User representations in the design process of Ambient Assisted Living technologies

25-06-2013

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Abstract

This paper identifies the user representations present in the field of Ambient Assisted Living (AAL) technologies and explains how they emerge. The reason for investigating this is that Ambient Assisted Living technologies are seen as a solution to combat the challenges Western economies face through demographic ageing. The increase of elderly people would put pressure on current health care systems as elderly are care-needing. Generally, elderly people are positioned as weak and frail people. As such images also underlie innovation processes in AAL, this would strongly influence the design of those technologies. In order to explain how the user representations emerge a framework on sources of use knowledge developed by Peine & Herrmann (2012) is used. This framework characterizes different sources of which use knowledge can stem from. Use knowledge can be described as knowledge about users and their needs and preferences, as well as knowledge about the functionality, usability and utility of a technology (Peine & Herrmann, 2012). Consequently, designers make their user representation on basis of this use knowledge. To investigate the user representations present in the design process of AAL scientific articles and documents were analysed. The results of this research show that also in the field of AAL narrow user representations of elderly users are present. The roots of these narrow user representations can be found in implicit representation methods of designers, as for instance earlier experience in the field. Consequently, the image created with this implicit representation guides the methods of more explicit representation methods. These narrow user representations bear several risks for AAL technology design and the users of the technology. Technology acceptance does not seem to be high due to stigmatization of elderly by technology. Also easy to use technologies that limit functionality are found to be not attractive. The research concludes that AAL technology should address both compensating technologies for disabilities elderly have, as well as technologies related to autonomy enhancement and life enrichment.

Contents

1. Introduction

1.1 Problem area

According to the World Health Organization, population ageing is one of humanity's greatest triumphs because of public health policies as well as social and economic development (World Health Organization, 2002). However, in recent years demographic ageing has become one of the biggest challenges western economies face. Statistics of the United Nations show that in developed regions the percentage of people with an age of 60 or over will increase from 19% in 2009 to 34% in 2050 (United Nations, 2009). This major increase in the number of elderly people will have its consequences for society. One of the consequences of demographic ageing that affects society is being found in health care. Generally, elderly people are related to diseases and disabilities, i.e. care-needing. With a larger percentage of care needing people the pressure on health care systems is increasing (Beard, 2010). Costs of aged care and health care in general are increasing and qualified personnel to care for older people is getting scarce (Sparrow & Sparrow, 2006). Although these are real problems, it is a narrow image to look at elderly people as being weak and frail and solely care-needing. This relates to earlier research by Rowe & Kahn (1997) who state that ageing is not only a biological process in which elderly encounter age-related losses, but that the ageing process also can be influenced by extrinsic factors. In this sense they proposed the term 'successful ageing' which they define as: "Including three main components: low probability of disease and disease-related disability, high cognitive and physical functional capacity, and active engagement with life" (Rowe & Kahn, 1997, p. 433). As can be seen, successful ageing is thus not only related to the care-needing aspect.
Besides, elderly people prefer to live independently as long as possible in their preferred environment instead of nursing homes for instance (Gibson, 2003; Sparrow & Sparrow, 2006). If this could be achieved it would thus reduce costs related to health care and it would satisfy the elderly. The World Health Organization argues that countries can afford to get old if governments, international organizations and civil society enact "active ageing" policies and programmes that enhance the health, participation and security of older citizens (World Health Organization, 2002).

In the research field of Gerontechnology, which is a combination of gerontology (the scientific study of ageing) and technology (Fozard, Rietsema, Bouma, & Graafmans, 2000), the overall goal is to explore the impact of technology on the quality of elderly peoples' lives and the process of individual ageing (Peine, 2007). In this field applications of Ambient Assisted Living (AAL) technologies and services are seen as an opportunity to enhance the quality of life of elderly people (Kleinberger et al., 2007; Sun et al., 2010). Ambient Assisted Living is an aggregation of Ambient Intelligence and Assisted Living. It means that Ambient Intelligent technologies are used to assist people with specific demands in their daily living. Ambient Intelligent technologies refer to intelligent, personalized, interconnected systems and services (Aarts, 2004) that are able to communicate with each other and with the user. The main goal of Ambient Assisted Living is thus to use innovative ICT-based products, services and technologies to enable people with specific demands, e.g. elderly, to live in their preferred environment longer (Kleinberger et al., 2007). Examples of AAL technologies for ageing at home include sensors measuring heart rate, blood pressure, and other vital signs providing the possibility of accurate and real-time control of the user's state of health, with mobile communication devices automatically dispatching emergency calls if necessary, automated household functions as regulating temperature and lighting, interpersonal communication technologies, etc. (Kleinberger et al., 2007; Emiliani & Stephanidis, 2005). These technologies thus vary from directly health related technologies to more life enrichment technologies.

When addressing societal needs by means of technological solutions, this inherently means thinking about how the technology is used and what characteristics the users have. As already mentioned by Fleck (1993), successful implementation of technologies implies both incorporating local practical knowledge and generic technology knowledge. This local practical knowledge includes knowledge about users and their needs and preferences, as well as knowledge about the functionality, usability and utility of a product or technology, i.e. use knowledge (Peine & Herrmann, 2012). According to van Lieshout et al. (2001) designers do not simply develop an artefact, they first develop some concept of the use context and lifestyle; a user representation. A user representation thus refers to the images designers have of potential users of technology (Akrich, 1995). These user representations are thus based on use knowledge and inform the design process. In order for designers to obtain use knowledge earlier research agreed on the importance of involving users in the design and development processes of innovative products and technologies (Haddon, 2002; von Hippel, 1988; Kujala, 2003) as user producer interactions increase chances for successful innovations (Nahuis et al., 2012). However, there are also studies which state that designers and producers should be careful in involving users because end-users may not be aware of their needs and may not be able to articulate them (Hekkert & van Dijk, 2001; van Kleef et al., 2005). In addition, empirical studies show that designers often are unable or fail in taking into account user needs (Panne et al., 2003; Coombs et al., 2001; Cooper, 1999). However, in order for designers to get insights in this 'use knowledge' several methods and techniques may be used. Some examples of these methods are for instance market surveys, pilot use of technology and user feedback after technology use. The methods that are used thus encompass different sources of use knowledge. This implies that designers can tap into different sources of use knowledge (Peine & Herrmann, 2012). These sources of use knowledge will be elaborated in the theoretical framework.

1.2 Research questions

Although the link between user representations and design is clear, there has been little attention paid to elder technology users and their user representations (Neven, 2010). Hyysalo (2003, 2006) did investigate methods used to obtain use knowledge and how users were represented in the case of a wrist-held safety device which aims to bring enhanced security for the elderly by monitoring the user's health continuously and activating an automatic alarm if the user's physical condition suffers a major change. However, Hyysalo was interested in design processes and the way in which users were represented in general. This research explicitly focusses on older technology users and tries to explain how certain user representations of older technology users come into existence. Next to older users of Ambient Assisted Living technologies, in the case of technologies directly related to health, public service providers are also likely to play an important role in the design process of these technologies (Peine, 2007). However, the focus in this research is on elder (potential) users of Ambient Assisted Living technologies. Elders are often positioned as having deteriorating health and needing costly care which is a narrow user representation of elders in which old age is strongly related to illness, frailty, lost competences, and expense (Neven, 2010). As such narrow user representation also underlies the innovation processes in Ambient Assisted Living technologies it will strongly influence the design of these technologies.

In order to gain a theoretical understanding of what user representations of older technology users exist and how they emerge in the design process of Ambient Assisted Living technologies, scientific articles and project documents are analysed. The reason for this is that scientific articles and documents are numerous and are likely to embrace multiple methods of obtaining use knowledge. To

this end the goal of this research is to investigate what user representations of elder users can be identified in the design process of Ambient Assisted Living technologies for ageing at home and explain the way they emerge. This results in the following main research question:

What user representations of elderly can be identified in the design process of Ambient Assisted Living (AAL) technologies and how can their emergence be explained?

In order to give an appropriate answer to this main research question, sub-questions are used to structure the research. The first sub-question relates to the user representations present in the design process of AAL technologies:

-*What user representations of elderly exist in the design process of Ambient Assisted Living technologies?*

In order to answer the second part of the main research question the methods and techniques used by designers to generate use knowledge have to be investigated. However, as said, by using different methods and techniques designers can tap into different sources to obtain use knowledge on which user representations are based. Therefore, the second sub-question becomes:

-*What sources of use knowledge were used by designers to obtain use knowledge regarding (potential) elder users of Ambient Assisted Living technologies?*

1.3 Relevance

The theoretical relevance of this research is that it contributes to a theoretical understanding of how a societal issue as demographic ageing becomes articulated in innovation processes. More specific, this research aims to fill the gap of the lack of understanding of what user representations of older technology users exist and how these user representations come into existence. It contributes by giving insights on how use knowledge is obtained and used in making a representation of the (potential) elderly user of AAL technologies and thus how use knowledge is used in the design process of AAL technologies. Since policy makers try to steer technological developments in desired directions, more insights in how use knowledge is obtained and how this influences user representations that underlie innovation processes is of societal relevance. Better insights could help policy makers in making policy that is more effective. Nowadays, a lot of money is being spent on projects on Ambient Assisted Living. For example, The Ambient Assisted Living Joint Programme which consists of 23 European countries has a total budget of more than € 100 million a year (ZonMw, 2012). More effective policy would thus increase efficiency of money being spent. In addition, the user representations of elderly users by designers influence the design process. More insights in these user representations and the way they come into being contributes to improving AAL technologies in order to better match elderly's needs and preferences with the ultimate goal of improving acceptation among elderly users.

