Designing an Interactive Messaging and Reminder Display for Elderly

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Abstract. Despite the wealth of information and communication technology in society today, there appears to be a lack of acceptable information services for the growing elderly population in need of care. Acceptability is not only related to human factors such as button size and legibility, but rather relates to perceived value and harmony in relation to existing living patterns. This paper describes the design of an asynchronous interactive communication system based upon a bulletin board metaphor. A panel of end-users was involved in various stages of the design process. To improve ease of use, functionality exposed to elderly users is limited, while caregivers are given extended control. A pilot field study with a working prototype showed a high degree of user acceptance. The user centered approach resulted in a design concept that was acceptable for the elderly participants.

Keywords: Product design, asynchronous communication, interactive message display, elderly users, acceptability

1 Introduction

In most industrialized countries, the number of elderly people is steadily growing. According to EuroStat, for every 100 EU citizens between 15 and 64 years old in 2005, there were 24.7 persons aged 65 and older. The old-age dependency ratio is expected to increase to 39.8 by 2030[1]. Many elderly people indicate they prefer to live independently in their own homes as long as possible, which was confirmed in interview sessions held by the researchers involved in this study. In many cases, however, support is needed to continue their everyday living routines. Whereas support is nowadays typically given by both formal and informal caregivers, support could also be given by technology. This assistive technology is expected to play an increasingly important role in the coming years.

Various kinds of technological solutions can already be deployed to support elderly, in which communication has been recognized as a central theme [6, 17, 19, 21, 23]. Existing communication means available to elderly include traditional telephones, mobile phones, and video communication. In recent years, services have

[1] http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsdde511

been developed for monitoring behavior and for providing automated feedback to users, e.g., giving medicine reminders. Even though these solutions might eventually contribute to the quality of life of elderly clients, elderly users still seem to have a hard time using modern technology.

Low acceptability of new technology might be partially caused by usability problems. Most ICT-based products require a basic understanding of computer applications, whereas many elderly have little experience with this type of systems. The very fact that functionality is hidden in menus and layers, for example, can be hard to grasp for elderly users. Furthermore, devices such as mobile phones require fine motor skills, whereas these abilities tend to be limited for elderly users. Such usability issues form a practical barrier towards acceptance by the elderly target group.

Apart from usability issues, other reasons can be found for elderly users having difficulties adopting new technology. For example, it can be difficult to change existing living patterns, thereby making it hard to introduce new procedures and products. Even though the added value of new technology appears to be obvious to the caregivers, elderly users tend to be skeptical and hesitant. Product designers therefore face the challenge of creating products that support the elderly user that make use of the possibilities offered by new technology, while maintaining appropriate acceptability levels.

2 Related Work

The design of assistive technology to support elderly users in living independently has been studied before. In the next section, existing work in the area of acceptability, cognition, perceived control, implementation and design in relation to designing assistive technology will be described.

2.1 Acceptability

Most existing projects in the area of assistive living share a common goal in terms of increasing the independence of elderly people [1, 4, 15, 19]. Supposedly, an increase in independence results in a decrease in professional care per client, which in turn would result in a cost reduction. From an economic perspective, the need for technological solutions seems obvious.

A major obstacle towards deployment of assistive living technology, however, appears to be acceptability [10, 15, 23, 25]. As will be discussed in the following paragraphs, existing studies revealed multiple issues that were found to be crucial towards creating acceptability.

Acceptability is a subjective construct that varies between users and in time. For example, personal circumstances, such as education and income, could influence the attitude towards new technology [10]. Absolute age, on the other hand, is expected to be of minor relevance.

Acceptability has also been found to be related to perceived benefit [23]. Supposedly, when elderly users experience little added value, acceptability is low.

When new products would better link to everyday problems, the perceived benefit is expected to be higher, and consequently acceptability is expected to improve. Guiliani et al. [10] studied the attitude of elderly towards technology, and found that technological innovations are likely to be accepted when the practical benefits are clear. Similarly, Czaja and Lee [6] studied the use of e-mail amongst elderly women, and concluded that perceived usefulness was an important factor with respect to usage.

