlandse bevolking. Respondenten jonger dan 25 jaar en respondenten ouder dan 65 jaar waren ondervertegenwoordigd en hogeropgeleiden waren oververtegenwoordigd in de steekproef.

De verkregen resultaten laten zien dat de houding van potentiële gebruikers ten opzichte van ambient intelligence toepassingen voor in huis varieerde van matig negatief tot matig positief en dat de intentie voor het adopteren van ambient intelligence toepassingen laag is. Om de intentie van de adoptie van ambient intelligence toepassingen te kunnen verklaren en te voorspellen is er een conceptueel model opgesteld waarin de volgende variabelen en hun onderlinge relaties zijn getoetst: waargenomen voordelen van ambient intelligence toepassingen voor in huis, waargenomen nadelen, houding ten opzichte van ambient intelligence toepassingen, uitkomstverwachtingen ten aanzien van ambient intelligence toepassingen en intentie om ambient intelligence toepassingen te adopteren. Uit de resultaten blijkt dat de houding van potentiële gebruikers en verwachtingen die mensen hebben ten aanzien van ambient intelligence toepassingen een belangrijke rol spelen in het verklaren en voorspellen van de intentie om ambient intelligence toepassingen te adopteren.

Samengevat geven de resultaten van het uitgevoerde onderzoek een goed inzicht in de confrontatie van het ontwerp en het geanticipeerde gebruik van ambient intelligence. Er is weinig bekend in de bestaande literatuur over de expliciete veronderstellingen die ontwerpers hebben ten opzichte van technologische innovaties en potentiële gebruikers hiervan. Dit onderzoek heeft getracht duidelijkheid te verschaffen over de veronderstellingen die ontwerpers van ambient intelligence toepassingen hebben ten opzichte van deze technologische innovatie en haar potentiële gebruikers en op welke wijze deze veronderstellingen het ontwerp van een technologische innovatie al in een vroeg stadium van ontwikkeling beïnvloeden.

Daarnaast blijken veronderstellingen die ontwerpers hebben, zoals de verwachting dat gebruikers potentieel privacy- en controleverlies grotendeels voor lief zullen nemen niet overeen te komen met de beoordeling van ambient intelligence toepassingen door hoe potentiële gebruikers op dit moment. De potentiële nadelen van ambient intelligence toepassingen blijken wel degelijk een rol te spelen in de houding van potentiële gebruikers ten opzichte van ambient intelligente toepassingen als men die op dit moment aan hen voorlegt in een survey; zij beïnvloeden namelijk de houding van potentiële gebruikers op een negatieve manier. Het uitgevoerde onderzoek heeft niet alleen recente inzichten bevestigd, zoals de rol die uitkomstverwachtingen spelen in het adoptieproces van een nieuwe technologische innovatie. Nieuwe inzichten zijn ook verkregen, in het bijzonder welke rol veronderstellingen van ontwerpers van technologische innovaties spelen in het ontwerpproces van een technologische innovatie en hoe deze het uiteindelijke ontwerp beïnvloeden.

In dit proefschrift is de nadruk gelegd op ambient intelligence toepassingen voor in huis. Ambient intelligence is evenwel een nieuwe technologische innovatie die elk aspect van ons toekomstige dagelijkse leven zou kunnen beïnvloeden, zowel binnenshuis als buitenshuis. Voor sociale wetenschappers is het belangrijk om in een vroeg stadium van ontwikkeling van nieuwe technologische innovaties in ieder geval te anticiperen op deze toekomst, omdat de veronderstellingen van ontwerpers en percepties van gebruikers een belangrijke rol zullen blijven spelen in de acceptactie en adoptie van technologische innovaties in diverse omgevingen, nu en in de toekomst.