The remainder of this research is structured as follows. In chapter two of this research the theoretical framework is described. Next, the methodology chapter elaborates on the research design chosen for this research, the case selection and data collection and analysis. In chapter four the results are presented and consequently analysed. Then, the conclusion chapter provides an answer to the research question proposed. Finally, the results are discussed and theoretical and practical implications are given as well as limitations of the research.

2. Theoretical framework

2.1 User representations

Regarding design processes of technology various concepts and theories have been developed. Important insights have emerged from Science and Technology Studies (STS) which study the ways in which technologies and users are co-constructed (Neven, 2011). In the so-called semiotic tradition in this strand of literature research looked at producers of technologies and how they generate knowledge about future users and use (Peine & Herrmann, 2012). A classic work in this regard is produced by Woolgar (1991). In his case study regarding a new micro-computer, he demonstrated how 'the user' was constructed from multiple viewpoints of users and use. Consequently, this construction was inscribed into the computer which resulted in several types of possible user actions. So in this sense not only the user is constructed (through designers) but also its possible actions are configured by means of the technology that is designed. However, Woolgar (1991) with his notion on configuring the user has been criticized. Firstly, designing is seldom conducted by one actor (designers) solely. Rather it is a process of interaction among several actors with various concerns and agendas (Stewart & Williams, 2005). Innovation is also not restricted to design, but continues throughout implementation and use. So the idea that users are just recipients of technology may seem somewhat simplistic. For instance, Pinch & Bijker (1984) came up with the term 'interpretive flexibility' which means that there is flexibility in how people think of, or interpret, technologies.
To elaborate on this, the term 'script' introduced by Akrich (1992) may be helpful. Also for Akrich (1992), designers inscribe a vision of future users and use into technology; a user representation. A user representation is a concept which refers to the explicit and implicit images designers have of potential users of technology and influences the decision making in design processes (Akrich, 1995). A user representation is thus a kind of projection of potential users built around various kinds of knowledge of potential users of technology. Eventually, such user representations can be built into a technology. This inscribed user representation consequently defines preferred programmes of action by users. So, user representations matter as: "The creation of successful artefacts depends on the ability of innovators to generate user representations and integrate them into their designs" (Akrich, 1995, p. 169). However, according to Akrich (1992), technical objects become real only through the use of actual users. Therefore, it is the adjustment between envisioned and real users that determines the success of a technical object. Naturally, users may also not subscribe to the script and develop alternative ways of using a technology; they try to renegotiate the original script. User representations, unlike configuring the user as described by Woolgar (1991), focus only on the way users are imagined in design processes and therefore allow analytical separation of imagining users and 'scripting' these images into technology (Neven, 2011). Existing research however mainly looks at how user representations are scripted into technology, but scarcely at how such user representations emerge (Peine & Herrmann, 2012). This research aims to fill this gap by looking at how user representations come into existence by focussing on the design process of AAL technologies.

2.2 User-involvement

In order to develop user representations designers make use of some kind(s) of use knowledge. This use knowledge can stem either from the user as well as from the designer. Use knowledge stemming from the designer is often referred to as the 'I-methodology', where designers project themselves as future users (Akrich, 1995). These implicit representations of use have been shown to be highly influential in the actual design process (Akrich, 1992; Akrich, 1995; Hyysalo, 2006). However, relying only on use knowledge stemming from designers would bring a very superficial image of prospective users and use to life. Therefore, use knowledge located at the user has to be obtained by

designers to develop more complete images of users and use. In this sense designers thus need to obtain knowledge about users' needs and preferences. However, user needs and preferences are not static but co-evolve with the specification of the design of a product or technology. These can be formed and changed in the process of product development and the use of products or technologies (Peine & Herrmann, 2012). In addition to this, Hyysalo (2003) argues that users can't have articulated preferences or needs for a product or technology that differs radically from their present practice and knowledge. In the face of these perceived problems user-centred design approaches (and also ethnographic studies) were adopted, in contrast to design centred approaches, which sought to develop richer understandings of the context and purposes of the user and build these understandings into technology (Stewart & Williams, 2005). Although the shift towards these approaches represent a positive development since these approaches produce much user related knowledge, it becomes dangerous to build in ever more extensive knowledge about the specific context and purposes of various users into design. As Stewart & Williams (2005) state: "In large degree the shortcomings of this view arise because the emphasis on the complexity, diversity and thus specificity of 'user requirements and contexts' (and the consequent importance of local knowledge about the user) is taken up within an essentially linear, design-centred model of innovation to emphasise the need for artefacts to be designed around the largely unique culture and practices of particular users". This implies that generalisation, which is required for effective design, becomes difficult. Basically, the design-centred model and the user-centred model can be seen as two extremes in which the first can be linked to the technology push model and the latter to the demand pull model. These linear models of thinking about innovation can't explain technological change appropriately since innovation is a process that responds to the supply and demand side at the same time (Dosi, 1982; Nelson & Winter, 1977). So in this sense, designers may need to balance between generic and specific designs.

2.3 Sources of use knowledge

Designers can use different methods and techniques to obtain use knowledge, as for instance prototype testing, interviews, focus groups and more implicit methods as for instance the I-methodology as mentioned earlier. Peine & Herrmann (2012) developed a framework in which they describe different sources of use knowledge. The methods and techniques employed by designers to generate use knowledge can be linked to specific sources of use knowledge which makes this framework relevant for this research. This is because it can help explain how certain user representations emerge. To clarify, prototype testing, for instance, is a method which delivers a certain kind of use knowledge by directly involving the user. This thus is a form of direct representation. Peine & Herrmann (2012) reviewed three strands of literature which see innovation as a process that combines knowledge of designers and users: user innovations, Science and Technology Studies (STS), and domestication research. In the user innovation literature the focus has been on the user as the source of innovation (v. Hippel, 1988). Science and Technology Studies have focused on the way users are imagined and constructed along technological design processes (Akrich 1992; Woolgar, 1991). Domestication research engages in how new technology is appropriated by its users (Silverstone et al., 1992; Silverstone & Haddon, 1996). Peine & Herrmann (2012) identified in these strands of literature six different sources of use knowledge into which innovators can tap:

- *Non-representation*: Users are not involved in the design process, nor is a representation made of them. Designers obtain use knowledge by means of personal experience and imaginations circulating in their professional network.
- *Implicit representation:* Earlier experiences in the field and technical traditions unconsciously form the basis of representations of use.

- *Indirect representation:* Use knowledge is based on the expertise of experts. These experts may be, for instance, consumer lobby groups or patient organizations. Such stakeholders may stimulate upstream demand articulation, which Boon et al. (2008, p. 645) formulate as: "An iterative, inherently creative process in which stakeholders try to unravel preferences for and address what they perceive as important characteristics of an emerging innovation". Also for instance literature studies comprise an indirect representation about users and use. All these sources of use knowledge have in common that they rely on generalized knowledge.
- *Direct representation:* Use knowledge stems from an empirical investigation of users and use in the context of a specific innovation project. In this sense are users directly involved by means of surveys, interviews, focus groups, user testing, etc.,
- *Co-creation:* Users participate directly with designers in order to co-create an innovation.
- *Domestication or learning by using*: When users appropriate a certain innovation and thus domesticate it, they start to create use knowledge. Users learn about the innovation's meaning and functions while using it.

3. Methodology

3.1 Research design

The aim of this research is to investigate what user representations can be identified in the design process of Ambient Assisted Living (AAL) technologies and to explore the way they emerge. To investigate this, the research is structured by means of sub-questions which firstly aim to identify different user representations in the design process of Ambient Assisted Living technologies and secondly aim to explore methods used to obtain use knowledge regarding (potential) older users of Ambient Assisted Living technologies. The framework developed by Peine & Herrmann (2012) is useful in this regard to identify the sources of use knowledge designers of AAL technologies make use of. The design process of Ambient Assisted Living technologies is quite a new and complex phenomenon and therefore an exploratory research is useful since it provides the researcher with detailed insights that can contribute to theory, i.e. abstracting away from the empirical level. The design process of Ambient Assisted Living technologies is thus the main element under study (the unit of analysis), i.e. the case. Although Ambient Assisted Living technologies embrace multiple technologies, these can be placed in the field of Ambient Assisted Living. Adopting a case study as research design thus allows for an extensive and in-depth exploration of what user representations are present and how they emerge in the field of Ambient Assisted Living technologies (Yin, 2003).

This research has made use of qualitative data sources. Qualitative research was an appropriate way to investigate the case of the design process of Ambient Assisted Living technologies since qualitative analysis offered a systematic and controlled way of analysing the data sources and thus resulted in gaining a deeper understanding of user representations and the way they come into existence (Bryman, 2008). As data sources, scientific articles and documents were analysed. The reason for this was that scientific articles and documents are numerous and are likely to embrace multiple methods of obtaining use knowledge. In theory building research the process of 'theoretical saturation' is an important aspect which means that new data do not add to theory anymore (Goulding, 2002). However, theoretical saturation is not actually reached in this research, but the amount of articles and documents that were analysed were useful in the verification of concepts as will be explained in the data analysis section. Although this research relied on secondary literature and studies, these studies contained sufficient empirical detail to obtain fresh insights about user representations and the way

they emerge in the field of AAL. The goal of this research was therefore to generalize results to theory rather than providing full evidence or truth statements.

