Designing Acceptable Assisted Living Services for Elderly Users

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Abstract. With today's technology, elderly users could be supported in living independently in their own homes for a prolonged period of time. Commercially available products enable remote monitoring of the state of the user, enhance social networks, and even support elderly citizens in their everyday routines. Whereas technology seems to be in place to support elderly users, one might question the value of present solutions in terms of solving real user problems such as loneliness and self-efficacy. Furthermore, products tend to be complex in use and do not relate to the reference framework of elderly users. Consequently, acceptability of many present solutions tends to be low. This paper presents a design vision of assisted living solutions that elderly love to use. Based on earlier work, five concrete design goals have been identified that are specific to assisted living services for elderly users. The vision is illustrated by three examples of ongoing work; these cases present the design process of prototypes that are being tested in the field with elderly users. Even though the example cases are limited in terms of number of participants and quantitative data, the qualitative feedback and design experiences can serve as inspiration for designers of assisted living services.

Keywords: design of interactive products, acceptability, assisted living, elderly users.

1 Introduction

Demographic aging is a phenomenon that affects most industrialized countries. According to EuroStat, every 25 senior EU citizens in 2005 were matched with 100 citizens between 15 and 64 years old. This so-called old-age dependency ratio is expected to increase to 40 by 2030 [1]. The traditional elderly care system, which is largely based on human resources and centralized care institutions, has major difficulties in managing the increasing number of care clients. Not only do care companies have problems finding adequate professional caregivers, the societal cost of elderly care is also rising dramatically.

Many elderly people indicate they would prefer to live independently in their own homes as long as possible [2], which was confirmed in our interview sessions. In many cases, however, support is needed to continue their everyday living routines. Whereas support is nowadays typically given by both professional and informal caregivers, support could in part be taken over and augmented by new technology. This assistive technology is expected to play an increasingly important role in the coming years [3].

When making an inventory of products that support independent living of elderly users, there are plenty of technological solutions available on the market. Typical examples include personal alarms, communication tools, remote monitoring of physical status, and home automation. Current products are generally not aware of the user's context. These products do not take into account the environment, behavior and current activities of the user. A typical solution offers remote access to physical status information such as blood pressure and blood sugar levels, regardless of the current user state. Increasingly, companies are working on products that are context-aware. Such products could help provide support that is tailored to the user's actual situations. Also, context-awareness enables efficient remote monitoring without extensive person-to-person communication. State-of-the-art products range from low-level sensor networks [e.g., 4, 5] to activity-awareness services [e.g., 6].

From a technological perspective, one might conclude that systems are in place to support elderly and improve well-being. When talking to end users, however, acceptability of new assisted living technology appears to be low. Many issues including usability problems, lack of user-perceived benefit, and user-perceived complexity of new technology are reflected in low acceptability scores of existing assisted living solutions [e.g., 7]. Products and services seem to be mostly designed to reduce the costs of professional caregivers, instead of enhancing the quality of life of the elderly user directly. Complexity of assisted living products might even increase due to the increased use of context-aware and pro-active technologies. Furthermore, existing products tend to be standalone rather than inter-connected in a meaningful way. Consequently, end users have to learn new interaction paradigms for each new product, and potential synergies and information-exchange between products are often not exploited. In short, research is needed in order to increase end user acceptability, thereby enabling industry to develop and market acceptable assisted living products.

This paper presents a vision of how to design acceptable and pleasurable assisted living products and services for elderly users. The end user group is primarily defined in terms of user needs, abilities and reference frame rather than age; the focus will be on senior citizens who can profit from assisted living technology towards living independently for a prolonged period of time, who are able to use assisted living technology, and who have similar living routines and a similar reference frame in terms of known metaphors. Acceptability issues of existing products and services were studied, and underlying design challenges were identified. A design approach is proposed in which perceived benefit by the end user and ease-of-use are used as guiding factors.

