Medical Monitoring for Independent Living: User-Centered Design of Smart Home Technologies for Older Adults

O.A. Blanson Henkemans[1,3], K.E Caine[2], W.A Rogers[2], A.D. Fisk[2], M.A. Neerincx[1,3], Boris de Ruyter[4]

[1]Delft University of Technology, NL; [2]Georgia Institute of Technology, US, [3]TNO, NL, [4]Philips Research, NL
o.a.blansonhenkemans@tudelft.nl

Abstract: **Formally involving users in the design of eHealth solutions can be beneficial. However, within the eHealth domain, the design process is often technology driven. In contrast, we present the need for and benefits of a user-centered approach to technology development. In addition, we argue that smart home environments, such as Georgia Tech's Aware Home, Philips' Home & CareLab and TNO/DUT's Experience Labs, facilitate this approach. In this article, we describe two studies that were recently conducted in the Aware Home to examine monitoring in a home environment. One project involved a formative evaluation of the perceived needs and perceived benefits of using visual sensing systems within the homes of older adults. The other involved the usability evaluation of a computer assistant for the supervision of older diabetics' self-care. Both evaluations suggested that older adults recognized the potential benefits of having these types of monitoring technologies in home environment.**

Introduction

Many Information and Communication Technology (ICT) solutions in the form of eHealth technologies are developed to support older adults in maintaining independence [1]. These technologies have the potential to help older adults perform activities required to live independently or, when unassisted independent living is no longer possible, to assist care takers in providing care at a distance. Because older adults are a segment of the population increasingly interested in using computers [2], and because of their unique health needs, the implementation of eHealth technologies to support older adults seems a logical and useful plan that should be pursued.

However, there has not been widespread deployment of eHealth solutions among older adults. One of the main reasons for the delay in adoption is the lack of the acknowledgement of the projected users and their personal and

cognitive requirements [3]. If designers of eHealth technology apply a predominantly innovation driven approach without the appropriate regard for usability, these technologies are less likely to be adopted. User-driven design and user evaluation during the development of new eHealth technologies is critical for successful adoption of such technologies [4] and thus critical for the adoption of eHealth solutions among older adults.

Those interested in designing user-centered eHealth solutions for older adults may question how best to study technologies, which are designed to be used at home, in a lab environment. We propose the use of smart home laboratories as an alternative to a traditional laboratory approach. A smart home laboratory facilitates testing prototypes by offering a comfortable domestic atmosphere and encourages natural behavior in an experimental setting. A research initiative that fulfills this description is Georgia Tech's Aware Home (www.awarehome.gatach.edu). Other examples of smart home laboratory environments are the Philips' Home&CareLab (www.research.philips.com/technologies/misc/homelab), and TNO/Delft University of Technology's (DUT) Experience Labs (http://www.usabilitytesting.nl).

Smart Home Laboratories

Georgia Tech's Aware Home, was built in 1998, is approximately 5000 square feet, and has two identical floors. It contains the functional and design requirements of a normal home, as well as additional sensing and display capabilities to support ubiquitous computing interventions for residents of the house. The Aware Home has a number of advantages over other laboratory environments, including contextualizing technologies under study. Because activities and goals within the home environment differ from those in office environments, traditional usability testing laboratories (which are often designed to look like offices) may be inappropriate [5]. One key difference is that in the home environment a person is free to choose how space and time are structured, what activities are undertaken, and who is involved [6]. This environment can facilitate understanding of older adults as a whole person including sensory, motor, and cognitive capabilities and the interactions of age related changes in these areas; in a broad context of a larger social unit, and in relation to their physical environment [7].

Studying older adults' perception of Georgia Tech's Aware Home reveals opinions, considerations, and ideas about introducing newly developing technology in the home as it might become available in the coming decades

[8]. In addition, early and iterative evaluation of new technology may increase the probability of acceptance, by ensuring that it is both useful and usable [9]. Finally, the Aware Home facilitates the bringing together of researchers from different disciplines, whose disparate knowledge and experience is beneficial in the design of technology. Other examples of smart home laboratories that promote this user-centered design approach are Philips Home&CareLab and TNO/DUT's Experience Labs.

The CareLab was developed at the Philips High Tech Campus in the Netherlands. At the CareLab special attention is paid to the study and design of technologies termed "Ambient Assisted Living" technologies which consist of technologies that address user needs by focusing on the safety and protection of the personal environment and the stimulation and enabling of older adults to maintain an active lifestyle. One example of this type of technology is the Intelligent Life Style Assistant which utilizes a remote monitoring service to provide safety and protection while also offering an interactive IP-TV platform that stimulates cognitive activities and enables continued participation in society.