3.2 Case selection

As demarcated in the introduction, this research focusses on older users of technology. In order to investigate how user representations of older technology users come into being this research took the design process of AAL technologies as case. AAL comprises an emerging technology which is solely directed at older people's lives. In the design process of AAL technologies there is a lot of user involvement as an initial search in the scientific database Scopus showed. The amount of user involvement in the design process of Ambient Assisted Living technologies made it an appropriate case to investigate user representations and the way they emerge since multiple methods of obtaining use knowledge were present. This made it possible to identify user representations and explain how they are formed. The field of Ambient Assisted Living technologies embraces a large pool of different technologies related to security, health, home-automation, communication, etc. So, Ambient Assisted Living comprises technologies directly related to health as well as technologies related to life enrichment. In practice these technologies can also be integrated in one technical system. For instance, a robot that assists with medication reminding and also provides interpersonal communication technology. For this reason technologies addressing one sort of the technologies or both at the same time are selected.

3.3 Data collection

An initial exploration of the field of Ambient Assisted Living technologies indicated that AAL has a lot of overlap with other concepts as ambient intelligence, home automation, home care systems, etc. Because of this a lot of different combinations of search queries were possible and were used in searching appropriate scientific articles and documents. In order to investigate what methods designers use to obtain use knowledge located at users, the data to be analysed had to include some form of user involvement in technology development related to Ambient Assisted Living. In selecting scientific articles and documents this was taken in mind.

In this research there is made use of theoretical sampling. This means that first some data was collected and consequently analysed to form initial concepts. Thereafter, new data was collected to refine those concepts. The processes of data collection and data analysis are thus not two separate processes but are interrelated. An initial search in the scientific database 'Scopus' on search queries as 'ambient assisted living AND elderly', 'ambient intelligence AND ageing', 'home automation AND elderly' indicated that the journal *Lecture Notes in Computer Science* was a leading journal in this field as it revealed by far the most articles. So as a first data source the journal *Lecture Notes in Computer Science* was selected. This journal contains several sub-disciplines as Human-Computer Interaction, Information Systems and Applications and Communication Networks and it publishes scientific articles on new developments in computer science and information technology research. It was an appropriate journal to analyse as starting point since an initial scan of abstracts of articles in this journal showed the presence of numerous studies on elderly user involvement in Ambient Assisted Living technologies. The abstracts of the scientific articles found were read in order to determine if the specific article dealt with Ambient Assisted Living technologies and some form of user involvement. Eventually, this resulted in 19 articles in this first journal that were published between 2008 and 2012. Also, when reading articles from this first journal, interesting references to other scientific articles (five articles) were found and consequently analysed. This is in line with the theoretical sampling process as it provided promising data in answering the research question. Next to

the articles in the first journal and the references mentioned, I have searched in Scopus on the search queries mentioned before for other scientific articles in order to further refine the concepts. This resulted in another 10 scientific articles published between 2004 and 2013. The reason for an open search in Scopus on the search queries mentioned, instead of selecting another journal, was that the articles outside the journal *Lecture Notes in Computer Science*, were quite spread over several journals.

Next to the scientific articles, project documents regarding Ambient Assisted Living were searched for in European Framework Programs by making use of the CORDIS (Community Research and Development Information Service for Science, Research and Development) website. Also for these documents the same search queries were used as for the scientific articles. This resulted in project documents from the 6th and 7th Framework Programme. In order to include documents the abstracts were read to see if there was some form of user involvement in the specific project. In addition, project documents were searched for in the Ambient Assisted Living Joint Programme which is a joint association of 23 European countries funded by the EU. The projects on their website are divided in several calls. In order to refine concepts, projects in call 3 (ICT-based Solutions for Advancement of Older Persons' Independence and Participation in the "Self-Serve Society"), were selected. The reason was that projects related to life enrichment could contribute to concept refinement at that time as technologies related to health were already abundant. Also for these project documents it was judged if there was some form of user involvement in the project when including these documents. Eventually, 11 documents published between 2008 and 2012 were analysed.

3.4 Data analysis

The first sub-question of this research aims at identifying user representations of elderly in the design process of Ambient Assisted Living technologies. In order to accomplish this, the data is analysed using the notion of a sensitizing concept as introduced by Blumer (1954). Sensitizing concepts, in contrast to definite concepts, give the researcher a general sense of reference and guidance in approaching empirical instances. Whereas definitive concepts provide prescriptions of what to see, sensitizing concepts merely suggest directions along which to look (Blumer, 1954). Prior theory on sources of use knowledge (Peine & Herrmann, 2012) and user representations (Akrich, 1995) served as inspiration in identifying a sensitizing concept. In this research the concept of 'use knowledge' regarding elder users of Ambient Assisted Living technologies is used as sensitizing concept. 'Use knowledge' includes knowledge about users and their needs and preferences, as well as knowledge about the functionality, usability and utility of a product (Peine & Herrmann, 2012).

The first step in the process of analysing data consisted of writing memos which are analytical writings that contain a brief description of the article or document and help moving beyond the raw data. In this research the content of these memos mainly focusses on the methods used for obtaining use knowledge and a description of the use knowledge obtained through these methods. After some memos of articles had been written, open coding was applied to these articles. In the process of coding the software programme NVivo10 was used. This program was very useful since it constituted a clear overview of all the coded data. First, the articles were 'segmented' which means that units of meaning (key words or phrases) in solving the (sub) research question were identified and placed in initial concepts. The sensitizing concept of 'use knowledge' regarding elder users of Ambient Assisted Living technologies was useful in this since it helped to identify knowledge on user needs and preferences as well as technology knowledge. Regarding user needs and preferences, for example, the following phrase: "The participants expressed concern regarding losing abilities if they rely on technology to do tasks they can do themselves" (33), was selected as unit of meaning as it includes

knowledge about what users prefer, namely they want to enhance their autonomy instead of only relying on technology to do tasks. Regarding to technology knowledge, for example, the following phrase: "Simplicity is highly important, not only in terms of usability but also in terms of the activity design. The activities have to be easy to understand, to learn and to conduct." (6), was selected as unit of meaning since it includes knowledge on how technology should function and what the ease of use should be. When coding an article, these initial concepts were constantly compared with each other and with units of meaning from other articles. Since concepts were developed right from the start of the analysis process these were provisional and were adjusted due to constant comparison. The amount of articles and documents used in this research contributed to the verification of the concepts by means of this constant comparative method which contributed to more valid findings (Silverman, 2005). For instance, in the beginning a lot of phrases related to different health shortcomings were found. Initially, these were coded as, for example, 'cognitive shortcoming', 'bad vision', 'bad mobility', etc. However, after comparing some of these codes across articles it was decided to group them in the concept 'impairments'. For more examples of how the concepts are constituted see the appendix[1].

In the next step, which can be called axial coding, those concepts are selected that seem most promising in answering the research question. Concepts with a lack of recurrence in the data or without explanatory power were left out (Goulding, 2002). Consequently, the selected concepts were compared on their properties and relationships. To give an example, technologies related to 'personal safety and security' were often designed for compensating specific 'impairments' which can be assigned a 'problem-need-solution' approach (as will be explained in the results chapter). This often resulted in elderly that felt 'stigmatized' by such technologies since they were positioned as frail people by those technologies. In addition, lots of elderly did not need such technologies, 'not for me', since they felt themselves quite vital. These concepts share a certain relationship and therefore they were placed in the category 'impairment focus'. Eventually, all selected concepts could be placed in different categories, which resulted in ideal-typical user representations. These are 'impairment focus', 'reluctant and not able to use technology' and 'elders have routines'. The concepts in each category (user representation) thus serve as characteristics of that category and together describe the particular user representation, as is elaborated in chapter 4.

In order to answer the second sub-question, which aims to identify methods (and therewith sources of use knowledge) used to obtain use knowledge, also open coding was applied. This was done in order to see for each scientific article or document which methods were used to obtain use knowledge regarding elder users of AAL technologies. After the identification of the ideal-typical user representations, each article and document was linked to a user representation which it broadly matched. Since the user representations are ideal-typical none of the articles and documents neatly resembles any of the user representations. However, the articles and documents were linked to that user representation which it contained most elements from. The methods used in the articles and documents linked to a specific user representation were analysed by means of the memos written for each article and the concepts regarding methods as identified by open coding. In this way of analysing I searched for similarities between methods of the several articles and documents linked to the user representations. These similarities of methods were then grouped into relationships which explain how a certain user representation emerged. An example of this relationship is the 'problem-need-solution approach' in which designers identify impairments elderly face, which they consequently translate in an elderly need for which a solution has to be found. Eventually, as methods can be linked

[1] For an overview of how all concepts are constituted the Nvivo file can be obtained by email via F.vanMeijel@students.uu.nl

to a specific source of use knowledge, the emergence of a user representation can be traced back to the source(s) of use knowledge made use of.

4. Results

In the analysed data a dominant vision is present that Information and Communication Technologies (ICTs) have the potential to solve the challenges of demographic ageing. These, so called, Ambient Assisted Living technologies are seen as resources to help elderly people live longer independently and increase the quality of life. However, the way in which AAL technology designers think of elderly people, and consequently the way in which technology should contribute, differs. The coding process used in this research has helped in identifying these different ways of thinking about elderly people in relation to AAL technologies. This process has resulted in the following categories of user representations (see table 1).