2 DESIGN VISION

Earlier work [e.g., 7, 8, 9, 10, 11, 12] on acceptability of assisted living technology by elderly users has revealed multiple barriers that keep elderly users from adopting new technology, including:

- **Complexity and learnability.** Elderly often regard technology as to be complex in use, and they consider themselves incapable of mastering new products. This feeling of complexity is reinforced by the lack of standardization; elderly users have to learn operating instructions for each new product they like to use. Consequently, the initial hurdle towards adopting new products tends to be too high.
- **Lack of perceived benefit.** Even though the benefit of new technology can be evident for caregivers, since technology can help improve the efficiency of the care process as well as tailor the care to individual users, perceived benefit for the elderly themselves is often too low. Consequently, elderly often reason that they can just as well do without.
- **Compatibility issues.** Current products are often standalone. Information exchange between products is limited, resulting in suboptimal product behavior. Both product benefit and product use can be affected by compatibility issues.

Due to these issues, elderly users often consider the cost of adopting new technology higher than the expected benefit, resulting in a hesitant attitude towards innovations in general.

Acceptability could be improved by increasing the perceived benefit, as well as by decreasing the perceived cost. In terms of creating benefit, there is a need to make explicit and/or increase the direct benefit of new technology. Whereas for example professional caregivers would like to be able to monitor the presence of their clients using sensor systems, there might not be a direct benefit for the care clients. Care clients tend to be interested in issues such as establishing self-efficacy and countering social isolation. Leveraging benefit by linking a presence monitoring system to –for example- a fall detection system is expected to increase acceptability.

In terms of reducing cost, much effort has been put in improving product usability. For example, products that are potentially very complex to use, can be made easily accessible by designing the right user interface. In the current situation, however, interoperability between products is low. Potential synergies and information-exchange between products, in terms of improved awareness for caregivers and products that better consider the context of use in their adaptive behavior is low. Products are generally not aware of the context of use, and they do not embed in the living routines and context of use of elderly users.

Since perceived cost and benefit change in time, product adoption needs to be considered as a dynamic construct. Rather than focusing on initial product adoption, products should support altering user needs. When a new product is introduced to the users, accessibility and simplicity in terms of learning curve can contribute to acceptability. The same product might be rejected after a few weeks since the perceived benefit does not match the user expectations in time. In other words, the desired level of system complexity can be dynamically linked to the level of user experience.

Towards creating acceptable assisted living technology for elderly users, five concrete design goals have been identified. Even though each of these five goals might be 'common sense' for designers, these goals are considered crucial in view of problems with existing products and in respect to needs and challenges specific to assisted living services for elderly users based on earlier work and design experiences. These goals could therefore serve as inspiration for designers of assisted living services.

Goal 1: Short-term benefit should outweigh short-term cost

Acceptability primarily depends upon short-term benefits. Each product that requires effort from the elderly users needs to give immediate benefit to the elderly in return. External benefit (e.g., benefit for caregivers) needs to be accompanied by internal benefit (i.e., benefit for elderly users). Long-term benefit (e.g., healthy body) needs to be projected on short-term benefits (e.g., being able to visit grand children).

Goal 2: Relate to existing living patterns and known metaphors

Elderly users often have difficulties changing their living patterns and learning new interaction paradigms. New products should therefore fit into existing living patterns, rather than enforce new living patterns. By using metaphors that are already known and that fit into the reference framework of the elderly users, new products can be mastered more easily.

Goal 3: Multiple interfaces, uniform interaction patterns

Assisted living services will be used in different situations and for different purposes. A single central interface will not suffice; for example, a television-based interface when assisting elderly in the bathroom will result in higher cost, since the user has to take more effort using the interface. Alternatively, users might select the optimal interface based on the situation. This could range from a static TV-screen to a mobile tangible device. Uniform interaction styles create a coherent interaction experience, and will enhance the usability of the different devices.

Goal 4: Leverage existing social network

Rather than shifting responsibilities from caregivers and social networks to a technological solution, products and services should respect existing traditions and responsibilities. Ideally, technology facilitates the process of human-human social interaction. For example, routine tasks with no social value could be taken over by an automated system, whereas human-human interactions could be encouraged. Likewise, caregivers, family and friends could be involved in complex product operations; hard-to-use functions can then be shielded from elderly users.

Goal 5: Facilitate adaptation in time

User needs and skills change in time. When these changes affect acceptability of assisted living services, these services should be able to dynamically adapt to the changing contextual setting. Furthermore, since the changes in user needs might require a change in services, a service platform should enable dynamic reconfiguration in order to cope with altering user needs.

