Smart Home Technology for the Elderly: Perceptions of Multidisciplinary Stakeholders

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Abstract. The "implementation" and use of smart home technology to lengthen independent living of non-instutionalized elderly have not always been flawless. The purpose of this study is to show that problems with smart home technology can be partially ascribed to differences in perception of the stakeholders involved. The perceptual worlds of caregivers, care receivers, and designers vary due to differences in background and experiences. To decrease the perceptual differences between the stakeholders, we propose an analysis of the expected and experienced effects of smart home technology for each group. For designers the effects will involve effective goals, caregivers are mainly interested in effects on workload and quality of care, while care receivers are influenced by usability effects. Making each stakeholder aware of the experienced and expected effects of the other stakeholders may broaden their perspectives and may lead to more successful implementations of smart home technology, and technology in general.

Keywords: smart home technology, perception, technology acceptance

1 Introduction

The most important developments in society for smart home technology are the socialization of care, extramuralization, and ageing [1]. Socialization of care means that people in need of care are no longer concentrated in large-scale institutions, but are returned a full-fledged place within society. Instead of concentrating on people's disabilities, one looks at a person's possibilities. Supporting aging adults to stay in their homes independently for a longer period of time concedes to the wishes and needs of many people in need of care, aiming for an improvement of quality of living and daily life. Extramuralization leads to less intramural residential facilities, remarkably more small-scale extramural facilities, but also to (re)new(ed) organization of services and an increased use of technological resources. Additionally, ageing plays an important role. The fact that the amount of elderly people is growing, and people become older as well,

leads to an enormous increase of care demand. The demand for houses for the elderly, for care, and for services will therefore grow in the coming years, while a shortage in care personnel is expected. The use of smart home technology to support independent living is hereby inevitable [2].

2 Multidisciplinary Stakeholders

Introducing smart home technology in care settings involves more than a technological innovation. It comprises of new processes and organisational changes. These changes all have to occur within regulations and financial rules that are most likely not adjusted to the use of technology. The stakeholders involved in the process of implementing smart home technology in extramural care setting therefore consist of: designers, care receivers, caregivers, care institutions, service providers, housing corporations, insurance companies, and the government. The perceptual worlds of these stakeholders vary due to differences in background and experiences, which lead to different interpretations on how smart home technology can be helpful in supporting independent living of elderly people.

In this paper we focus on the perception of the caregiver, the care receiver, and the designer. Problems in the interaction between the user or end-user and the technology can partially be ascribed to the design, which indicates the importance of considering both the care receiver's perception and the designer's perception. The caregiver, however, is also expected to be a user of smart home technology, and as the care processes also have to be taken into account, we consider the caregiver as third stakeholder.

2.1 The Care Receiver

Care receivers, in our case elderly people, are often considered as technofobic. Although this perspective does not apply to all elderly people, and is remonstrated by several studies (e.g. [3,4]), we believe elderly care receivers are less keen on new technologies than young people are and show lower technology usage rates [5]. One of the reasons for this technofobic perspective might be "self preservation". Elderly people have to deal with more and more limitations due to the ageing process, which make them more vulnerable and dependent than before. As older adults have less experience with computers and other (new) technologies [5], they are confronted with their (cognitive) limitations when they have to work with it, which makes them more afraid of making mistakes. Their (computer) anxiety results in unutilised chances to live and function independently [5], or to be enabled and empowered by technological possibilities [6]. Elderly people may therefore seem peevish and conservative, as they do not want their current life to be influenced too much by external factors.

An older person appears to become less technofobic when he or she knows and understands the usefulness of the technology [7]. Unfortunately, older adults often do not realise what advantages technology can bring them [5, 6]. Proper guidance and information when new (smart home) technology is introduced and

used is therefore important to let the older care receiver get a positive view on the technology, and realise the possible benefits of it.

2.2 The Caregiver

Although most caregivers are younger than the care receivers, caregivers are also known for their technophobia. This reluctance towards technology can partially be explained by the caring character of caregivers. People who choose for care delivery or nursing as a professional occupation often prefer working with people who need them. Giving away personal contact, through a technology intervention, raises an aversion. Even in situations where technology replaces physical presence by virtual presence, like telecare, the caregiver gets the feeling he or she has to renounce that which is experienced as "caring". Caregivers also experience a reduction in time spent with clients as a direct decrease in quality of care [8]. According to caregivers' perception, technological developments that are cost-cutting - and are developed for that purpose - result in a loss of quality of care. Raappana et al. [8] state that technology and care service are commonly not felt as being connected, which results in unwillingness by caregivers to use technology, and difficulties when new technologies are introduced. This perception may be due to a lack of abilities and skills among caregivers, which leads to feelings of incapability, with decreased work motivation and distress as a result. Fortunately, caregivers are willing to see utilisation of a safety system as part of their professional care skills - unlike the use of a personal computer as such - and describe technology as a positive change in the (quality of) work [8].