Table 1: Categorization of user representations

User representation	Concepts
Impairment focus	Impairments
	Personal safety and security
	Stigma
	Different user groups
	Not for me
	Problem-need-solution
Reluctant and not able to use technology	Technology skills
	Technical system aversion
	Technology simplicity
	Usage of available technology-services
	Acceptability
	Different user groups
	Technology-capability mismatch
Elders have routines	User routines
	Obtrusiveness
	User role
	Autonomy enhancement
	User control
	Privacy
	Acceptability

These user representations are ideal-typical user representations and are not necessarily standalone representations, but are (partly) combined in different AAL projects. Below, in the coming three sections first the elements of the user representations are described. Consequently, the way in which the user representations emerge is described. Finally, a summary of the user representations is given. In the last three sections of this chapter these results are analysed. First the usefulness of the identified user representations is elaborated on. Then, the underlying mechanisms of the emergence of the user representations are discussed. Finally, insights for improving user representations are presented.

4.1 Impairment focus

4.1.1 Elements of impairment focus

One way in which the elderly user of Ambient Assisted Living technology is represented is in terms of its impairments. Designers think of elderly of having certain impairments due to the ageing process. They try to design technologies which could help the elderly live independently in their preferred environment longer. This vision arises when designers adhere to the idea that demographic ageing puts pressure on current health care systems and therefore technologies are needed which help compensate for functional and cognitive decline in order to let elderly live in their preferred environment longer. If elderly could live at home with the use of technology less hospitalization of elderly is needed, which would reduce costs related to health care. In addition to this, the elders can stay at home which is deemed desirable. In this view functional and cognitive limitations are at the heart of the design process. Designers think of ageing as a process which is accompanied with a decline in functional and cognitive limitations (2, 9, 17, 24, 27, 30, 31, 32, 41, 40). For instance: "In the pursuit of independence, often the older adult's safety and health are at risk as they try to cope with health-related issues such as falls, sensory impairment, immobility, isolation, and medication non-compliance" (40). Also in (2) they state that during the design of ambient information systems the elderly's needs and problems regarding their natural functional limitations such as cognitive, visual and auditory decline should be considered. In addition, in (17) the participants were asked to full in a demographic profile with questions regarding chronic health conditions and usage of assistive devices in order to ensure that the participants were really persons who could benefit from Ambient Assisted Living technologies. Technology then should compensate for these limitations in order to let the elder live independently as long as possible at home. This is for instance reflected in: "During aging, older adults present losses in their functional capabilities. This may cause older adults to stop performing their activities of daily living (ADLs) at home independently. Consequently they need to be assisted in different ways: they may need help to complete an activity; they need to be reminded as they may forget some events or tasks that impede completing an activity appropriately; they may need to be warned when facing risks associated with performing an activity; and they may need to be motivated or persuaded in order to maintain a healthy lifestyle" (2). Also in (41) they started with an extensive literature review to identify physical, psychological and other changes that tend to come with the process of human ageing. This was done in order to lay the ground for the identification of key challenges to independent living, with a view to identifying options for the provision of an adequate technological response to these. Elderly people here are thus positioned as dependent persons that actually need to use technology that delivers services which make them more independent. However, not only technologies related to personal safety and security, as for instance medication related technologies or fall assistance technologies, are designed taking the impairments elderly face as starting point. Also in technologies not directly (fully) related to personal safety and security, i.e. smart microwave (24), banking services (30) and robot assistant (31), functional and cognitive limitations were taken as the starting point for designing the technology. For instance, in (24) it is assumed that a deterioration of cognitive skills makes it very difficult to remember the simplest sequence of steps or procedures to prepare a meal. Therefore, a special smart microwave is designed in order to compensate for this deterioration. Also in (30) the designers state that the main problems regarding interaction with an automatic teller machine are due to lack of fine motor control (size of buttons, etc.), reduced vision (contrast of buttons and text), hearing loss (output auditory information) and cognitive decline (number of options and hierarchy of menus, language complexity). Their goal is to design a banking service in which these impairments are compensated for.

In addition to this, it turned out that a lot of study participants involved in different AAL projects

experience technologies related to personal safety and security as a sign of weakness and vulnerability (7, 23, 44, 40). They were afraid of using such technologies in the case someone could notice that they were dependent on such technologies and thus were seen as weak and frail, as for instance in (7): "The visibility of the system within the home (by friends, family members) created a feeling amongst older people of reliance and dependency i.e. visible sign that they are vulnerable". Also in (23), participants thought that smart technologies may be a "stigma to some older people" and more symbolic of their frailty than of their supported independence and health. Next to this, it was even thought by participants that elderly would reject to use such systems because they are afraid of being stigmatized as frail or needing special assistance (40). This stigma that care delivering technologies carry indicates that elderly don't like to be positioned as merely care-needing, fragile people.

Overall, designers acknowledge the differences present in the group of elderly regarding age and thereby health and cognitive status (2, 4, 7, 30, 44). For instance, in (30) they state that the older population is a very heterogeneous group consisting of elderly without any functional limitation to elderly with severe disabilities. Also in (4) they say that elderly are often associated with multiple functional limitations, but acknowledge that this does not apply to every elder. However, the idea that users differ in the problems they face is often not taken into account in designing the technology. Often technologies are designed that take elderly with the most severe impairments in order to secure a good solution to these impairments. This is for instance illustrated in (34). In this project they aim is to develop a personal robot to support daily living of elderly with an emphasis on supporting personal health care and improving independence in living environments and the quality of life. They also acknowledge the difference in age and the varying needs of health care among elderly, as quoted: "There are significant differences in the attitude towards technology between several age groups from 62 to 95, but there are no clearly identifiable borders. The group of people that are used to technology is growing, and the resistance towards the use of technology in care is decreasing. At this moment, there is the curious situation of some 70- year olds, who do have the skills to use technology, but do not feel the need to use it, and the 80-year olds, who need the technology, but lack the skills. In 10 to 15 years from now, this situation will completely change". This quote implies that although it is known that there are different user groups, they actually are designing technology now for 80-year olds only. In their eyes the 80-year olds need to use the technology, while the 70-year olds don't feel the need to use the technology. They also developed different personas of what future users might be. However, these personas were all based on impairments. This could eventually also be the reason why the 70-years don't feel attracted to use the technology. They don't need technology that is directed at compensating a certain disability.

When technologies are especially designed for people with a specific impairment, elderly without such impairment don't feel attracted to use the technology. Although, they appreciate the technology they don't have the need (yet) to use it. They imagine that it could be useful for those who really need it, but they see it as 'not for me' as they see themselves as independent persons (33, 44, 8). This is for instance reflected in (44), in which a system is designed with which a home can be controlled using voice commands. Although, almost all participants appreciated the technology, they are not going to use it. They think such a way of interacting is devoted to people with disabilities and is not (yet) appealing to them because they are still autonomous. As quoted: "For someone with a disability, I agree it'd be great. But for now I'm not interested" (44). Also in another project the same comment was made: "[Voice control] would be a very good thing for a person who is physically disabled—if not, I think it is good to get up and move around" (33). In (8) the participants also found the technology of being monitored by sensors (i.e., a bed sensor, gait monitor, stove sensor, motion sensor, and video sensor) useful for people with greater levels of frailty than themselves. Most of the

participants found that their functional and physical status was such that there was no need for monitoring at the time.

4.1.2 Emergence of impairment focus

The impairment focus user representation mainly arises when designers investigate elderly's cognitive and physical problems, which they consequently translate in an elderly need for which a certain technological system can bring a solution; this can be seen as a 'problem-need-solution approach'. In this approach the cognitive and physical problems elders face become apparent through earlier experience in home automation and health care (implicit representation) (44, 26, 10, 41) and by means of literature studies (indirect representation) (7, 26, 40, 15, 41). Also use knowledge was obtained through involving caregivers (3, 5, 36, 43, 44). This however remained limited to problems and impairments elderly face. Consequently, elderly people are involved and are interviewed or given questionnaires (direct representation) to refine the proposed problems elderly face, which then are translated in generic situations that threaten older people's life. Finally, designers translate these threatening situations in an elderly need of solutions to these situations. This is for instance reflected in a project's goal: "We are concerned with the detection of situations in which, the subject under monitoring is suffering some problem. For example, lying immobile on the floor" (28). Eventually, the goal is to develop a solution to this problem which is perceived as an elderly need of being helped.