To achieve these goals, designers need to carefully study the domestic routines, social network, experiences, needs, values, limitations and potentials of the elderly users. Designers can make more use of qualitative instruments such as interviews, diary studies, cultural probes and focus group sessions to elicit the required information. Information is needed not only on how people experience technology, but also on how people interact with products and people. Such insight enables designers to create interactions that are embedded in the daily lives and routines of people, thereby creating natural experiences. Also, such studies provide a baseline measure that can be used when evaluating the interventions that result from the newly designed products.

In order to understand the acceptability of design concepts, user studies with working prototypes need to be conducted. It is questionable whether or not user-product interaction with assisted living products and services can be studied in a laboratory setting. These products and services are generally linked to living routines, and the validity of studies of living routines in an artificial environment is not clear. Longitudinal field studies are therefore considered an essential part of the design process of assisted living services.

There is no single 'right' procedure for designing acceptable products and services for elderly. A central theme in the design process needs to be the involvement of the end users; the right tools and techniques depend on the problem at hand. The three cases as described in the next section serve as examples of how the design goals can be used to guide the design process.

3 EXAMPLE CASES

Three example cases of ongoing work are described in the following sections. In these cases, end users have been involved in the early stages of the design process, in order to understand the user needs and reference framework. For each of the cases, the design goals as presented in section 2 have been used to guide the design process. The first example case has resulted in a prototype that has been tested in the field with users; the second and third case represent work-in-progress that yet has to be tested in the field. The findings are generally qualitative in nature; designers tend to be receptive to qualitative input in their design process.

3.1 CASE 1: Interactive Bulletin Board

A first case study focused on creating a message-based interaction platform. The main goal of the case study was to develop an easy-to-use communication product for elderly users [13]. The resulting design concept aims to create direct benefit for the end user (goal 1), is based on a known metaphor (goal 2) and aims to lower the threshold for communicating within the care network (goal 4) and family or friends at home. It was decided to consider multiple interfaces (goal 3) and adaptation in time (goal 5) in a later project.

For the targeted user group of older seniors with little or no prior experience with computers, message-based communication using the Internet could help maintain or improve their social network. Furthermore, a message display could be used to present system-generated messages, such as for example medicine reminders. A field exploration, which aimed to understand the user needs and the context of use, revealed that the user group was reluctant towards adopting new technology; even though they acknowledged the value of communication, they indicated that even though new technology could help, it would surely be too complex to use for them.

In informal interviews, five elderly care clients indicated that they regularly feel lonely, since the number of visits from relatives and friends is low. The feeling of isolation is strengthened by current developments in professional care that leave very little time for social interaction. The interviewees point out that they would like to be actively involved and contribute to the lives of people they know, rather than being dependent and passive. Whereas many of today's care products inflict stigmatization of the latter, they prefer products that do not underline their weaknesses. The care clients indicated a dislike of 'modern' interaction metaphors. Moreover, they were scared off by the complexity of new products in terms of for example functionalities and layered menu structures [9].

Towards finding existing products that could be used for creating an interaction metaphor for messaging systems, the designer visited the homes of the care clients. Participants were asked to describe objects in their homes that were valuable to them. Participants indicated that they most valued objects based on emotional value, in terms of memories and social ties. Souvenirs from abroad, drawings from grandchildren, and pictures of family and friends were also considered valuable. The home visits were also used to get to know the living environment of the participants, and as a source of inspiration for the design phase.

Three messaging metaphors were constructed and evaluated with a panel of three designers. First, a photo frame metaphor was considered. The photo frame represents social contacts; an enhanced photo frame could be used to display status information and to start communications. Second, a convenience chair based interaction metaphor was considered. Each participant had a convenience chair close to the television; since the chair was used a lot, it could be used as a central location for communication. Third, a bulletin board metaphor was considered. The bulletin board is a well-known mechanism to store reminders and notes. These three metaphors could be linked to context-aware technology, in such a way that the technical nature of the systems could be shielded from the users. The three concepts were evaluated based on ease-of-use, functionality, and 'naturalness' of the chosen metaphor. The bulletin board was found to be the most intuitive and would fit best in the homes of the target users.