Even though the study by Raappana et al. shows that safety technology is viewed as useful, the implementation of smart home technology results in extra work for caregivers. The caregivers' unfamiliarity with the technology, the lack of skills among care substitutes, along with an increased number of false alarms, result in time-consuming efforts for caregivers. This indicates the importance of professional training to reduce both the expected and the experienced extra workload of the caregivers. Another concern of caregivers is that they expect elderly people to become even more lonely when technology is introduced into the care process. However, screen-to-screen contact may increase social contacts among elderly and between elderly and the community or their relatives. This emphasises the importance of proper guidance and training for caregivers when smart home technology is introduced. The use of (care)technology should actually become part of care education, in which both usage and implications of smart home technology are taught. Besides, by means of good orientation on useful technologies most negative effects that caregivers experience can be eliminated.

The idea that all care workers are reluctant towards using technology needs some nuances. In a study among care workers by Lyons et al. [9] administrators appear to judge computers much more positively than physicians and nurses do, not surprisingly as computers were first introduced in the administration work field. Physicians, however, declare to be unmotivated to learn how to use computers, while nurses feel insecure and perceive the computer as a barrier between

themselves and their clients. Especially the differences between managers and the nursing staff is of importance, as decisions - on the use of technology - are mostly taken by managers, without much consultation with those people who have to work with it later.

2.3 The Designer

The designer, on the other hand, is nothing but technofobic. This, at the same time, is his weakest point. For a technician it is hard to imagine the perceptual world of a technofobic user. The focus of the designer is mainly on the functionality of the technology, achieving the effective goals. The advantage of this focus is that the designer is well-aware of the benefits that the technology can bring. However, due to an often experienced vocabulary difference between the designer and the users and end-users (e.g. [10]), the designer may not be able to convince the technofobic (end)users of the usefulness and the benefits that smart home technology can have.

3 Perceptual Differences on Prevention and Privacy between Caregivers and Care Receivers

Prior to the implementation of smart home technology in care processes, a decision is made on the proper technologies which the care receiver needs. These decisions, however, are often made by the managers, based on recommendations by technicians, and have resulted in choices that were not in accordance with the actual needs of the care receiver [11, 12]. The reasons for the perceptual differences are explained here.

As mentioned before, caregivers are known for their caring character. In their perception, the care receiver is most important, but this also means that no risks will be taken. This protective view, possibly also due to a need for controllability, may in some cases result in situation that are too safe, in which elderly people are insufficiently stimulated to undertake actions by themselves and thus stay independent. Elderly people who move to a care facility often show a great regression in their functioning and their abilities, due to the increased support in comparison with the home situation. One of the goals of the caregivers should therefore be: continuation and stimulation of the independence and autonomy of the care receiver. Becker [13] refers to this inevitable change as "making care humane". He considers caregivers as the "suppliers of human luck". The protective mentality of caregivers also results in the protection of privacy of the care receivers. Caregivers are well-aware of the fact that people who are in need of care always have to deal with a loss of privacy. Protecting the remaining part of their privacy is one of the main issues for caregivers. Several studies, however, have shown that people in need of care are willing to lose some privacy if they get more independence or quality of life in return [14, 15].

In the study by Kearns et al. [14] the perspectives of 6 focus groups, including elderly nursing home residents, volunteer caregivers, care staff, medical surgical

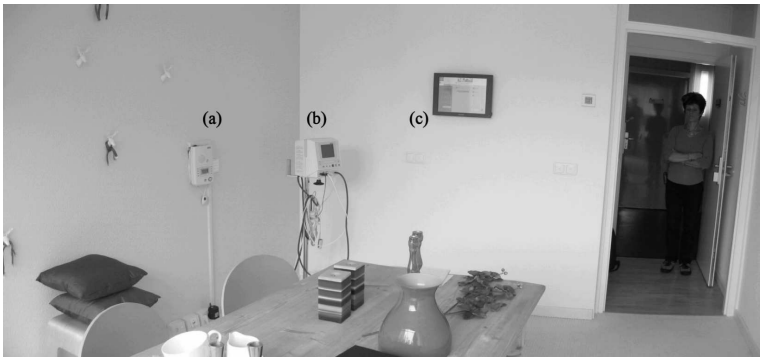

Fig. 1. Demonstration room with smart home technology: (a) Alarm unit; (b) Telemedicine monitoring system; (c) Touch screen with electronic patient file.