The 'problem-need-solution approach' is, for example, used in (2) in which an Ambient Information System to support the elderly in carrying out their activities of daily living is designed. The designers start with the underlying assumption that due to ageing several functional capabilities will decrease. This then can cause elderly to stop performing certain activities of daily living. Therefore, they have a need to be assisted in performing these tasks. In this certain project the focus is on medication adherence. Through interviews (direct representation) the designers identified the problems elderly face in adhering to their medication routine. These problems were: forget to take medicines, not able to read text of medicines and taking expired medicines. These problems were assumed to be the cause of visual and cognitive impairments. The designers consequently translated these problems in a need of being assisted with medication intake. On basis of design attributes derived from design guidelines (indirect representation) for Ambient Information Systems they developed a prototype which assists the elder in medicine taking. The prototype consists of a wearable notification display for medication adherence. This display is an ambient information system that assists elderly in taking their medicines by reminding them they need to take their medicines and refill them on time. To do this, the system coaches the user by presenting critical information that enables them to carry out these two tasks. If an older adult persists in not performing any of these two important tasks, the notification display will periodically remind and coach the user in order to persuade him/her to achieve its medicating routine.
The design guidelines used informed the designers about the notification level and the modality of notification to be used. In the system a high level of notification is used since the tasks to perform are deemed important. Therefore, a strident sound is used to notify them that it is important to take their medicines and this demands action of older adults to go to their medicine dispenser to stop the notification. Regarding the modality of notification an audible alarm is used to attract attention and consequently visual elements are used to display the information. Their intention was to use visual notification elements that do not demand the user's attention for long periods and that can be easily read and be interpreted. Overall, it is thus the designer who articulates the need on basis of the problems the elderly face and consequently comes with a solution.

In another project (43), for example, they basically work the other way around. They start from the assumption that elderly want to live as long as possible in their homes and technology then could play a role in this. The aim was then to examine the match between the needs and motives of the potential users of ambient assisted living technologies, and the solutions offered by these technologies installed in the home environment. They make use of the Unattended Autonomous Surveillance (UAS) system which is under development. This system offers the following functionalities: mobility monitoring, voice response, fire detection, wandering detection and prevention. This system can thus be seen as a 'solution' to particular problem(s) elderly may face. Consequently, in order to investigate user needs and motives, respondents were selected according to a number of criteria. These were as follows: "The client is mobile and has the tendency to fall, or the client is bed-ridden and wants no bedrails. In such situations, mobility monitoring in combination with cameras may be desirable to check whether a client is in need of assistance. The client has a tendency to wander. There is a need for wandering detection/prevention. The client activates the alarm once or twice a day via his/her emergency response system/service system. Professional carers want to have a method to check whether the alarm is false or valid, using a video connection. The client has feelings of loneliness and needs social contacts. Via the so-called EyeCatcher technology, the client can contact care professionals and relatives. The client feels unsafe/insecure at home, or professional/family carers have doubts about the safety situation at home." In all these criteria first a problem elders should face is described, which is consequently translated in a need elderly (or carers) have. These 'needs' were already built-in the Unattended Autonomous Surveillance (UAS) system. So respondents were selected which match (one of) the criteria in order to really benefit from the system. Interviews (direct representation) were carried out with the respondents on basis of a topic list which was based on a literature study (indirect representation). These interviews were carried out before and after the installation of the system in order to test how the system influenced the living at home.

4.1.3 Summary of impairment focus

The elderly is in this type of representation imagined as having certain impairments due to the ageing process. As designers see these impairments as a risk of living independent at home, which is desired, they consequently see this as an elderly's need to be assisted with these impairments. Finally, a solution is proposed in the form of an Ambient Assisted Living system which compensates for the impairments elderly face. A lot of health related systems are proposed on basis of these impairments, such as medication related technologies and fall assistance technologies. However, also technologies related to for example home automation take impairments of elderly as starting point in designing those technologies. These impairments were mainly studied by making use of indirect of direct representation. It however appeared that acceptance of such compensating technologies was in general not very high. This was because technologies related to health and security were seen as a sign of weakness and vulnerability. Elders were afraid of being stigmatized when using such technologies. In addition, elderly often felt themselves quite vital and did not need such technologies that assist them in everything. They thought such technologies would be useful for elderly that had serious impairments and they did not see themselves that way.

4.2 Reluctant and not able to use technology

4.2.1 Elements of reluctant and not able to use technology

Another way in which potential users of AAL technologies were represented was in terms of technological illiteracy. Older users were framed as persons without or with low technological skills (6, 12, 30, 28). This is for instance reflected in (6): "Older persons are regarded to have more

difficulties in acquiring new skills than young people and might achieve a lower level of performance". Because of this, it was assumed that interaction with new technologies would provoke serious difficulties. Elders were appointed as a user group that requires special attention in terms of usability due to their limited computer skills and requirements. Also in (30) the assumption is present that elderly have a lack of technological skills and that therefore special banking services are needed that take into account capabilities of elders. In addition to this, elderly were assumed to be not very keen on technological systems in general (1, 12, 14, 19, 20, 26). They were for example imagined as people who don't trust technology and are not prepared to rely on it (26). They would also not take the time to learn to use new technical systems (12). This latter statement was also found in (14) in which elders tested a smart home system which basic functionalities of the system were the provision of health related security and the enhancement of living comfort. As quoted: "People basically interested in the project were not willing to participate anymore when informed that a system supporting aging in place has to be based on computing and internet technology. Many of them expressed that they would not want to grapple with complicated technology in their retirement" (14). In a project in which a prototype of a touch screen based videophone system for communication was developed the designers even decided to mask the whole system as an ordinary piece of furniture. As user feedback provided that the system didn't look like a technical system, the designers thought they were not averse to the self-contained use (1).

The technological unskillfulness of elderly combined with the aversion against technical systems was thus the incentive for designers to design a system that is simple to use. This is for instance reflected in a project called Florence (35, 36, 37) in which a robot is designed in order to improve the well-being of elderly as well as improving efficiency in care. Their thought is that: "Ease of use is of critical importance for AAL services, and the complexity of the services and products device should be shielded from the elderly user" (35). In order to increase the ease of use of the robot, the designers used questions like: "Is the application easy to use for the user? (Easy to use = No more than 3 tries to perform each action)" (37) to evaluate the ease of use of the robot in the field tests. In another project in which a robotic home assistant is developed the designers took the simple to use conventional walking aids as example for developing their robot as these conventional walking aids are easy to use even by inexperienced people (31). Eventually, the field tests showed that the intelligent walking aid robot can be used even by technically inexperienced users without difficulties. Also in a project related to an online communication platform (5,6) simplicity of technology was important as the following quotes show: "When developing a system to support elderly care, the challenge arise from the need to make it simple to use (e.g., using only a few buttons) and support elderly by providing a kind of help desk (e.g., understandable, easy instructions) supported by pictures that visualize the next steps" (5)."Simplicity is highly important, not only in terms of usability but also in terms of the activity design. The activities have to be easy to understand, to learn and to conduct" (6). Since acceptability of AAL systems is a key issue for designers, they try to compensate for the lack of technological skills by offering simple to use devices for elderly.

In order to reduce the barrier of using technology they try to develop AAL systems based on devices which elders are already familiar with. It is assumed that the current elderly generation as well as less technical inclined people, adopt easier and with lesser rejection the traditional interaction mean of for instance a TV (42). Also in another project developing a system for videoconferencing, vital signs and parameters monitoring and reminding the majority of the participants who had indicated to have difficulties in controlling technical systems was quite concerned and reluctant to use the system. However, when heard that the user interaction was based on a television, a device they are familiar with, their enthusiasm for using the system increased (20). In (11) the designers even first investigated

which technical systems were already used by elders and consequently they decided which of these systems could be used as user interface for delivering assistive services. By making use of already available technical devices designers think they can increase acceptability of AAL systems because elders are keener on using devices they already know. The use of devices which elders are already familiar with would thus take away the aversion elderly have against new technical devices.

Although in projects it was acknowledged that there are different levels of technological skills among the elderly, the majority of projects were aiming to design technologies that can be used by everyone. This means that elderly with the lowest level of technological skills should still be able to use the technologies. For instance in (31), in order to enable all users to operate a household robot without difficulties, the user interface must be designed in order to make it suitable even for users without any prior technical knowledge. Next to this, although it is recognized that elders have different needs and preferences, this is often not taken into account in the design of the technology. Since the usability of the system is seen as the key point in accepting the technology, the focus is on making the technology simple to use in order to make it usable for all elders. However, in for instance (20) the designers envisioned an AAL system to be simple which required effortless interaction with users. In prototype testing it appeared that the older elderly appreciated the simple and easy to use system. In contrast, the young elderly found the system low interactive and little attractive. This implies that there are different user groups among the elderly.

4.2.2 Emergence of reluctant and not able to use technology representation

This type of user representation arises when designers make the assumption, either through literature studies (indirect representation) or through earlier experience in the field (implicit representation), that the design should be easy to use. This is due to the reluctance and inability elderly users have to use technical systems according to designers. Consequently, designers try to design technical devices that meet the abilities of elders. The approach they take often comprises a user-centred approach in which they follow an iterative process of prototype development (1, 4, 20). This implies that users are directly involved in order to obtain use knowledge (direct representation). For example, mock-ups are used in focus groups which then deliver feedback to the designers (7, 10, 26). Based on this feedback, a (first) prototype is designed or adjusted. In consequent iterative steps this prototype is then (further) adjusted to better match the elder user's abilities. This is for instance reflected in: "Animated mock-ups of the various use-cases were developed in order to facilitate feedback from older people and stakeholders. The findings from this phase were analysed by the project team and the technical partners and used to drive a second prototype design. There then followed a second prototype testing (component tests) which involved 51 older people in testing the usability of the system components within group sessions across the partner sites. The findings were implemented into a final prototype of the SOPRANO system" (7). Also in (20) a first prototype was designed of a system for videoconferencing, vital signs and parameters monitoring and reminding. In a second and third prototype the usability of this system was repeatedly improved on basis of feedback provided by respondents. These mock-ups and prototypes were however proposed by the designers, and the elderly were assumed to give feedback on the proposed design. This implied that difficulties in using a certain prototype were seen as points for design improvement and would be refined in the next prototype. In this sense designers identify a certain 'technology-capability mismatch' (Peine & Neven, 2011). Consequently, they try to design the technology in such a way that it matches the capabilities the elderly have.