Next to perceived benefit, reliability has been found to be important by McCreadie and Sanchez et al. [15, 22]. In a study on the acceptability of assistive technology, 67 people aged over 70 were interviewed. No participants were found to be technophobic. However, reliability of technology was judged to be an important condition for product adoption. In line with the studies above, elderly were found to be willing to use assistive technology, despite opposite expectations, if only the system would address their needs correctly.

Finally, to increase acceptability, technology might also have to be pleasurable in use. Interview data collected by Selwyn [23] showed that elderly are less involved in the pleasures of ICT than younger users, which makes it hard to fit ICT solutions into their everyday lives.

2.2 Cognitive Aspects

Several cognitive issues might underlie the control problems that elderly users encounter when using new technology. For example, the ability to learn new skills relies on fluid intelligence, which is the capacity to associate, independent of previous specific practice or instructions [9]. Since the capacity to learn new skills to operate technology decreases when people get older, elderly people can have difficulty using new products [6]. Furthermore, the spatial memory capacity of elderly users tends to be reduced. It is therefore suggested that designers should aim to reduce demand on the spatial memory resources of elderly [6, 11]; this could be achieved by using simple and flat interface structures. Thirdly, elderly users were found to be sensible for failures and inconsistencies; young users tend to be less affected by usability problems than elderly users [6, 11, 22]. The learning process should be simple. Inconsistencies in the interface may slow down the learning process, especially for elderly users, and should therefore be avoided.

2.3 Interaction Issues

Whereas humans are capable of interpreting contextual information and providing feedback, computer based systems tend to offer limited data, often lacking desired qualitative information. Combining human input with raw data collected by sensors, is a complex issue [3]. In the CareNet study of Consolvo et al., the suggestion to enrich data with background information (adding a “human touch”) made potential users anxious, because they were suspicious of being given extra responsibility. Implementation of ‘common sense’, which appeals most to the perception of inexperienced users, into autonomous products is still complex [8].

When designing pro-active systems, controllability could be a challenge. Even though people tend to accept a large degree of system autonomy [2], the sense of being in control has great value to elderly users [3]. Perceived control is, amongst others, related to the predictability of a product behavior.

2.4 Role of Designer

The difficulties elderly experience accessing modern technology could partly be caused by the fact that product designers are not aware of the special characteristics of the target group, or do not know how to implement the needs of elderly in the design process [6]. Sanchez et al. introduced the expression 'imperfect automation', which represents the design of 'perfect' products, not performing according to the criterion of the task, and, consequently, not satisfying its users [22]. Elderly users form a user group with special needs and desires, which need to be addressed by designers.

Research by Irizarry on promoting the use of modern technology and Internet access for Australian people over 55 indicated that elderly preferred to use technologies that are recognizable in everyday use [12], which could be a motivation to use existing interaction principles. However, recent ambitions to provide elderly with ICT technology are often based on the assumption that ICT is useful and desirable for everyone, while in reality, seniors are often not served by these technologies [23]. When designing assistive technology for elderly users, designers should consider the specific needs of the target group in terms of, for example, understandability, controllability and perceived benefit, in order to create acceptable products.

2.5 Social Network

Interaction with modern ICT solutions could be stimulated by members of the social network of an elderly person. Involvement in a social network is also beneficial in terms of well-being [17]. In a user and concept study on the acceptability of mobile communication services for elderly, future services where perceived as beneficial when social relationships were maintained, as well as health and the ability to live at home. Besides this benefit, engagement and connectedness could have "powerful health benefits" [5, 18], which is another motivation to stimulate social commitment.

Several applications of communication services for elderly have been studied. An example of a communication device involving distant relatives can be found in the study of Mynatt et al., in which a Digital Family Portrait was tested in household environments [19]. This picture frame, which is an augmented domestic object, provides back-story information about geographically distant people. They found that the target group of elderly users demands the complexity to be restricted. The study results also emphasize the importance of supporting ageing adults, in terms of peace of mind for all members of the care network.

2.6 Medicine Reminders

An interesting application of assistive technology is providing care clients with medicine reminders [7, 14]. Reminders could be dynamically linked to user activities, which can be monitored using various sensors. An example is the iCabiNet [14], which is designed to select the most appropriate communication device for each reminder. Whereas iCabiNet creates a flexible mechanism for reaching users, the system has so far only been tested using a mobile phone.