staff, and engineers, were combined to find requirements of elopement management systems. Although all focus groups agreed on the use of a non-stigmatizing device to attach to a wanderer (an inconspicuous device should, for instance, resemble a necklace or a watch), there was a different perception on the use of an implanted "tracking chip". The elderly focus group was less reluctant towards using an implanted chip than expected. When privacy and ethics were brought up by the researcher, it was quickly diminished as secondary. Apparently safety and independence are more important to elderly people than privacy. Kearns et al. refer to this as the liberating role of technology.

In a study by Willems [15] both elderly people and caregivers were asked to interpret the smart home technology available in a demonstration facility. One of the rooms of the demonstration facility is depicted in Fig. 1. The study showed that caregivers are more focussed on safety and security technology that may prevent harm and injuries, while elderly people are more eager to agree on care technology. Although the elderly subjects found an alarm unit useful for safety issues, they did not believe it would be necessary for them. This finding can be explained by the negative stigmatizing association that seems to overrule the positive safety effect of an alarm unit. On the other hand, elderly people are willing to hand in some of their privacy in order to facilitate the care giving process. Caregivers only agreed on the technology when they were sure the care receivers fully accepted the technology.

There is clearly a different interpretation between caregivers and care receivers in how smart home technology can be helpful supporting independent living of elderly people. While "implantables" seem accepted by the elderly, caregivers as well as researchers [16] believe that even more common technology applications likethe use of cameras for remote monitoring of people with mental disabilities is ethically not acceptable. Caregivers should realise that in situations where cameras are used to increase the safety and independence of the mentally disabled, care receivers will probably agree on the use of cameras despite the loss of privacy. The lack of concern about privacy might be ascribed to technological

and social developments, such as cell phone networks, cameras in public spaces, blogs and home videos on the world wide web, and reality television shows like "Big Brother". Privacy is becoming a global good, and in some situations less relevant than safety.

Another explanation for the different perceptions between caregivers and care receivers, may be the fact that caregivers have certain habits that do not always correspond to the clients' needs [17]. As the care giving process often does not involve technology use, caregivers may react quite reluctant towards the implementation of smart home technology, and its accompanying procedures. This preference for care giving in the way people are accustomed to irrespective of care receivers' needs, does also apply to situations in which technology is used. Patient lifts, for instance, are often used in situations where clients actually do not need a lift yet [18]. Apparently caregivers accept those technologies they are accustomed to in care giving situations. These technologies, however, are often prescribed by protocols in which the labour conditions are set, which are rigidly applied to all situations (independent of client needs). Caregivers should better deviate from routines and make use of only those technologies, including new ones, that serve the needs of the care receiver. To implement smart home technology properly, caregivers have to become aware of their habits by analysing their perceptions and their way of acting.

Studies on technology perceptions of caregivers and care receivers are important to understand the acceptance of smart home technology, although these perceptions may change over time, due to experience. In the study by Willems [15] the answers were given in foresight: respondents were asked to reply on a situation which they were not yet familiar with. Answers may therefore be different than if respondents are living in a smart home, or have to work with the technology in a care setting. A passive alarm, for example, a basic functionality in many smart homes in the Dutch "Vitaal Grijs" program, appeared not to be as effective as expected before implementation [19]. On the basis of (negative) user experiences the functionality was disabled or removed in most houses. This indicates a difference between expected benefit and experienced benefit. But also questions like "willingness to pay for", as in the study by Willems [15], may result in responses different than can be expected on the basis of actual purchases and use. In case of an active alarm unit, elderly people are reluctant towards buying the technology, as initial costs are relatively high while benefits are unknown. After (effective) use people appear to judge this technology and its costs positively, as the usefulness becomes obvious (see [20] on the role of usefulness in technology acceptance).