In (12) a prototype of a vital signs monitoring system has been tested. The following quote of the results of this test illustrates this process: "difficulty that some patients have for using this type of technology, where either by age or inexperienced in the use of mobile devices, they feel some rejection for new technologies that consider takes them time to learn. These results help us to detect possible corrections in such a way that the user should be offered a more robust and friendly architecture" (12). Another example of this 'technology-capability mismatch' (Peine & Neven, 2011) can be found in (4,5,6) in which the designers identify isolation as a potential problem for elderly due to for instance bad mobility. By means of a literature review (indirect representation) they found that social contact is very important for the well-being of older people as loneliness can lead to depression. Therefore, they translated this problem in the elderly's need of social inclusion. Consequently, they see ICT's as a solution to maintain social inclusion through supporting elderly's social interactions. This thought can also be seen as a 'problem-need-solution approach' as mentioned in the impairment focus user representation. However, in developing a communication technology the designers first identified communication preferences and other needs by means of workshops and interviews (direct representation). Based on these results they deduced attributes that are relevant to the design and implementation of successful online communication activities (for instance: shortness and simplicity). Consequently, a prototype was designed which was tested in user studies in a laboratory setting (direct representation) in order to evaluate whether the attributes were successfully met. The studies focused on the usability (e.g., overall usability, effectiveness, and efficiency) of the system and on the users' experiences. The participants were asked to perform some predefined tasks. After each task, the participants were asked about the ease of use and the satisfaction with the performance of the platform. The participants experienced many difficulties while using the system. Therefore, design improvements were made so that even elders with low technological skills could use the system. The following quote illustrates this process: "Within the post interview 9 Austrian participants (n = 10) complained about too much complexity (i.e. the usability factor efficiency), like "there is too much text and information on each single page" or "it is too much effort of reading throughout the whole procedure". However, in the second round of user studies in Finland, the participants did not complain about the complexity at all. Thus, the improvements, including more pictures and bullet points, or simplifying the invitation procedure, were successful. Even for the Finnish participants with rather or very low computer skills the platform was not too complex anymore". So, in this project they try to adjust the design in order to match the abilities of the users which can be related to a 'technology-capability mismatch' in which the technology is consequently adjusted.

4.2.3 Summary of reluctant and not able to use technology

In this type of user representation elderly were seen as technological illiterate. They were seen as people with none or very low technological skills. This was among others due to the assumption that elderly have an aversion against the usage of technical systems in general. Due to these low technological skills elders are assumed to not be able to interact with existing technologies. So in this sense designers identified a certain 'technology-capability mismatch' (Peine & Neven, 2011). Starting from these assumptions designers thought that a system had to be designed which was easy to use in order to increase the acceptability of the AAL systems. By better matching the technology to the elderly's capabilities the designers thought that acceptability would increase. This was also a reason to make use of technologies elders were already familiar with. In practice this meant that every interaction with a prototype that went wrong, was too difficult or was not intended by the designers was seen as something that had to be improved. Consequently, this would be refined in a next prototype.

4.3 Elders have routines

4.3.1 Elements of elders have routines

Elderly people were also seen as having certain routines and habits in their daily life. These comprise for instance certain places in the house and methods to take medicines (2) or shopping trips, visits from the carer, trips out with the family, etc. (7). Individual routines and familiarity are deemed important to maintain and therefore it is assumed that elders don't want to modify their routines and habits in unfamiliar ways (13). For instance in (14) the designers assumed that an assistive system should give the elderly additional benefits without the need of changing their habits, not forcing them to actively use devices they do not want to or to carry devices with them. Also in (34) they share this view as this quote shows: "Individual routine and familiarity will be important to maintain. Older people tend to like to sit in the same place to watch TV, or to eat dinner. They like routine and familiarity in their everyday lives. So as part of the effort in designing and developing the technology, the work on user acceptance will also need to research into methods for introducing the MOBISERV technology so it is not seen as an intrusion on existing patterns of behaviour, and does not force people to modify their routines and habits in unfamiliar ways" (34). Because of this thought, in order to increase acceptability of AAL systems, the technology should be designed in such a way that it is not seen as an intrusion on existing patterns of behaviour (7, 13, 14, 32, 34).

So in this sense, designers got the incentive to develop a minimal obtrusive system which required low levels of interaction in order to not disturb activities of daily life. This implies that the system should work almost entirely autonomously with minimal action of the elderly (12, 20, 31, 33). The following quote, for example, underlines this: "With the given system architecture, Care-O-bot is able to plan and execute complex tasks autonomously" (31). Also this quote, regarding a mobile system for medical control, points to this low level of interaction: "This is a not intrusive application with low level of interaction that once obtained the measurement of vital sign; the application can perform all activities of processing and visualization of the results" (12). In an investigation regarding the acceptance of Ambient Assisted Living systems (17) the participants expressed great concern about the way an AAL system could affect their behavioural freedom at home. In fact, several reported they would likely behave differently under the perceived watchful eye of an AAL system. The following quote from this project underlines this: "Participants envisioned a number of scenarios: that the person and home would need to be neat in order to videoconference; that vital signs monitoring could cause stress; and that excessive monitoring could remind them of the deficits they are experiencing in their lives" (17).

When AAL technology is designed in such a way that it requires minimal action of the user in order to be non-intrusive it allocates the elderly a passive user role. However, when users were directly involved in the design process, e.g. in focus groups and prototype testing, it turned out to be that the elders do not want to be that passive. They want to continue as much as possible to perform activities that require physical and cognitive efforts in order to stay in good condition (15, 33, 36, 44). The following quote, which indicates this, stems from a participant regarding a voice based home automation system: "I like to act rather than talk […] I like to close the blinds, etc. […] I prefer to do things because otherwise it's going into inactivity. It should be that I can't do it anymore, because otherwise we do nothing, we go to bed and that's that" (44). Furthermore, in this project almost all elders did not like being informed by the appointment reminder by being interrupted because it gave them the feeling of being assisted. They are afraid they would not use their mind anymore and thus lose their intellectual capacities if they do not train them. Also in (36) for example the following

statement was made in a focus group session: “If you leave the home, you don’t want to have a list of forgotten things, you want just a notice that something (unknown) is missing (training effect). The more assistance the people have, the more skills they will unlearn” (36). Also in (33) the participants expressed concern regarding losing abilities if they rely on technology to do tasks they can do themselves. So, it appeared that elders want a system which stimulates in enhancing their autonomy instead of an autonomous system. This is for instance reflected in (36): “The robot should not take over odd jobs, but motivate people to get into action (!). It should not make people lazy”.

In addition to this, the issue of privacy is a difficult subject in the development of the AAL systems. This is shown by: “Many saw the loss of privacy and 24/7 monitoring as a way to ensure safety and security but an “equal threat to dignity in one’s own home”” (23). The issue of privacy by participants is also reflected in the following quote: “Participants were very concerned that technologies were being developed to perform functions, e.g., 24/7 home monitoring, “because the technology can do it” rather than it was necessary or desirable. More than one of the group questioned if there were any ethical or value-based foundations that technologists were using to inform the development of these systems. According to one participant, “ethics should be used as veto point to decide between what we can do and what we should do”” (23). The elderly found that having their own say when regarding their personal state was most important (3). This implies that the user should be more in control of the system to indeed have their own say. For example, in (36) participants found it no problem that health-related data would be sent to a therapist, although they would like to be able to control what is sent. They also would be able to turn off the robot or stop its communication. They don’t like the robot to indicate to friends/relatives that it is a good time for getting in touch; they prefer to keep the initiative. When privacy could be linked to acceptance of AAL systems as this quote shows: “Acceptance was also found to be linked to concerns regarding potential invasion of privacy” (34), user control becomes even more important. This was also assumed in (26) in which the designers thought that elderly would accept technology based help more readily if they had more say in what information is sent out, to whom and under what circumstances.