TNO Human Factors division and Delft University of Technology both have experience laboratories to accommodate research that samples the experiences of home occupants who use of technologies and services which are still under development. An important focus of both of these laboratories is to develop personalized environments in such a way that a broad range of occupants, including older adults, can easily access the services that might be of interest for them [10]. User, activity, and context profiling technologies are included in the environment to allow the home's system to adapt to the occupant's task performance and well-being. The infrastructure of the laboratories is flexible to enable research with users who move between home and other locations (e.g., office, hospital or gallery), and those who communicate with persons from other locations using personalized information technology (e.g., tele-conference or chat [11]).

Recent Aware Home Studies

To illustrate the potential for technology designed in contextualized laboratories, we will provide two recent examples of studies conducted in the Georgia Tech Aware Home. The focus of the first study was on technology to support older diabetics. Many older adults suffer from type II diabetes and often require support to successfully cope with their disease. There are two types of solutions which have successfully provided support

for diabetics in the past. First, educating patients and raising their level of commitment to manage their diabetes can help them take better care of themselves [12]. This sort of self-care, defined by Bhuyan [13] as activities individuals, families, and communities undertake with the intention of enhancing health, preventing disease, limiting illness, and restoring health, can improve a patient's lifestyle, medical adherence, and future health outcome. Second, to provide patients with hands-on care, lower expenses, and meet with staff shortages, health care is increasingly beginning to rely on Telecare, which is the provision of remote care to people at home by means of information and communication technology (ICT).

One way to address both of these solutions is through the use of a computer application that supervises the patient by monitoring their personal characteristics including personality traits and cognitive abilities, as well as the person's environment. Based on these data, the assistant supports self-care, maintains medical instruments, co-manages the Electronic Patient Record (EPR), and mediates communication with (remote) medical specialists.

In the study conducted in the Aware Home, participants were asked to use the computer assistant to complete sample tasks. The older adults made very few errors using the computer assistant which suggests that the technology was usable for the sample tasks. In addition, participants were interested in a mobile version of the computer assistant, reporting that many of the features of the system would be useful outside of the home environment. This experiment is part of the SuperAssist project that comprises complementary empirical investigations in all three laboratories mentioned above [14].

The second example study addressed the ideas of monitoring and privacy more in depth. It may be particularly important for users to understand the benefits of monitoring technology because they may have concerns (e.g., privacy) that need to be weighed against potential benefits. Some benefits of monitoring technology include the ability to raise an alarm in response to concerning situations such as changes in activity levels of the residents or unusual events occurring within the house, such as doors being left open over extended periods of time. Additional monitoring options include well-being monitoring, physiological monitoring, monitoring of chronic diseases [15], and monitoring cognitive functions. The idea of being monitored may even alleviate a sense of social isolation [16]. However, monitoring may provide a sense of false confidence for both users and caregivers [15]. One study of monitoring technology in the Aware Home included a formative

evaluation of the perceived needs, concerns, and benefits of using visual sensing systems in the home environment.

In this study participants were given a tour of the Aware Home and introduced to three different types of visual sensing devices: a video camera, a point-light camera and a blob tracker. Each device captures and transmits a different level of information about the person being monitored. A video camera for example, transmits images similar to those found on TV; a point light camera transmits images where the activity of a person being monitored may be distinguished, but not the identity; and the blob tracker shows only location information. After being introduced to each device participants completed a 2-part structured interview. They were first asked about their general opinions of monitoring technologies and how they imagined them being used within a home they might live in. Next, they were presented with different scenarios and asked about privacy concerns as well as potential benefits each device might provide in that situation.

Results from the first section of the interview suggested that privacy was an important design consideration for older adults. Participants mentioned a number of ways privacy could be achieved or maintained through design details. Results from the scenario based portion of the structured interview suggested that although participants had more privacy concerns about devices which captured detailed information, like the video camera, they also perceived the video camera as more beneficial [17].

Conclusion

Both evaluations presented here suggest that older adults perceived the potential benefits of having monitoring technologies in home environments designed to support independent living. Because the studies were conducted in a smart home environment, participants may have been more able to imagine themselves using monitoring technologies in their own home. The rich environment can enable potential users to consider the technologies in context and therefore provide richer input which in turn can be used throughout the design process. Smart home laboratory environments, like Georgia Tech's Aware Home, Philips' Home&Care Lab and TNO/DUT's Experience Labs, are important for representative user-centered evaluation of eHealth monitoring technologies.