4 Perceptual Differences on Requirements between Designers and Care Receivers

A design engineer of smart home technology for older care receivers should be able to understand the needs and wishes of the users. The designer, however, has to deal with a potentially technofobic user but also with an older user. The

Fig. 2. The room controller allows you to control lighting, room temperature, and television, for example. This room controller is negatively evaluated by both care receivers and caregivers, mainly due to poor legibility [15].

process of aging brings along many limitations or disabilities that are difficult to imagine for a non-limited and non-disabled designer. During a symposium [21] this gap was described as: "young males have to design technology for old females". Although the emphasis should not be so much on the gender difference, the age difference is truly a relevant factor [22]. As described earlier, aging often brings along changes in vision, hearing, attention, and memory. Additionally, physical disabilities due to rheumatoid arthritis or paralyses due to a Cardiovascular Accident (CVA) happen more and more often. Designing technology considering an average adolescent would not be very useful in this case, as an adolescent differs strongly from an elderly person on these physical factors. In case of sound-signals, for example, the designer must be aware of the fact that elderly people can not or hardly hear sounds of 2000Hz and above. Also, no robust actions should be needed for handling the devices, and no difficult procedures should be required. Buttons have to be larger, symbols or texts should be well-legible, and thus larger, due to decreased vision. An example of such designer/user gap is found in Fig. 2 that shows a room controller with poor usability. The design of the interface does not correspond with the abilities and expectations of the (elderly) user. The LCD screen, for example, is difficult to read, due to bad illumination and low contrasts. The use of both sides of the device as buttons is not in correspondence with intuitive use, which is important particularly for elderly users, as they have difficulties learning new skills. Depending on the limitations of the end-user, the design requirements should be altered, in favor of the user (see for example [23] on design principles for elderly). Although all design principles may be relevant when designing for the older care receiver, the consequences of their limitations for the design obviously depend on the intended functionality, and should therefore be considered separately for each technological design.

A solution to the difficulties elder care receivers experience when using (smart home) technology may be found in "inclusive design", "design for all", or "universal design". Designers of technology for the elderly have been requested for inclusive design by gerontologists for quite some time [24, 25]. Inclusive design implies that older and disabled people are part of the potential user groups in all product development processes. The design for older (and disabled) people, however, requires special attention for their needs and abilities. We may question whether designing for "all", including the elderly and the disabled, is useful and appealing to a young non-limited person. We believe it is more important that the designer of new technology takes into account those needs and wishes of the user he is designing for. This design process, however, should not only focus on the technological usability specifications, as Nielsen proposes in his user-centered design [26]. As in scenario-based models [27, 28], the technology should be viewed from different approaches. However, it should concern an iterative process in which not only the expectations people have of the technology and its interaction with their environment are taken into account, but also their eventual experiences with the technology. We expect best results when the design process involves all relevant stakeholders, at several stages of the process.

5 Perceptual Differences on Functionality between Designers and Caregivers and Relatives

The design engineer, or technician, clearly believes in the functionality of the technology. The other stakeholders, in most cases, rely on the designer's knowledge and promises. This may result, however, in expectations that are too high. The study by Raappana et al. [8], for example, shows that relatives and caring family members were satisfied with the technology, as they had the feeling that the safety of their relative was secured. One of the problems caregivers saw in the interaction between caring family members and the technology, is that they relied more on the technology that was actually possible. Relatives should be informed that the technologies cannot replace all health monitoring, while technicians should be honest about the (im)possibilities of technology [10].

Another barrier designers experience with caregivers is the so called *not invented here syndrome* [18,29]. The fact that the technology is not solely designed for care purposes, or that is designed for another care institution is often used as a reason not to accept the technology in the care professional's own organization. Care institutions however should better be open to knowledge of, and experience with technologies used in other places in order to learn from it and make better (smart home system) decisions.

6 Analyses of Multidisciplinary Stakeholders' Perceptions

To decrease the perceptual differences between the stakeholders, we propose an analysis of the expected and experienced effects (E-E Analysis) of smart

home technology in care situations for each group. This means we are not only aiming at effects in relation to "effectiveness" - is the technology doing what it is supposed to do? - but also effects on the relationship between caregiver and care receiver, effects on the well-being of the client, on the nature of care giving, and matters like privacy, safety, security, and many more [18].

We are not only dealing with a gap between perceptions of various stakeholders, but also a difference between technological possibilities, related expectations, and the eventual use of the technology. The expectations and the actual use, including the subjective evaluations of the use, differ along the stakeholders and should be taken into account for successful implementation of smart home technology. This is why the analysis should include the expected and experienced effects of smart home technology of each stakeholder. The survey of these effects on all levels requires a multidisciplinary vision on this issue.

