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Towards Adaptive Interfaces for Supporting Elderly Users in Technology-Enhanced Home Environments

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Abstract. This paper describes first steps in the design process of an open and integrative test bed for studying the acceptance of Ambient Assisted Living technologies. The research work reported in this paper was conducted within the project "eHealth - Enhancing Mobility with Aging", an interdisciplinary research project funded by the Excellence Initiative of the German Federal and State Governments. In the first part of the paper, several formative studies are described, which were conducted in order to analyze personal and medical needs of potential end users, as well as the habits they have in dealing with their illnesses. The insights gained in these studies were used to define fundamental requirements for the design of an intelligent home environment. The second part of the paper shows how the concept was realized and presents several technical prototypes of intelligent home components.

Keywords: Ambient Intelligence, Ambient Assisted Living, Ubiquitous Computing, User Interfaces, User-Centered Design, User Study.

1 Introduction

Due to the increasing number of middle-aged and older people in most western societies, the development of supportive medical systems, which enable frail or (chronically) ill persons an independent life within their own homes, gain particular importance. While these so-called *Ambient Assisted Living* (AAL) environments will certainly open up new medical perspectives, the design of such systems will also raise new questions of usability and user acceptance.

In contrast to traditional information and communication technologies, assistive medical devices are mostly used by older and diseased persons, who have very specific needs [7]. Compared to the average computer user, older people differ considerably regarding their cognitive as well as motor skills. As known from a vast body of literature (see, e.g., [1] or [2]) the ageing process impedes the interaction of older users with technical devices to a considerable extent. Age-related changes in the cognitive system usually lead to a decline in working-memory capacities cause a general slow down in processing speed, and reduction of spatial abilities [3]. As a result, persons with reduced spatial abilities frequently experience disorientation

when navigating through menu structures of computer systems. A reduced working memory capacity hampers the untroubled menu navigation additionally, especially when using small screen devices, where the provision of optimized or additional information is often not possible due to the limited screen estate [8].

In the context of medical technology usage such declines become especially critical when task demands are high, as for instance when using novel or complex devices, or when it is the matter of sensitive data like in health-related context. As a result, older people face greater difficulties in extracting relevant information from used technical systems or they are simply overwhelmed with a high information density in applications and technical devices.

3 Acceptance of Intelligent Homecare Systems

When discussing aging and technology usage, the willingness of older people to use computer technology or to interact with medical systems is a crucial aspect that needs to be carefully considered. A number of earlier studies (e.g., [6]) examining the interaction with technology have shown that the success of the technological innovation is largely influenced by the extent to which the user population accepts the technology. Empirical evidence suggests that different age groups have different reasons to accept or reject medical technologies. In this context, it is very likely that the actual impulse to use a specific device is largely influenced by motivational factors. On the one hand, usage motives are related to perceived advantages and gains, which at the same time support the positive attitude towards the technology. However, disadvantages and barriers can overshadow the intended interaction, and - as a consequence - provoke an averseness to accept and actually use the system. On the other hand, the user motives to employ medical technologies might also interact with the their individual characteristics such as gender, educational level, previous technical learning history or the resulting technical self-confidence. Thus, emotional factors need to be carefully considered in the analyses of usability and acceptability aspects of medical systems.

In order to examine the different influences of user diversity on technology acceptance and usage behavior, a user-centered approach is necessary, which considers the characteristics of highly heterogeneous user groups. Therefore, a broad range of explorative studies and methods is needed. Additionally, a consequent dialogue and interaction between developers and patients is necessary, to ensure a user-oriented development process. The acceptance of applications and systems is a decisive factor for a successful implementation of medical support system as it reflects whether the technology actually meets the requirements of potential end users.

4 Designing for Special Needs

As illustrated above, most older or handicapped people have very specific needs, which require the input and output devices of future homecare technologies to be

individually adapted for each user. Besides these individual user characteristics, cognitive as well as motor skills of older users are not constant over the years, which makes an additional adaption over time necessary. Those dynamically changing requirements could be reflected by integrating various interaction devices into new systems, which would enable the combination of different input and output modalities, like speech or gesture, in order to individually support different types of users. But experiences with previous systems showed, that the preferred interaction modalities do not only depend on the physical abilities or the personal preferences of users, instead they are also likely to be influenced by a variety of other factors (see, e.g. [4], [5], [6] or [9]).