4.3.2 Emergence of elders have routines representation

Such ideas about elderly users come about when the assumption is made that elders don’t want to (partly) change their current lifestyles (implicit representation). Therefore, designers want to know more about the activities of daily living of elderly. They want to understand the user’s life situations so they know the context in which the technology will be used (10, 16, 41). For instance: “Scenarios are a means to consider the contextual information of a person using a solution. In our case, these solutions are each of the AAL Services that will be provided within a “Context of Use”. It helps in identifying why the person is using a particular service, in what environment this person is using it and with whom the person is interacting” (10). Also in (41) they state that the context of use of a system is important in developing such systems. Therefore, the project needs to develop methods to prototype context with users. In order to do this literature studies (indirect representation) (15, 41) were carried out and focus groups (direct representation) (15, 16, 41) were held in order to develop use cases/scenarios (10, 15, 16, 41). For instance in (29) questions were presented to the users in order to obtain a better understanding of their activities of daily life and to better predict what routines users already employed to accomplish their daily goals. In the first place this was done to gather feedback on the key challenges to independence and quality of life without specific reference on how technology could be used to cope with these challenges. It was done to identify opportunities for introducing technological support, without being driven by a predefined technical agenda. Consequently, the use cases were developed to describe how technology could contribute to those

challenges to independence and quality of life (10, 15, 16, 41). For example in (15), their goal is to get insights in the context of use of the potential technical system to be used. As they state: "SOPRANO does not only want to gain a quick insight in the system usage and user acceptance but also gain understanding of learning effects that are especially important in applications that are used on a daily basis" (15). In order to do this, they made use of an ecological model. As they state: "The underlying argument of the model is that the activities that comprise a person's everyday life are shaped by a range of different factors, including attributes of the person (functional ability, cognitive ability, psychological factors etc.) and attributes of the immediate (formal support network, social network, physical environment) and wider socio-cultural contexts. These personal and situational factors operate together in a functional, 'ecological' relationship to facilitate or constrain (affordances) a person's activities. The ecological approach is useful in looking at the independence and quality of life of older people, because it highlights the impact and experience of age-related dependency (e.g. cognitive impairment) within its context and allows us to explore how this affects everyday life and well-being". In order to bring this model in practice they started with an extensive literature review (indirect representation) to gain a better understanding of physical and other changes that tend to come with the process of human ageing and their potential impacts on a person's experience of life in old age. This was done in order to identify key challenges to independent living. Combined with feedback received from those project partners who have experiences in providing support services to older people (indirect representation) generic situations were derived which threaten older peoples' independence or quality of live. Consequently, users were directly involved via focus groups and interviews to gather feedback on the generic situations and give initial ideas on how technology could be harnessed to better cope with these challenges. This resulted in several themes which were described in use cases that explained the interactions between the users and the system. These use cases were developed to assist with medication reminding, safety & security, falls detection, home automation, exercise, remembering, social isolation, and entertainment.

Next to this, for example, in (44) the assumption that elders have routines and don't want to change those routines (non-representation) resulted in a system for home automation based on voice command. The designers' main motivation was to: "make it highly acceptable and usable" (44). However, after a Wizard of Oz experiment (direct representation) feedback provided by the participants indicated that although they appreciated the possibility of controlling the house using voice commands they were not going to use it since they think such way of interacting is for people with disabilities. In addition, they were afraid of losing their autonomy. The following quote of a participant describes their opinion regarding the system: "But then you don't do anything anymore, it's a thing for lazy people, it's a lazy life and then when you're old, the less you do the more you get in a rut, it's not good eh! For someone with a disability, I agree it'd be great. But for now I'm not interested" (44). Instead they want a system which enhances their autonomy. This becomes also apparent from the designers evaluation: "Surprisingly, while the system was supposed to bring more independence, it raised concern in the aged population that such a system would make them less autonomous by encouraging a lazy lifestyle and provoking quicker degradation of health condition."

4.3.3 Summary of elders have routines

In this representation elderly were seen as people that have certain routines in their lives. It was assumed that they don't want to change these routines in order to live independent at home. Because of this assumption designers wanted to design Ambient Assisted Living systems that were unobtrusive in order to not interfere with the elderly's daily activities. The consequence of this was that often autonomous working systems were designed which required low levels of interaction. This implied

that the elderly most of the time had a passive role. However, as the elderly indicated they don't want to be that passive, but they want to enhance their autonomy. They want a system which makes them more active in order to train their cognitive and physical skills. Next to this, privacy is a difficult aspect to deal with for designers. In order to assure the privacy of the elderly regarding for instance monitoring technologies it became apparent that the elders have to able to control the technologies themselves. So, if they want to turn off a household robot for instance, this should be possible. However, in technologies directly related to health this may be more complicated in the case there can occur life-threatening situations.

4.4 Usefulness of user representations

In order to let elderly live independent in their preferred environment longer the use of Ambient Assisted Living technologies seems to be a potentially fruitful option. These technologies differ greatly in their aim; measuring vital body signs, interpersonal communication and monitoring every movement of the user. In contrast to living in nursing homes or receiving home care as the current situation comprises, living independently by making use of AAL technologies implies a totally new way of living, which requires interaction with high tech technologies. In order to design such radical technologies, it is important to develop richly informed user representations since these eventually become 'scripted' into technology. The identified user presentations describe the current practices in technology development in the field of Ambient Assisted Living. Remarkably, these user representations show a limited view on elderly. They are seen as weak and frail and also as persons who can't handle technology adequately. In addition, they would not want to change their daily routines in order to live independently at home. These narrow representations of elder users of technology bear several risks for designing technology.

In the first place, impairments of elderly were taken as starting point in designing technology. This was not only the case for technologies directly related to health, but also for everyday technologies. Consequently, the aim of designers was to compensate for these impairments. Starting from such impairments and consequently compensate for them is indeed a good thing when thinking about directly health related matters as for instance vital body signs measuring. However, also starting from impairments elderly people face in designing technologies not directly (fully) related to health constitutes a very narrow representation of elderly. This was also reflected in the projects were elderly felt they were stigmatized by technologies compensating for every disability they face. It gave them a feeling of being solely dependent on technology. There was also a group of elderly who stated that they don't need such technologies (yet). They thought it was for elders with disabilities and they didn't see themselves as such. This indicates that the group of elderly is a heterogeneous group with varying degrees of impairments. So, not all elderly want technology that compensates for every disability they face. It turned out that elders also want to be more active and rather would use technology that enhances their current abilities instead of being passive recipients of technology.
Secondly, the idea that elderly people are technology illiterate often resulted in designing technologies that focussed on the ease of use and simplicity of the specific technology. Although, ease of use of technology generally is considered a good thing, it may be less good if it limits functionality. Since designers regard acceptability of technology as important they often designed technology in such a way that even the less skilled elderly could use the specific technology. This then resulted in technology that is usable by all elders. This was accomplished by for instance limiting the possibilities of the system's interface (e.g. using a few buttons) in order to secure that the user uses the system as intended. However, more skilled elders may not be attracted by such very easy to use technologies as it leaves them in a passive role. In addition to this, the next generation elderly is more used to use

technology and therefore they probably have acquired more skills regarding technologies (Peine et al., 2012). This contrasts the view on elderly as technology illiterate persons. Next to this, assuming that elderly don't want to change their routines and habits in order to keep living at home causes designers to design technologies that are highly unobtrusive and function quite autonomously. Consequence of this is that users are devoted a passive role. Generally, this was not seen as a good thing among elderly because they wanted to be more active in order to enhance their autonomy. Also users want to be more in control of AAL systems since it gives them more privacy which is deemed very important in the acceptance of the technologies.

In short, AAL technologies designed on basis of these narrow user representations are likely not to be accepted widely among elderly. By making use of the current user representations generally technologies are designed which stigmatize elderly people as care needing people and not as people who want to maximize value of life. These user representations also cause designers to rank simplicity of technology much higher than functionality which causes more technology skilled users to find the technology unattractive. It thus appears to be that technology (unintended) mainly is developed for the older elderly.

4.5 Underlying mechanisms of narrow user representations

In the analysed documents there is a consensus that AAL technologies can be a solution to tackle the challenges that come with demographic ageing (5, 7, 13, 15, 16, 17, 21, 30, 33, 34, 41, 44). Demographic ageing is seen as a process which brings problems related to health care, i.e. high costs, shortage of personnel, etc. Seeing AAL technologies in first instance as the solution to solve these problems, implicitly categorizes these technologies as compensating technologies. That is, by using AAL technologies elderly can keep living independently at home without being placed in nursing homes for instance, which would save costs. So the first reason to make use of AAL technologies is to compensate for health related matters. This then results in a situation in which the elderly is helped with his or her problems and impairments and it also contributes in combating the growing pressure on health care systems. Although this seems a logical way of reasoning, it guides designers into the thought that impairments elderly face, have to be compensated for. This, of course, is necessary in case of directly health related matters. However, this way of reasoning also leads designers (unintended) to design for the weakest and most frail elderly. This is because in their mission to let elderly live in their own homes as long as possible, instead of being placed in nursing homes for instance, designers try to design technology that compensates for every imaginable problem or impairment. By means of implicit or indirect representation these problems are concretised as described earlier. So the assumption that elderly face a lot of impairments due to ageing, guides the designers into research on problems elderly face. Through direct representation these problems are consequently refined and translated in generic situations that threaten elderly's lives. In some cases, as for instance in (43), respondents of the study even were selected on basis of specific impairments and problems the envisioned technology could compensate for. In projects where they did not specifically selected certain elderly, thus involving elderly of different ages and varying impairments (direct representation), this led to technologies that were easy to use but with a limited functionality. This was due to designers making the design usable for elderly with the lowest level of technological skills. Generally, the assumption that elderly are technology illiterate, mostly based on implicit representation, led designers to design technology that is easy to use since this would increase acceptability of the technology. For instance, refining a prototype on basis of actions performed by users which were not intended by designers (direct representation) (20). In the case of prototype testing often predefined tasks had to be executed. When these tasks seemed to be too difficult to

handle (too much attempts needed to complete a task), this would be corrected in the next prototype. These corrections often meant a more easy to use interface in order to simplify the execution of the predefined tasks. It can be identified here that designers by means of implicit representation, i.e. assuming that elderly have low technological skills, are steered towards identifying a certain 'technology-capability mismatch' (Peine & Neven, 2011) in direct representation methods. Consequently, they try to fix this mismatch by for instance refining a prototype as just described.
Also the assumption, through implicit representation, that elderly are resistant to change their behaviour guides designers into research on investigating current way of living of elderly. This investigation mainly happens on basis of direct representation with the aim of developing use cases which predefine how elderly interact with the proposed technology. So in this sense the assumptions made through implicit representation guide the methods of direct representation, i.e. designers focus on making technology easy to use in order to let technology illiterate elderly interact properly with the technology and they study the current way of living of elderly in order to design technology that does not require changing routines.