For the E-E analysis of effects the attribute-consequence-value *(A-C-V) model* [30] can be used, to get to higher and lower level effects. Attributes relate to aspects of the product or service, like functionality and design, on a very basic level. Consequences concern the functional and psychological effects of the technology, e.g. technology acceptance, while values resemble higher order merits, such as goals. The next step is to survey these attributes, consequences and values for each stakeholder involved. It is important to analyze the different layers of the technology, ranging from the functionality of the system to the behavior of people. While the designer may only be looking at the functionality, and whether or not the technology functions right, the user is interested in lower level effects, like the usability of the interface or the effect of the environment on the technology and vice versa.

To increase the acceptance and use of smart home technology, the technology should fit into the daily routines of users and end-users. The designer must be aware that his design determines how the technology intervenes with the orderliness of life-supporting everyday activities. The design of the technology may have an impact on timeliness, reliability, dependability, safety, and security [6]. Cheverst et al. propose a full user needs assessment, to analyze how the (end)user interacts with the technology from a psychological, emotional, physical, and social perspective. Also broader social and ethical effects of the technology should be identified and taken into account by the designer. As long as there are difficulties with the acceptance of smart home technology, the designer must consider an iterative design process [31], in which problem specification, matching the system to the real world, and the evaluation are an ongoing process [6]. The analysis of the effects should thus include a user-technology interaction assessment on a daily routine scale.

The E-E analysis thus displays possible mismatches between stakeholders as well as between expected and experienced effects. The implementation of a passive alarm, as mentioned earlier [19], is a good example of these differences between stakeholders and expectations and experiences. Care receivers expected great usefulness of a passive alarm, as it would give them feelings of safety and security. Their experiences after implementation, however, were feelings of insecurity and unreliability due to a high amount of false alarms. A false alarm is generated when elderly people forget to turn the switch in their house to indicate whether people are home or not. The - misplaced - expectation of the design engineer and the caregivers was that care receivers would be able to learn this new routine. By taking all of the effects into account in an iterative smart home design process, the design would better not contain a switch that needs action by an elderly user. A more valuable and less preferred solution that was chosen in the "Vitaal Grijs" project, however, was to disable or remove the technology [19].

The E-E analysis can not only be made by taken into account the expected effects on each stakeholder, but also by actually including the (end)users in the design process. Several studies have focussed on involving caregivers or elderly care receivers in the designing process [22]. In specially built user centers, user experiences can be tested beforehand, in the prototyping phase [32,33]. Another method occasionally applied is the use of drama [34]. These time-consuming processes, however, become less urgent when designers are aware of the perceptual world of caregivers and care receivers.

Analyzing the expected and experienced effects of smart home technology for each stakeholder involved, leads to better insight into human-technology interactions, which will result in better choices in the design process and system development. The possibility that the technology will not be accepted by the (end)users decreases, which will cut down expenses. At the end, the analysis may lead to the development of standardization in smart home technology. The downside of the analysis are the extra work and initial costs involved, although this will be compensated by the increase in technology acceptance. As the benefits of the investment are unclear until later, the return of investments appears negative at first. This is also the reason why care organisations are quit reluctant towards large-scale implementation of smart home technology. The initial costs of the technology and the organisational changes are relatively high, while the benefits (reduction in workload and costs) only become obvious after even more investments (increased workload). Additionally, we may also question whether elderly care receivers as well as caregivers actually know what is best for them. The latter implies that a multidisciplinary view, by combining all stakeholders' perceptions is crucial for effective smart home technology implementation.

7 Discussion

To decrease the perceptual differences between the stakeholders, we proposed an analysis of the expected and experienced effects of smart home technology (E-E Analysis) in care situations for each group. For designers the effects will involve effective goals, caregivers are mainly interested in effects on workload and quality of care, while care receivers are influenced by usability effects. It is not the case that technological possibilities are insufficient to solve the problems with smart home technology in care situations. Actually, on a technological level even more is possible than is yet applied in so called "smart" technology. Maybe the problem lays more or less in the functionalities of smart home technology that do not correspond to the actual needs of the care receivers or caregivers. Even though many researchers have stated that user requirements should be taken more into account in smart home projects, much technology development is driven by technological possibilities (technology push). The actual users obviously need to get involved in the development and implementation process of smart home technology. By involving the care receiver and the caregiver in the process, the designer may gain more insight into the true perceptions of the stakeholders he or she is designing for. As a result, the list of functional requirements for

a smart home system or a smart home project must consist of more than just technological functionalities, and should comprise all stakeholders' attributes, consequences, and values. Finally, stakeholders should not only be aware of the expected effects, but also of the actual experienced effects, which may influence the list of requirements.

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