2.7 User Experiences

User experiences with interactive technology are often studied inartificial settings [13, 14]. User experiences in a home situation can be quite different [24]. If target group users participate in user studies in a lab setting, they are often requested to reproduce every-day activities, which is hardly realistic. Bringing the prototype to the user is likely to initiate more natural behavior, which contributes to the validity of the findings.

2.8 Project Goal

Even though new technologies might support elderly in their everyday lives, acceptability of existing systems tends to be low. The goal of the present case study is to find out how existing technology can be made accessible to elderly users in an acceptable way. In the case study, the focus is on the design of an interactive product that enables communication between elderly people and their care network, which can be applied to present medicine reminders as well.

3 Design Steps

3.1 Field Exploration

To get insight in the application domain and user needs, technology suppliers, potential users and caregivers were interviewed. Ten experts in hard- and software for technological care solutions, promoting their products on a Care&ICT fair, were asked about the problems and challenges in their domain. They indicated that many companies are guided by the availability of modern technology in developing their products. Involvement of elderly end users in the design process tends to be very limited; requirements are generally set by care companies. In the near future, the main focus seems to be on developing integrated support systems, rather than developing new products for each single need. However, the vast number of “standard” communication protocols slows down the development of integrated support systems.

To explore how new technology can be implemented in the life of elderly care clients in an acceptable way, a care giver was observed in her morning round, and the target sample group (n=5) was interviewed. The informal interviews were held with elderly care clients living at home or in a protected housing environment. In terms of user needs, all elderly participants indicated a desire to remain living independently as long as possible. This desire is complicated by the understanding that they are starting to, or may soon start degenerating mentally and physically. The interviewees also complained about people in their surroundings who slowly but surely change their attitude towards them. Relatives and friends tend to visit the elderly less frequently, which leads to an increase in loneliness. Loneliness could contribute to the mental degeneration of elderly individuals. Having influence on their social environment and being involved in every-day activities was preferred over being a passive client of care.

The interviewed care clients stated that being confronted with inevitable degeneration creates a despondent feeling, in spite of the fact that one has much time to prepare for this. The elderly complained that many available care solutions stress their weaknesses, because usage is similar to admitting one's degeneration. This is alleged to be a difficult psychological coping process, which is hard to imagine for younger adults. The interviews showed that elderly prefer to use products that do not directly confirm their limitations and carry a negative connotation for them. New support technology could thus best be based on familiar interaction principles, preventing stigmatization.

During the field exploration, care clients as well as caregivers underlined an unwanted development in the care context. Due to efficiency improvements, there is less time available for social interaction between caregivers and clients; this consequence is supported by neither caregivers nor clients.

In general, the elderly expressed their appreciation for contact with family members and friends, as well as caregivers. Elderly enjoyed the interaction, and the attention made them feel safe and respected. The effort of the other party to establish contact is highly appreciated. Communication features can contribute to the acceptability of new devices, since elderly seem willing to communicate.

An interesting example of modern ICT in the context of elderly users is the mobile phone. A large part of the elderly participants recognize the added value of being reachable, and having the possibility to call someone in case of emergency. However, few actually use the mobile phone. One older individual, who owns a mobile phone and recognizes its advantages, did not know how to use the device. This attitude towards modern technology is representative for the acceptability problems that need to be challenged.

3.2 Concept Development

In the interviews, the elderly participants indicated their dislike of 'modern' interaction metaphors, such as Windows-like layout details. These are tempting to be exploited by a younger group, but would almost certainly not appeal to elder users. Even worse, they tend to be scared off by the complexity of new products, even though the benefit of these products is recognized. In designing new products for

elderly, one should therefore conceive interaction principles that are already familiar to the target group. The interaction should have an intuitive character, which needs only short introduction.