In designing the electronic bulletin board, the functionalities and affordances of traditional bulletin boards were analyzed and mapped to electronic equivalents. Figure 1 shows the resulting working prototype. A touch screen interface is mounted on top of a secretaire. Using the touch screen, users can view and remove notes. New notes can be added using a scanner built in the secretaire. The number of functions available to the elderly is limited in order to improve system understanding; therefore, notes cannot be archived or re-arranged. In order to be able to save notes, a printer is attached to the system and integrated in the secretaire; a note can be printed by selecting an on-screen menu option on the touch screen.

Fig. 1. The interactive bulletin board provided the user with messaging functionality using a known interaction metaphor.

The bulletin board is linked to an intelligent reminder service. When needed, a medicine reminder can be displayed using multiple levels of intrusiveness. Furthermore, the bulletin board is linked to the Internet. Family members, friends or caregivers can view and modify the contents of the bulletin board via a website. Adding, removing and modifying reminders is only possible using the website; elderly users were not exposed to these management tasks.

To assess the usability and acceptability of the design, the prototype was tested in the field. Field-testing was limited to two participants, four and seven days per participant respectively, due to time constraints. Participants were senior citizens (76 and 84 years old), both living independently in their own houses, taking medicines, and both relying on professional care. Each participant asked a non-professional caregiver to take part in the test; these caregivers were asked to check and update the bulletin board via the website. The bulletin board was placed in the living rooms of the participants; the supervisor then gave an introduction to the bulletin board.

When looking for participants, several potential candidates indicated that they thought they were unable to control an electronic messaging board. Proper presentation of the test was found to be crucial towards recruiting participants. When targeting 'young' seniors rather than 'old' seniors, problems related to technophobia are expected to be of minor relevance. During the introduction of the bulletin board both participants indicated they were afraid of using technology repeatedly, even though they could not indicate why.

Preliminary results indicate that both participants were positive about the way they could interact with the system, and the functionalities the system provided. They considered the system to be a bulletin board rather than a computer system. Since the bulletin board was not experienced as a computer, the fear of using new technology was not found to be a problem during the test. Even though both participants had not used a touch screen before, they were able to control the interface without significant problems. In case the participants did not know how to manage their goals using the

bulletin board, a trial and error approach generally led to the desired results. One participant tended to forget the skills right away; he had to re-learn much of the interface time and time again.

The user studies did provide feedback that can be used to improve the design of the bulletin board. First of all, personalization of the content was found to an important facilitator of acceptability. Whereas automated messages were impersonal, content provided by caregivers was personal. The participants explicitly indicated that their enthusiasm in terms of using the prototype was encouraged by personalized content.

Second, the touch screen was found to be a suitable interaction device for this specific application, as the users easily understood the link to the bulletin board metaphor. In order to fit in the user context and environment, some improvements could be made, e.g. regarding day/nighttime differences. One of the participants attempted and succeeded in switching off the system at nighttime because the screen was too bright. A backlit screen device should therefore adjust the brightness to the environment.

In terms of design goals, the bulletin board by nature scored high on short-term benefit (goal 1) and on leveraging the existing social network (goal 4); participants enjoyed the low-threshold communication to their care network that was provided by the system. The interaction metaphor was deliberately chosen based on the interviews and the home visits; the participants considered the system to be a bulletin board rather than a computer system, and intuitively knew how to use the system. This confirms the expected merits of using a known metaphor (goal 2).

3.2 CASE 2: Physical Exercise Coach

A second case study focuses on stimulating the physical activity of elderly people. The amount of physical activity of senior EU citizens tends to be below a healthy level. As a result, their physical condition deteriorates. Assisted living technology could be used to motivate elderly to exercise more. One solution might be to link coaching and motivations directly to the activities done by the elderly user. There are however practical obstacles towards deployment of automated motivational systems. First of all, the long-term benefit of physical exercise (i.e., a healthy body) often does not appeal to the short-term motivation. Secondly, the sensors and user interface that are inherent to automated solutions could scare off end-users. Third, from a technical point of view, it can be hard to measure actual physical activity levels that are needed to link an exercise coach to user activities.

The main goal of this example was to develop a motivational system that appeals to the elderly user group and the naturally fits into their existing living patterns (goal 2). In terms of motivation, the resulting system would have to link to short-term gains rather than long-term goals (goal 1). It was decided to consider the use of multiple interfaces (goal 3), social motivation (goal 4) and adaptation in time (goal 5) in a later project.

