Exploring Privacy: Mental Models of Potential Users of AAL Technology

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Abstract: Ambient Assisted Living (AAL) technologies have a high potential to combat healthcare challenges while supporting older adults to live independently at their own home. Despite the general positive uptake of such technology, perceptions of barriers of acceptance persist, a major one regards privacy. With an explorative qualitative approach, the current study aimed at investigating participants` cognitive representations of a scenario in which AAL is installed in the own home as a support at an older age. Special focus was on eliciting participants` implications for privacy in this scenario and to understand the individual requirements of using AAL technology at home. Opinions of 12 participants (age range: 23-81 years) from Germany and Switzerland were assessed through semi-structured interviews. The paper presents descriptive results and emerging themes of the mapping approach. The results show the usefulness of the method to understand thought processes of potential users regarding privacy preferences and technology usage. Findings might be useful to inform technical designers as well as lawmakers to consider these usage requirements during technology or law development.

1 INTRODUCTION

Ambient Assisted Living (AAL) technologies are intended to be a constant part of the day-to-day life of older adults in need of care (Blackman et al., 2016; Muñoz et al., 2011). Such technological solutions have a high potential to effectively combat healthcare challenges and support people living at home in older age (Peek et al., 2014) – improving quality of life for them as well as their caregivers (Pollack, 2005). Various sensors, actuators, smart interfaces, and artificial intelligence are integrated into homes and lives of the elderly to provide support for functional capabilities of “activities of daily living” as well as sensing and preventing risky situations such as falls (Blackman et al., 2016; Calvaresi et al., 2017). In the context of AAL, many sensors, either wearable or ambient installed, are used for lifelogging. The latter term refers to digitally tracking and documenting everyday live by recording physiological and behavioural data in real time which is stored for a subsequent knowledge extraction (Selke, 2016). To adequately log people`s lives, data recording is always on and usually shared with stakeholders such as care personnel or medical practitioners to adequately design independent-living strategies (Selke, 2016).

1.1 AAL Technologies, Acceptance and Privacy

Generally, many of these specific applications are perceived positively by a broad range of users and are thought to be helpful and beneficial, providing an increased feeling of safety and greater independence (e.g., Garg et al., 2014; Gövercin et al., 2016; Lorenzen-Huber et al., 2011; Wild et al., 2008). Potential barriers and concerns raised by different user groups are the lack of personal contact, perceived control, continuous monitoring, fear of data misuse as well as invasion of privacy (e.g., Beringer et al., 2011;

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Demiris et al., 2004; Kirchbuchner et al., 2015; van Heek et al., 2018). An increased need for care (Offermann-van Heek et al., 2019; van Heek et al., 2017) as well as care experience can have an influence on technology acceptance. Care experienced people seem to rely more on emotional aspects compared to inexperienced potential users (Offermann-van Heek & Ziefle, 2019). General findings from Offermann-van Heek and Ziefle (2019) suggest that data access and privacy are the most relevant factors when deciding on AAL technology usage for both, caretakers and caregivers. Indeed, privacy concerns are a main barrier to acceptance of AAL (Peek et al., 2014; Yusif et al., 2016) and they largely come about when the actual level of privacy does not match the desired amount (Altman, 1976). The "ideal" amount of privacy and the balance between sharing and protecting individual data mainly depend on the context and personal attitudes (Altman, 1976; Bergström, 2015; Nissenbaum, 2010). This reflects findings that privacy concerns in the context of AAL are tradeable in adequate circumstances. Ulrich et al. (2020) show that older adults are willing to trade privacy for safety due to their need for autonomy, suggesting that users` willingness to reduce privacy is altered especially when they feel in control of the situation. Similarly, privacy concerns are reduced if the devices provide positive contributions to health and wellbeing, are easy to use, and do not cause stigmatization (Ulrich et al., 2020). Findings from a longitudinal study of Himmel and Ziefle (2016) reveal that technology acceptance depends on the location of the devices in the user´s home. Technology in more private rooms such as the bath and bedroom are less accepted compared to the kitchen, living room or the home office.

Taking the previously reviewed literature into account it becomes evident that privacy is a multidimensional construct and its evaluation in the AAL context of whether it is a concern, a desired state, or even a tradeable unit depends on multiple contextual as well as personal factors. Based on previous definitions of privacy Burgoon (1982) makes a distinction of four dimensions of privacy that account for the complex circumstances in the context of AAL (Schomakers & Ziefle, 2019). Namely, in the AAL context dimensions of *social privacy* (control over social contacts, interaction, and communication), of *physical privacy* (degree of physical inaccessibility) as well as of *psychological privacy* (degree of inaccessibility to thoughts, feelings, and intimate information), and of *informational privacy* (control over personal information) might play a pivotal role.