3.2.1 The Interaction Metaphor

To provide the elderly users with communication possibilities, an asynchronous messaging product is being developed. Since product designs based on familiar metaphors are expected to lower the threshold to start using new technology, an appropriate metaphor had to be found to present information, specifically for in a domestic environment. First, a photo frame metaphor was considered (similar to the Digital Family Portrait of Mynatt et al.), since the interviewed elderly had many pictures of relatives and friends in their homes. Although each frame could symbolize contact with the person in the picture, the mental step required to perceive it as an interactive device was expected to be too abstract. As a second step, a bulletin board metaphor was considered. A bulletin board is a central place for physical notes and reminders, which are somehow interesting for passers-by (figure 1). A bulletin board display could easily be linked to context-aware technology and does not stress the technical nature of context-aware systems.

Fig. 1. The interactive bulletin board resembles a traditional bulletin board.

3.2.2 Functionalities

The usability of a bulletin board with (too) many functions would probably be low. In designing the product functionality, complexity and usability need to be balanced.

In developing the electronic bulletin board, the affordances [20] of a traditional bulletin board were mapped to functions of the interactive bulletin board. Affordances can be described as a product's properties defining how it could possibly be used, to a reasonable extent. Table 1 shows the affordances of a bulletin board. Re-arranging items and pinning/removing thumbtacks have not been mapped to the interactive bulletin board, in order to improve the ease-of-use of the system.

Table 1. Affordances of a bulletin board

Affordances	Traditional Bulletin Board	Electronic Bulletin Board
Read	√	√
Pin (=add) items	√	√
Remove items	√	√
Re-arrange items	√	-
Pin/remove thumbtacks	√	-

To create an interactive bulletin board, an LCD monitor could be linked to a keyboard and a mouse. However, these modern devices could nullify the perception of the bulletin board metaphor. Therefore, a touch screen was used as the interaction medium to make sure users have to touch the items on the bulletin board physically (figure 2). A webcam is used for adding messages to the bulletin board. The snapshots from the webcam automatically appear on the board as new items. Electronic items can be stored by sending it to a printer; items can not be stored electronically, since this would unnecessarily increase the system's complexity. Figure 3 shows the options that are displayed when an item is selected by the user.

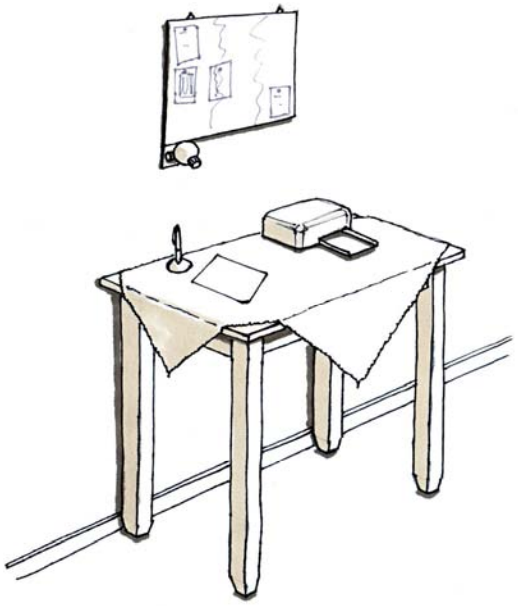

Fig. 2. The basic components of the electronic bulletin board, all controlled by a personal computer.

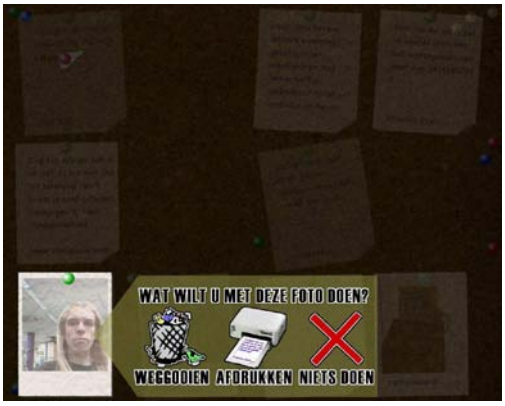

Fig. 3. The context menu enables the user to delete and print items. The last option is hiding this menu.

Fig. 4. The web site enables family and friends to inspect the bulletin board (bottom half), and to add messages and pictures (top half).

3.2.3 Development of the Prototype

The monitor, webcam and printer have a distinct modern and technologic appearance, which could have a negative impact on the user. A secretaire, selected for its traditional appearance, was used to shield the technical parts. The main interaction device of the prototype, the touch screen, was placed on top of the secretaire (figure 5). The webcam, the printer and speakers, were visible to the user. A laptop, adapters, (extension) leads and hubs were hidden behind the doors of the secretaire. The visible side of the secretaire was free of redundant wiring and other electronic connections.