In order to analyze the influences of these factors, it is important to observe different target user populations in everyday situations. To do this, we conducted several explorative studies using focus groups, personal interviews as well as survey methods for collecting relevant data. The overall goal of the evaluations was to identify the specific needs and wants as well as barriers and perceived impediments of ill or handicapped people (but also healthy persons for comparison matters). Moderated focus groups with a small number of participants were used to stimulate discussions about medical functionalities, possible navigation issues, interaction options as well as about users' wishes, barriers and needs regarding future homecare technologies. In a second step, questionnaires were used to collect quantitative data and to determine different influences on participants' usage behavior (e.g., ageing concepts, coping strategies, user characteristics, affinity towards technology usage, context of usage etc.).

Since most homecare technologies will be used by long-term care patients, our research focused on patients with chronic illnesses and in particular people with cardiac and circulatory heart diseases. In this context, we conducted several semi-structured interviews with artificial heart patients at *The Hearth and Diabetes Center North Rhine-Westphalia* in Bad Oeynhausen (Germany). As the interviewees' lifes depend on absolutely intact and reliable medical technology, their feedback provided value insights into the requirements of acute care patients. The opinions of such highly technology-dependent persons are exceedingly valuable for the development of intelligent medical assistance and help researchers to identify user requirements, special needs or issues, and insuperable obstacles for the interaction with it. The studies showed that not all users of medical technology face the same difficulties and that a careful consideration of the varying requirements of the different target groups is indispensable for successful system design. As the acceptance of assistive medical technologies is influenced by a multitude of individual factors, an understanding of the users' capabilities and limitations as well as of their motives and barriers is crucial for an appropriate conception and adequate system development.

5 The Future Care Lab

The insights gained during the formative studies were used to design the *Future Care Lab*, an experimental space for studying users' "life" at home and examining how they interact and communicate with invisible technology [10]. The lab enables to

explore how future homecare environments have to be designed such that they meet technical and medical requirements and at the same time satisfy fundamental user needs regarding data protection, dignity, and intimacy.

Within the *Future Care Lab*, the development of user-centered smart healthcare technologies is realized by a truly multidisciplinary team of individuals coming from the fields of psychology, communication science, computer science, medicine, engineering, and architecture. The *Future Care Lab* provides a full-scale technical infrastructure to test various immersive systems. It consists of a simulated home environment (see Figure 1), which allows researchers to use various prototype interfaces with test persons of different ages and health states.

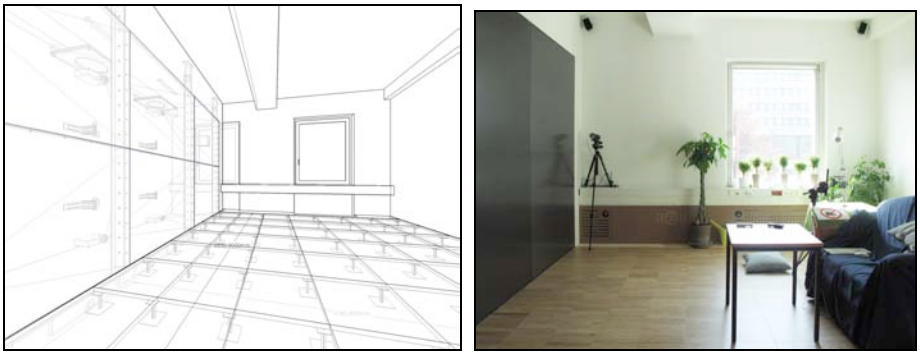

Figure 1. The *Future Care Lab*: technical concept of interactive walls and floor (left) and finished experimental space (right).

The lab provides an intelligent care infrastructure, consisting of different mobile and integrated devices, for supporting elderly people in technology-enhanced home environments. The setup of the lab enables in-situ evaluations of new care concepts and medical technologies by observing different target user populations in realistic usage situations. As the lab relies on a modular technical concept, it can be expanded with other technical products, systems and functionalities, in order to address different user groups as well as individuals with differences in their cognitive, health-related or cultural needs. By this the lab has the potential to be sensibly adapted to new technical developments as well as societal changes and needs.

6 Ongoing Work and Outlook

We are currently conducting several evaluations with target user populations in order to explore the acceptance of different implementation concepts and medical solutions for chronically ill or motorically handicapped patients. In the next step the interaction of potential users with the system will be observed in realistic usage situations to analyze the influences of the described factors. Based on the results gained in these studies we plan to formulate design recommendations for technology-enhanced home environments with a special focus on long-term care patients.

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