Towards selecting an effective motivational mechanism, persuasive principles as described by Fogg [14] were studied. Based on these principles, multiple design goals were defined, including allow self-monitoring of physical activity, induce intrinsic motivation, act at the right time (kairos), and enhance accessibility and simplicity.

Three conceptual designs were created and evaluated with a user panel in a focus group session. The first concept was based on goal setting; graphs were used to continuously show progress and goals. The second concept was based on rewards; new family photos would be released when goals were met. The third concept was based on social actorship; a flower that would be happy when the exercise levels were good represented the activity coach.

Five elderly people were invited to join the focus group session. The goal of this session was to discuss the three concepts and to extract key elements of each concept that were or were not appreciated. The participants of the session explained that they would like to have a direct and simplified overview of their current status, so without too much detailed information. They also indicated that they would not like to have their family pictures linked to their activity, as it would seem an illogical link. They much rather would have the clear flower image, but with the possibility to ask for additional information when needed.

Strong elements of each of the three concepts were integrated in a final design: a photo frame sized screen displaying a happy to unhappy flower (figure 2, left), with a second layer of detailed information on activity performance (figure 2, right).

Fig. 2. A photo frame sized touch screen displaying a happy to unhappy flower (left) provides the user with up-to-date information on physical activity. Users can request a detailed overview of the activity levels in respect to preset goals (right).

A working prototype has been developed and will be tested in the homes of three elderly users. Whereas ideally the system would use real-time activity data, the current system is based on a FitSense ActiPed [15] pedometer that streams step-count data to a database on the Internet.

Towards creating a final version of the system, several challenges yet need to be solved. First, the goal setting mechanism needs to be elaborated. Medical doctors are not yet consulted towards setting exercise goals that are balanced with daily activity levels. An understanding of optimal exercise targets in relation to day-to-day activities is needed. Second, an understanding is needed of how automated exercise coaches can be used to actually change user behavior. Third, a non-intrusive mechanism is needed for real-time measurement of physical activity levels.

Even though objective ratings of the design concept cannot be given at this stage of the project, the use of the design goals guided the process towards a concept that supposedly easily fits in the homes and living routines of elderly people. User evaluations are planned to capture actual user experiences of participants for seven days in a row.

3.3 CASE 3: Activity Journal

A third case study focuses on creating a labeling mechanism for user activities. Activity recognition algorithms are increasingly being used not only to remotely monitor living patterns and detect irregular situations [e.g., 16], but also to link routine support to actual activities [17]. As described in section 4.2, one might even link a physical exercise coach to the actual activity levels based on activity recognition.

Activity recognition is based on identification of recurring patterns in sensor data. In order to be able to automatically recognize activities, activity recognition algorithms need to be trained using sensor data with activity labels. Since the sensor layout and user activities differ between people and between locations, algorithms need to be trained for each new setting.

The process of labeling activities might be experienced as interruptive and unacceptable by end users. The perceived cost of interrupted activities and requested effort can be high, whereas the short-term benefit might not be clear to the users. The main goal of the case study was to develop an acceptable activity-labeling interface. The resulting design concept aims to lower the cost (in terms of required user effort) of activity labeling (goal 1), and to improve the ease-of-use by using a known interaction metaphor (goal 2). It was decided to consider multiple interfaces (goal 3), linking to the social network (goal 4) and adaptation in time (goal 5) in a later project. A conceptual design is currently under development and yet has to be finalized.

In line with the first design goal, as stated in section 3, acceptability could be improved by increasing the immediate benefit, for example by developing a new service that uses activity information to support the user. In the present study, it was however decided to focus on the labeling interface only; therefore benefit could not be improved.

Instead, the cost of labeling could be decreased. One option would be to delegate the labeling effort to a third party. For example, all labeling questions could be sent to a family member, thereby shielding the labeling process from the elderly users. This would be in line with goal 4, but a problem would be that a delegate has no clear overview of the situation at hand, resulting in false labels. For the present study, it was therefore decided to involve the elderly users in the labeling process.