The software runs on the laptop, and all data is centrally stored on a web server; communication with the bulletin board is via the Internet.

To keep the elderly user socially involved in the everyday lives of others, connectivity to the Internet offers possibilities. To realize social contact, family and friends, as well as caregivers, can consult and adjust the contents of the bulletin board by using a website (figure 4).

Compared to the bulletin board, located in the homes of the elderly user, the web site offers more complex functionalities. The system offers the possibility to enter and display reminders, of which the presentation can be adapted to the urgency of the reminders.

Fig. 5. The final prototype. New messages could be added using a webcam (with the yellow button). Messages could be printed using a printer.

4 PILOT STUDY

4.1 Services

To create a 'live' prototype, two realistic messaging services have been linked to the bulletin board. The first service enables family and friends to add messages using the Internet. Since the elderly interviewees enjoyed displaying personal knickknacks of relatives and friends around the house, reminding them of valuable people and experiences, photographs could be added to the messages as well.

Secondly, a context-aware reminder service is linked to the prototype. Reminders are automatically generated whenever the user forgets to take medication, in reference to a predefined medicine schedule. A micro-switch sensor was linked to the medicine-box in order to monitor the intake of medication. Each reminder gradually asks for more attention, until the user touches the reminder of the bulletin board, or medication is taken. Eventually, an alarm message could be sent to a caregiver. This alarm-function has not been implemented in the prototype.

4.2 Goal and procedure

A small-scale pilot study was conducted to collect user experiences with the prototype in a realistic setting. Given the time constraints on the project, the study was limited to two participants.

Participants for the pilot study were selected on the basis of being older adults, living at home, receiving professional care, and taking medication on a regular basis. Two subjects were recruited (76 and 84 years of age). The first subject had to take medication twice a day, and was slightly forgetful. The second subject had to take eye-drops twice a day. Both participants were asked to indicate which person they were most involved with. The first participant selected her daughter as the most important person in her daily life. The domestic helper was chosen as the most important helper for the second participant. These persons were involved in the test.

Before starting the field test, the prototype and procedure were demonstrated in the homes of the participants. The participants were shown how to add, print and remove items. During the test, interaction with the bulletin board was monitored through an online log-file. In the course of the field test, the supervisor contacted the participants every other day to check if everything was in order. After the test, an evaluation interview was held, in which the experiences of the elderly users and their problems concerning usability and perception were discussed.

In both tests (which lasted for four and seven days, respectively), the bulletin board was placed on a central position in the living room. When awake, both subjects spent most time of the day in the living room, and thus in viewing distance of the bulletin board.

5 RESULTS & DISCUSSION

Both participants perceived the usability of the prototype as being clear and uncomplicated, which made their general opinion positive. The participants understood the applied metaphor; they literally indicated to be using a bulletin board, and did not label the prototype with a technology-oriented name.

5.1 The metaphor

The affordances of a traditional bulletin board that were mapped to the interactive bulletin board were easily accepted; the participants understood its functions without explanation. An example of adopting an original affordance can be given by explaining an automatic action of the second subject. To select an item, he touched the thumbtack rather than the message. Physical interaction with notes on a bulletin board starts by pulling out the thumbtack, which could be an origin of this behavior. This shows that the affordances of a traditional bulletin board create certain expectations. This link between physical and virtual interaction has added value for the elderly user, since it relies less on their fluid intelligence.

During the second test, a pop-up window appeared for a software update. The test subject chose to add a question about this event to the bulletin board, in which he claimed that the pop-up window was just another item on his bulletin board. The subject was found to be completely unacquainted with the concept of Windows-based computer interfaces. In this case, the bulletin board metaphor was fully accepted.

5.2 User Expectations

A general hesitation towards technology was found to be a recurring theme throughout the study. During the introduction of the study, both subjects stressed their fear of technology repeatedly. Afterwards, both participants claimed that this attitude had not changed. However, they both had to admit that their hesitation towards the bulletin board in particular was low. At this moment, it is difficult to grasp what influenced their hesitation most.