# Dankwoord

Er zijn van die kinderen die van kleinsaf aan al weten wat ze willen worden: politieagent, zuster of profvoetballer. Toen er na de middelbare school een keuze gemaakt moest gaan worden welke vervolgopleiding ik zou gaan volgen, benijdde ik mijn klasgenoten die direct wisten wat ze gingen kiezen. Ik daarentegen had geen flauw idee wat ik later wilde worden. Maar nu, na een aantal jaren gewerkt te hebben aan dit proefschrift, denk ik dat ik steeds beter weet welke kant ik op wil gaan. Niet alleen het promotietraject is mij goed bevallen, ook de mensen die ik daardoor heb leren kennen in de afgelopen jaren hebben een belangrijke rol gespeeld in de leerzame en leuke tijd die ik heb gehad. Er staat maar één naam op de voorkant van dit proefschrift, maar daar hadden makkelijk een aantal meer namen bij gekund, aangezien het schrijven van zo'n proefschrift niet iets is wat je alleen doet. Daarom wil ik graag iedereen bedanken die me op de een of andere manier heeft geholpen met dit proefschrift. Een aantal van hen zou ik graag in het bijzonder willen noemen.

Mijn promotor, Jan van Dijk, wil ik graag bedanken voor zijn vertrouwen en vrijheid die ik in de afgelopen jaren heb mogen ontvangen. Jan, al vanaf de eerste dag heb je mij vrij gelaten in de wereld die wetenschap heet. Nadat ik had besloten dat de vier oorspronkelijke onderwerpen die er lagen niet helemaal mijn 'ding' waren en ik mijn eigen onderwerp mocht kiezen, bleek dat je voldoende vertrouwen in me had om het aan te durven. Ik denk dat er maar weinig promotoren zijn die hun promovendi zo vrij laten gedurende het hele promotietraject, mijn dank daarvoor.

Mijn assistent-promotor, Oscar Peters, wil ik graag bedanken voor zijn dagelijkse steun in de afgelopen jaren. Het doen van onderzoek is mij erg bevallen, mede omdat jij in de eerste maand al vroeg of ik niet mee wilde doen met het BlackBerry-onderzoek waardoor ik meteen aan de slag kon. Oscar, erg bedankt voor alle steun in de afgelopen jaren en natuurlijk voor alle statische hulp. Door jouw enthousiasme voor getallen en modellen ben ik statistiek zelfs leuk gaan vinden.

Onderzoek is op zijn tijd behoorlijk solistisch werk, maar dankzij alle collega's van de afdeling Toegepaste Communicatiewetenschap was het vaak een gezellige boel, daarvoor mijn dank. In het bijzonder wil ik graag een aantal collega's bedanken die een grote steun zijn geweest in verschillende fasen van het promotietraject. Egbert, jou wil ik graag bedanken voor alle motiverende woorden op diverse terreinen gedurende de afgelopen jaren.

Karen, met jou heb ik veel gelachen gedurende dit promotieonderzoek en natuurlijk tijdens onze reis in San Diego. Heel erg bedankt voor de gezellige tijd.

Er wordt weleens gezegd dat de laatste loodjes het zwaarst zijn, en in mijn geval was dat ook zo. Maar dankzij jouw steun, Yvette, kon ik er weer helemaal tegenaan, bedankt daarvoor.

Lynn, jou wil ik graag bedanken voor het corrigeren van mijn 'Dutchy sentences'. Super dat je het in zo'n korte tijd hebt willen doen. En Erika, jou wil ik graag bedanken dat je de omslag van dit proefschrift hebt willen maken.

TDC Enschede, jullie wil ik heel graag bedanken voor alle uitstapjes, etentjes, sauna's, etc., waardoor het proefschrift weer even van de voorgrond verdween. Het onderwerp 'proefschrift' kan nu dan ook van de lijst worden geschrapt en plaats maken voor nieuwe onderwerpen die ongetwijfeld besproken zullen worden.

ابي و امي شكرا على ما بد لتموه ولا زلتم.

En natuurlijk, wil ik jullie, lieve broers en zussen, ook bedanken voor de altijd zeer gezellige weekenden waar de één vaak nog grappiger is dan de ander en waar ik de meest ontnuchterende uitspraken heb gehoord met betrekking tot het proefschrift. Dank daarvoor!

Lieve, lieve, Mohammed, jou ben ik erg dankbaar, omdat je elke oceaan met mij durft over te steken zonder daarover na te hoeven denken.