4.6 Improving user representations

The narrow user representations identified will likely not lead to AAL technologies that are appreciated by the heterogeneous group of elderly. Designers think about elderly using AAL technologies in combating the challenges that come with demographic ageing. This thus encompasses a totally new way of living by making use of high tech technologies. However, in designing these technologies designers base their design on a narrow user representation of elderly. Designers should be aware that their implicit representation methods have great influence on the final user representations. These user representations consequently are an important means in the eventual design as is found. Take for instance the user representation that elderly are reluctant and not able to use technology. This may apply to a specific group of elderly. However, it certainly does not apply to all elderly. In addition, the next generation elderly is more used to use technology in their daily lives and therefore they probably have acquired more skills regarding technologies (Peine et al., 2012). For those elderly a technology which is very easy to use but limited in functionality may be not attractive to use. Designers also try to gain user requirements by for instance delve deeper into the daily lives of elderly; getting to know their daily activities etc. Consequently, use cases are developed which pre-estimate how a participant will interact with a technology. First of all, Ambient Assisted Living technologies are a new way of living. Therefore, participants may be not fully aware of what they want from technology, especially not when they have to make their judgment on basis of a mock up for instance. Also trying to elicit user needs and preferences by means of interviews and focus groups regarding such radical new technologies is almost impossible since users can't have articulated preferences or needs for a product that differs radically from their present practice and knowledge (Hyysalo, 2003). In this sense the source of use knowledge 'co-creation', in which users directly participate with designers in order to co-create a technology, could be a fruitful option to deal with these problems. Next to this, when delving deeper into activities of daily living and specified user needs of some participants (often very few participants were involved in direct representation phases of technology development), this makes it hard to generalize these results to other potential users. This relates to what Stewart & Williams (2005) state that designers need to balance between generic and specific designs as described in the theoretical framework.

5. Conclusion

The research's aim was to investigate the design process of AAL technologies. AAL technologies are seen as a means of coping with the ageing society. This research investigated the design process of AAL technologies by looking at the user representations underlying the design of AAL technologies and the way these representations emerge. By using a qualitative approach, scientific articles and documents regarding the design process of AAL technologies were analysed. This resulted in three ideal-typical user representations underlying the design process of AAL. In the impairment focus user representation designers see elderly as people with deteriorating health. The impairments elderly have are taken as key point in designing technologies. In the reluctant and not able to use technology representation elderly are seen as having an aversion against technical systems in general. In addition to this, they were seen as technology illiterate people. In the elders have routines representation elderly are represented as having certain routines and habits that they don't want to change when making use of AAL technologies. These identified narrow user representations have their roots in implicit representation methods used by designers. Mainly based on earlier experience in the field these narrow images of elderly technology users arise. This implicit representation consequently influences the direct representation methods used by designers. This is for instance reflected in the 'problem-need-solution approach' in which problems elderly face (assumed through implicit representation) are translated by designers in an elderly's need for which a solution has to be found. By consequently involving users through interviews, focus groups, etc. the problems elderly face are translated in generic situations that threaten elderly's lives.

As indicated in the introduction, a narrow representation of elderly would strongly influence the design of technologies. In the field of Ambient Assisted Living also a narrow representation of the elderly is present. Elderly face a lot of impairments, are technology illiterate and don't want to change their routines in order to keep living independently at home. These narrow images, in a nutshell, characterize the way of thinking about elderly in the field of AAL. Eventually, this has consequences for the design of AAL technologies and for the users. Technology appeared not to be attractive to use since the easiness of use, which on basis of the narrow user representation was highly important, limited functionality. Next to this, elderly felt stigmatized by technologies that would compensate for every disability they face. In addition, a group of elderly felt they didn't need such technologies at the moment, because they could still manage without. This resulted in a low acceptability of technology among the elderly. Concluding, it can be stated that elderly need technologies that compensate for directly health related measures. However, also technologies are needed that stimulate autonomy enhancement and contribute to live enrichment. Not only to overcome the problem of stigmatization, but also to maximize value of live of elderly people. As Rowe & Kahn (1997) state, in order to age 'successful' also technologies are needed that contribute to high cognitive and physical functional capacity and active engagement with life.

6. Discussion

6.1 Theoretical implications

This research stated in the introduction that demographic ageing bears several challenges. The main challenge has to be found in the growing pressure on health care systems. Ambient Assisted Living technologies were considered as a potential solution to cope with this challenge. Earlier research stated that user representations are a useful means of investigating how technology is designed, since these user representations become scripted into technology (Akrich, 1992, 1995). This research identified how narrow user representations (negatively) influence the design of AAL technologies, which implies that these user representations are an important means in establishing a proper design process. The identification of the user representations of elderly and the way they emerge that this research has accomplished contributes in filling the gap in existing research as identified in the introduction.

In all three user representations basically first an assumption, based on implicit representation, is made regarding the problems or needs of elderly, which consequently drives the content of the methods of (in)direct representation. For instance the assumption that elderly face a lot of impairments due to ageing, guides the designers into research on problems elderly face. Consequently, solutions are sought for to compensate for these problems. This implies that these implicit representation methods are an important means in the design process. This complements earlier findings on the importance of more implicit methods, next to explicit representations of use (Hyysalo, 2006). There seems thus to be a relation between implicit and explicit representations of use. This is an interesting insight regarding the framework on sources of use knowledge developed by Peine & Herrmann (2012). In order to better understand how user representations emerge it could be a suggestion for further research to investigate this relation more closely.

6.2 Practical implications

Designers should be aware that their user representation has strong influence on the design of technology. Especially, their implicit representation largely influences the design process. The narrow representation of elderly technology users of Ambient Assisted Living technologies implies several risks for technology design and the users as mentioned. Especially, the coming generation of elderly are likely to be more familiar with technological solutions. Therefore, technology based on such a narrow representation of elderly will likely not bear attractive technologies for those elderly. So designers have to bear in mind that they design for a generation which is more familiar with technology than the current generation and an easy to use technology with limited functionality may easily be rejected. Also technologies designed for compensating specific impairments easily stigmatize elderly which does not contribute in the acceptance of the technology, as intended by designers. Focussing on both compensating technologies as well as on technologies related to life enrichment would likely contribute in tackling the stigmatization problem.

6.3 Limitations

This research used a qualitative approach in answering the research question. This approach proved to be an appropriate one since it resulted in a deeper understanding of the user representations and their emergence in the design process of AAL technologies. Scientific articles and documents were analysed as data. These data often presented only a part of the whole design process. In understanding

how certain user representations emerge, ideally one wants to collect data from the whole design process and be in close connection with the designers. Such design processes have a long time span and collecting data from the whole design process was not achievable in the time span of this master thesis. However, the choice for analysing articles and documents resulted in a great amount of data with a lot of different projects. This made it possible to apply theoretical sampling and that helped in refining the concepts by means of constant comparison of those concepts. This contributed to the validity of this research. That is, the results are grounded in a broad field of data.

In explaining how the user representations emerged each project from the articles and documents was linked to a certain identified user representation. Because these user representations are ideal-typical none of the projects contained all the elements of the user representations it was linked to. Some maybe contained few elements from other user representations as well. However, the projects were checked on prevailing elements of the user representation and consequently linked. Since the explanation of the emergence of the user representations relied on multiple projects they were linked to, this method of explanation was justified.

In this research theoretical sampling was used in order to collect and analyse the data. By means of theoretical sampling data were collected on basis of constant comparison of the concepts in order to identify interesting aspects regarding the research question. Therefore, the data analysed is not necessarily representative for the whole AAL field. Results are therefore not generalizable to the whole AAL field, but should be generalized to theory.

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Appendix

Table 2: Coding example

Unit of meaning	Concept
"These examples show that persons with cognitive impairments require specific approaches to the use of technologies." (43)	Impairments
"During aging, older adults present losses in their functional capabilities. This may cause older adults to stop performing their activities of daily living (ADLs) at home independently." (2)	Impairments
"The main problems of older persons when interact with ATM are due to: • Lack of fine motor control: It affects to with size of buttons, slots, etc. • Reduce vision: It affects to h size and contrast of buttons and text. • Hearing loss: It affects to output auditory information." (30)	Impairments
"The elderly are afraid of being considered as a dependent person if they decide to adopt this system at home." (44)	Stigma
"First, there is the fear of being stigmatized by having and needing (robotic) AAL services at home. This even more applies to robots. Robots could be considered as a „device for handicapped" with the fear of stigmatization if they are used for well- being purposes." (35)	Stigma
"When developing a system to support elderly care, the challenge arise from the need to make it simple to use (e.g., using only a few buttons) and support elderly by providing a kind of help desk (e.g., understandable, easy instructions) supported by pictures that visualize the next steps." (5)	Technology simplicity
"it can be determined that most people actually use very few of the many buttons provided, making it possible to limit the user interface to the necessary buttons only, making it easier to understand and possible to have larger icons that will be easier to see." (9)	Technology simplicity