5.3 Perceived Control

The test subjects were offered continuous control over the content of the bulletin board. However, lack of control was displayed during the first night of the first test. A medicine reminder was displayed in combination with a subtle sound, but the test subject did not dare to stop the reminder, being afraid that something might break. Consequently, the bulletin board continued playing the sound. The test subject complained about this to her neighbor and daughter, who simply stressed that touching the relevant item would solve the problem. In this situation, absence of interaction with the user interface resulted in lack of user control.

The feeling of being in control was found to be related to how smooth an interaction was experienced. Just before the end of the second study, a server-side problem caused the bulletin board to stop functioning. The screen got a static appearance and all functionality was lost. The failure made the participant doubt his own skills to control the bulletin board, while it was totally due to external parties.

5.4 Usability

A touch screen was used for display and manipulation of the items on the bulletin board. Barriers for actually touching the screen were found to be anxiety and forgetfulness. Although both subjects had not used a touch screen before (even though the second subject knew the term), this interaction skill was easily mastered. Moreover, the participants indicated that the bulletin board offered sufficient usability clues (figure 6), which improved their skillfulness with the prototype in general. The test showed that even a trial-and-error process led to desired results, since the first subject tended to forget the instructions.

Fig. 6. A participant using the prototype.

6.5 Social Network

The role of friends and family was found to be decisive when looking at the hesitant attitude towards technology of the elderly subjects. The personal items provided by members of the social network and the subsequent enthusiasm were found to be a catalyst for using the prototype.

Finding suitable participants for this study appeared to be difficult. Several potential test subjects eventually decided not to participate, since they were scared of new technology. The communication between the elderly participants and their social

network gave problems grasping each other's frame of reference. Caregivers, family and friends often assigned computer characteristics to the prototype, in the presence of the elderly user. These subconscious contributions might have caused confusion. In introducing the prototype to potential participants, it therefore seems important to use plain language.

5.6 Test Setting

An event during the second night of the first study illustrated the unpredictable nature of a realistic environment. In the belief that the subject's wishes were met, the neighbor of the elderly user dropped by to put off the bulletin board. The neighbor did not realize that she was not able to turn the bulletin board on again (it was expected to be impossible to turn it off as well), as she had planned to do the next day. The neighbor applied her basic computer knowledge to reason how the prototype should function. This event is a clear example of the structural difference between a lab environment and the field; it would probably not have happened in a lab.

5.7 Design Process

Based on the results of the pilot study, one might conclude that designers should get to know the reference framework of the target group, by exploring the user's earlier experience, in order to design acceptable solutions. Even though a wide range of technologic possibilities are available, and tempting for designers to implement in the context of elderly users, the early involvement of elderly care clients catalyzed a process in which modern technology was cut down to a basic and accessible concept, while at the same time avoiding stigmatization.

6 Conclusions and Future Work

This pilot study shows that new technology can be presented to elderly individuals in an accessible manner, by understanding the context of use, user needs and experiences, and by leveraging existing interaction metaphors.

The technology used in current ICT applications might well be used for applications for elderly users. When these applications are designed without considering the user group appropriately, acceptability problems might occur. These acceptability problems are partly caused by poorly chosen interaction principles of applications for the elderly. Familiar interaction principles can contribute to usability.

The case study showed that by involving the target group early in the design process, the interaction principles applied could be better linked to user needs. As a result, the complexity of the prototype could be limited to a basic level, thereby improving the usability. Where 'upgrading' products seems to be the tendency for modern electronic devices, in terms of user needs and system functionality, 'downgrading' would be more appropriate designing products for elderly users.

The bulletin board might be a future solution to allow elderly to live independently at home longer. It is explicitly not designed to replace personal contact, but rather to encourage social involvement of elderly users.

The question remains how far designers should go in providing the oldest old with new technology, considering the fact that coming generations of elderly users may be more capable of handling computers. However, problems related to reduced fine motor skills and limited cognitive resources shall always be an issue. For the current elderly, designers should be looking for solutions that fit the experience and perception of this group of users.