As the choice of interaction metaphor can affect the learnability and understandability of the final design, the first stage of the design process involved an exploration of suitable metaphors. First, a calendar metaphor was studied. Because activities are linked to time frames, a calendar seemed a logical way to present activities. A calendar-based concept was sketched and evaluated in a focus group session with five elderly users. The participants however indicated that a calendar metaphor led to false expectations and misunderstandings. They also stated that that

they never write day-to-day activities in their home calendar, since they do not consider these activities as appointments. Therefore, the calendar metaphor was rejected.

A second concept is based on an activity journal metaphor, as a journal seems to be a logical place to write down activities. A journal-based interface could be used to present system suggestions and ask for user feedback. Furthermore, since the journal concept can easily be manifested in a mobile book-size device, technology does not seem to be a limitation for implementation. The journal could be placed on any location where elderly have the time and willingness to use it, for example on a coffee table.

This design process has so far resulted in a design concept (figure 3) that is focused on accessibility, understandability and direct feedback. This way, the design links to the design goals as described in section 3 in terms of relating to existing patterns and known metaphors (goal 2). As a next step, the concept is now being implemented in a working prototype, in order to collect user experiences in a realistic setting, and to iteratively improve the design.

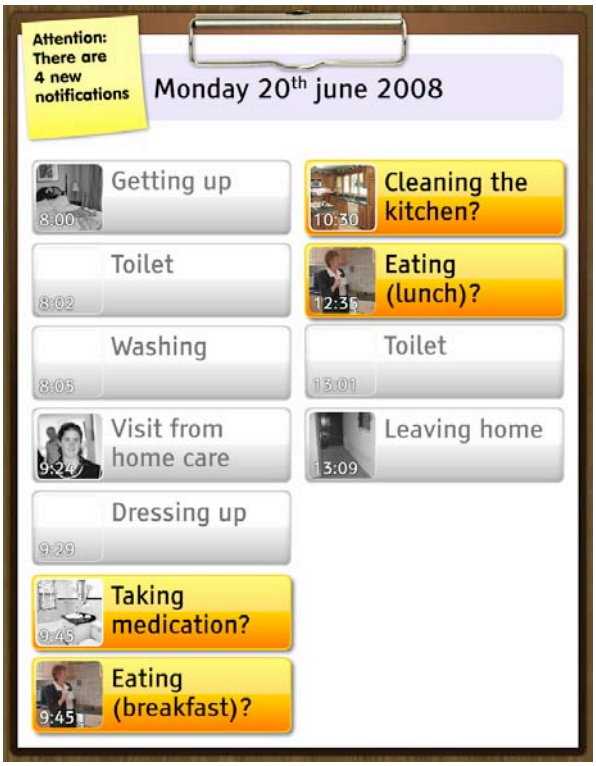

Fig. 3. An activity journal enables elderly users to label activities while hiding system complexity.

4 DISCUSSION AND FUTURE WORK

While assisted living technology is gaining attention of researchers and companies, an integrated user centered design vision in which the focus of user-product interaction is developed around end-user acceptability is lacking. Acceptability of current care products targeted at elderly users tends to be low.

The case studies as described in the present paper show how acceptability of assisted living products and services can be improved by a design vision targeted at creating short-term benefit, leveraging known interaction metaphors, and leveraging existing social networks. The design goals guide the design process, thereby making sure that the designer focuses on issues relevant to the domain and end user group. Even though the user studies so far were limited in duration and number of participants, the studies do suggest that the design concepts were acceptable; the elderly participants were willing to adopt the new technology, even though they were skeptical at first.

Only three of the five design goals were covered in the example cases; *multiple interfaces, uniform interaction patterns* (goal 3) and *facilitate adaptation in time* (goal 5) were not studied. Since none of the example cases resulted in a system with multiple user interfaces, uniform interaction was not an issue. Adaptation in time could not be covered by the case studies presented here; this goal will be studied as soon as a stable platform for longitudinal tests in the field is available.

Whereas the case studies were based on dedicated sensor systems and communication platforms, creating a generic activity-aware service platform could enhance the design process. A generic service platform is now being developed and will be deployed in a series of houses towards facilitating the iterative design of future prototypes. Furthermore, by linking multiple prototypes to a single platform, researchers will be able to study the use of multiple interfaces to a single system more easily, and they can better embed interactions in domestic routines of elderly users.

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