References

[1] Curry, R. G., Tinoco, M. T., & Wardle (2002). The Use of Information and Communication (ICT) to Support Independent Living for Older and Disabled People. Retrieved January, 2007 from http://www.rehabtool.com/forum/discussions/ictuk02.pdf.

[2] Goodman, J., Syme, A., & Eisma, R. Older Adults' Use of Computers: A Survey. HCI 2003, Bath, UK, Sep 2003
[3] Kaufman et al. (2003). A Cognitive Framework for Understanding Barriers to the Productive Use of a Diabetes Home Telemedicine System. Proceedings of the AMIA.
[4] Niman, B. v., Sund, T., Rodriguez-Ascaso, A., Brown, S., & Garner, P. (2006). User Experience Design Guidelines for Telecare Services. Proceedings of the 8th conference on Human-computer interaction with mobile devices and services.
[5] Hindus, D. (1999). The Importance of Homes in Technology Research. In Streitz, N., Siegel, J. Hartkopf, V., Konomi, S. (Eds.), Cooperative Buildings – Integrating Information, Organizations, and Architecture. Proc CoBuild'99, October, 1999.
[6] Kidd, C.D., et al. The Aware Home: A Living Laboratory for Ubiquitous Computing Research. In Streitz, N., Siegel, J. Hartkopf, V., Konomi, S. (Eds.), Cooperative Buildings – Integrating Information, Organizations, and Architecture. Proc CoBuild'99, October, 1999.
[7] Mynatt, E. D., & Rogers, W. A. (2002). Developing Technology to Support the Functional Independence of Older Adults. Ageing International, 27, 24-41.
[8] Sarkisian, G. P., Melenhorst, A. S., Rogers, W. A., & Fisk, A. D. (2003). Older Adults' Opinions of a Technology-Rich Home Environment: Conditional and Unconditional Device Acceptance. Proc Human Factors & Ergonomics Soc..
[9] Caine, K. E., O'Brien, M. A., Park, S., Rogers, W. A., Fisk, A. D., Van Ittersum, K., Capar, M. & Parsons, L. J. (2006). Understanding acceptance of high technology products: 50 years of research. *Proceedings of the Human Factors and Ergonomics Society 50th Annual Meeting.* Santa Monica, CA: Human Factors and Ergonomics Society.
[10] Neerincx, M.A., Lindenberg, J. & Grootjen, M. (2005). Accessibility on the Job: Cognitive Capacity Driven Personalization. HCII 2005, St. Louis, Missouri: MIRA Digital Publishing.
[11] Lindenberg, J. Pasman, W., Kranenborg, K., Stegeman, J. & Neerincx, M.A. (2007). Improving service matching and selection in ubiquitous computing environments: a user study. Personal and Ubiquitous Computing, 11, 59-68.
[12] Golin, C.E., DiMatteo, M.R., Leake, B., Duan, N., & Gelberg, L. (2001). A diabetes-specific measure of patient desire to participate in medical decision making. Diabetes Education 27(6), 875-86.
[13] Bhuyan, K.K. (2004). Health promotion through self-care and community participation: Elements of a proposed programme in the developing countries. BMC Public Health 4(11).
[14] Blanson Henkemans, O.A., Neerincx, M.A., Lindenberg, J. & van der Mast C.A.P.G.. (2006). SuperAssist: A User-Assistant Collaborative Environment for the supervision of medical instrument use at home. First Int Conf on Pervasive Comp Tech for Healthcare 2006, Inssbruck, Austria, 29 Nov-1 Dec, 2006.
[15] Reeves, A. A., Ng, J. W. P, Brown, S. J. & Barnes, N. M. (2006). Remotely supporting care provision for older adults. In Proceedings of the International Workshop on Wearable and Implantable Body Sensor Networks.
[16] Rowan, J. & Mynatt, E. D. (2005). Digital family portrait field trial: Support for aging in place. In Proc SIGCHI.
[17] Caine, K. E., Fisk, A. D., & Rogers, W. A., (2006). Benefits and privacy concerns of a home equipped with a visual sensing system: A perspective from older adults. Proc Human Factors & Ergonomics Soc.

Author Note

This research was supported in part by National Institutes of Health (National Institute on Aging) Grant P01 AG17211 – Center for Research and Education on Aging and Technology Enhancement (CREATE).