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References

1. Arcelus A, Jones MH, Goubran F, Knoefel F – Integration of Smart Home Technologies in a Health Monitoring System for the Elderly – AINAW 2007, pp 820-825
2. Barkhuus L, Dey A – Is Context-Aware Computing Taking Control Away from the User? Three Levels of Interactivity Examined – Ubicomp 2003, pp 150-156
3. Consolvo S, Roessler P, Shelton BE – The CareNet Display, Lessons Learned from an In Home Evaluation of an Ambient Display – UbiComp 2004, pp 1-17
4. Consolvo S, Roessler P, Shelton BE, LaMarca A, Schilit B – Technology for Care Networks of Elderly – Pervasive Computing April-June 2004, pp 22-29
5. Coughlin JF – Technology and the Future of Aging – Technologies for Successful Aging, Journal of Rehabilitation Research and Development Vol. 28, No. 1, pp 40-42 – 2001
6. Czaja SJ, Lee CC – The Impact of Aging on Access to Technology – Universal Access in the Information Society Vol. 5 2007, pp 341-349
7. Dey AK, Abowd GD – Cybreminder: A Context-Aware System for supporting Reminders – Proceedings of the 2nd International Symposium on Handheld and Ubiquitous Computing 2000, pp 172-18
8. Erickson T – Some Problems with the Notion of Context-Aware Computing – Technical Opinion, Communication of the ACM, Vol. 45 No. 2 - 2002
9. Gray P – Psychology – 4th edition 2002
10. Guilliani V, Scopeletti M, Fornara F – Elderly People at Home: Technological Help in Everyday Activities – IEEE, International Workshop on Robots and Human Interactive Communication – 2005
11. IJsselsteijn W, Nap HH, de Kort, Y, Poels K – Digital Game Design for Elderly Users – Social and Behavioral Sciences – 2007
12. Irizarry C, Downing A, West D – Promoting Modern Technology and Internet Access for Under-Represented Older Populations - Journal of Technology in Human Services Vol.19(4) 2002, pp 13-30
13. Kaushik P, Intlle SS, Larson K – Observations From a Case Study on User Adaptive Reminders for Medication Adherence – Pervasive Health 2008
14. López-Nores M, Pazos-Arias JJ, García Duque J, Blanco-Fernández – Monitoring Medicine Intake in the Networked Home: The iCabiNET Solution – Pervasive Health 2008

15. McCreadie C, Tinker A – The Acceptabiliy of Assistive Technology to Older People – Aging & Society Vol. 25 2005, pp 91-110
16. Meyer S, Schulze E – Smart Homes and the Aging User, Trends and Analyses of Consumer Behavior – Berlin Institute for Social Research, presentation on Symposium 'Domotics and Networking', Miami – 2006
17. Mikkonen M, Väyrynen S, Ikonnen V, Heikkilä O - User and Concept Studies as Tools in Developing Mobile Communications Services for the Elderly - Personal and Ubiquitous Computing, 2002
18. Morris M, Lundell J, Dishman E, Needham B – New Perspectives on Ubiquitous Computing from Ethnographic Study of Elders with Cognitive Decline – UbiComp 2003, pp 227-242
19. Mynatt ED, Rowan, J, Jacobs A, Craighill S – Digital Family Portraits: Supporting Peace of Mind for Extended Family Members – SIGCHI 2001 Vol. 3, Issue No. 1, pp 333-340
20. Norman D – The Design of Everyday Things – The MIT Press, 1988
21. Romero N, Markopoulos P, van Baren J, de Ruyter B, IJsselsteijn W, Farshchian B – Connecting the Family with Awareness Systems – Personal Ubiquitous Computing 2007 Vol. 11, pp 299-312
22. Sanchez J, Calcaterra G, Tran QT - Automation in the Home: the Development of an Appropriate System
23. Selwyn N – The Information Aged: A Qualitative Study of Older Adults' Use of Information and Communications Technology – Journal of Aging Studies Vol. 18, pp 369-384 – 2004
24. Tolmie P, Pycock J, Diggins T, MacLean A, Karsenty A – Unremarkable Computing – CHI 2002, april 20-25
25. Vastenburg MH, Visser T, Vermaas M, Keyson D – Designing acceptable assisted living services for elderly users – European Conference on Ambient Intelligence, Nuremberg, Germany – 2008