One way to study the multifaced construct of privacy is through the assessment of mental models. This has already been done, for instance, to assess laypersons general conceptualization of privacy (Oates et al., 2018), older adults` understanding of privacy in digital and non-digital contexts (Ray et al., 2019, 2021) as well as older adults` privacy expectations in adaptive assistive technologies (Hamidi et al., 2020).

In the context of ageing and living with AAL, however, mental conceptualizations of privacy still require further investigations.

1.2 Mental Representations of Privacy and Cognitive Maps

Mental models are cognitive representations of the external reality that guide people to interact with the world around them (Craik, 1943; Johnson-Laird, 1983). Based on personal life experiences, perceptions, and understandings of the world individuals create a cognitive structure that shapes the basis of reasoning and decision making. Cognitive maps have an influence on what information individuals focus on and how they perceive it, thus, ascribing them a leading role when it comes to integrating and interpreting new information (Kaplan & Kaplan, 1982). According to Collins and Gentner, (1987) to explain unfamiliar domains people make use of familiar mental models similar to the unknown. As studies show (e.g., Rickheit & Sichelschmidt, 1999), phenomena that are not directly perceivable in the external reality are explained in the same way as unfamiliar domains. Kaplan and Kaplan (1981) view cognitive maps as mental models that are schematics of individuals' cognitive representation of a specific situation or problem. Kearny and Kaplan (1997) argue that the most important, significant, and concerning contents of a cognitive map are those quickly coming to mind.

Even though, to date there is no consensus on the definition of a mental model (e.g., see Thagard, 2010) and still confusion about the nature of cognitive maps (e.g., see Kitchin, 1994), various methods exist to elicit and study people´s internal cognitive representations of the world. Among the latter, there is the open-ended 3CM (conceptual content cognitive map) method, a corroborated method proposed by Kearney and Kaplan (1997) for assessing peoples` cognitive structures and processes. It has already been used in the field of healthcare to understand personal perceptions and concerns of people diagnosed with

lung cancer (Lehto & Therrien, 2010) and to understand nurses` perceptions of children's pain (Van Hulle Vincent, 2007). The method is suited to measure people`s viewpoints on complex domains (Kearney & Kaplan, 1997) and as such, the interaction and support with AAL technologies can be seen. Particularly suited for small-scale samples and for in depth-exploration the open-ended version of the method will be employed in this study to gain information about individuals' perspectives of a personal healthcare scenario with assistive technology.

Besides exploratively testing through semi-structured interviews the effectiveness of the described method within the given AAL and care context, the aim of the study is to deeply understand thought processes regarding the role of personal privacy while being supported and cared for by AAL technology in older age. The goal is to get insights on opinions of a diverse sample consisting of people from two different European countries, being of all ages, with and without (professional) care experience and various levels of technical understandings. In line with previous theoretical explanations and given a scenario where people are confronted with using AAL technology in their own home for the first time, they would immediately think of and possibly reveal core contents of their existing mental representation regarding this scenario.

2 METHOD AND MATERIALS

This chapter outlines the empirical approach of the study. First, the characteristics of the semi-structured interviews and its successive data analysis are explained. Subsequently, the interview guidelines and procedure are described in detail including the AAL scenario. Lastly, participants of the study are presented.

2.1 Semi-structured Interviews and Data Analysis

The interview was divided into two main parts. The first part consisted of questions regarding privacy in daily life and feelings of privacy violation. The second part started with the introduction of the AAL scenario. Based on the Conceptual Content Cognitive Map (3CM) method described by Kearney and Kaplan (1997) participants were guided to create their mental representation of this scenario.

The interviews were audiotaped and transcribed verbatim. The theoretical foundation of the analysis was the thematic qualitative text analysis as outlined by Kuckartz (2014). The study was carried out in both German and Italian. The selected quotes were translated into English for this publication.

2.2 The Interview Procedure

Participants were welcomed to the interview with a general introduction into the topic of privacy and AAL technologies.

The first part of the interview consisted of four main questions regarding the meaning of privacy, privacy behaviour, and feelings of privacy violation.

The second part of the interview started with the introduction into the AAL scenario and was followed by the task of creating a mental map. Therefore, participants were asked to imagine themselves in this scenario and were told that their answers of the upcoming three questions were written down in boxes to create a visualization of their thoughts – each box corresponded to another mental object in this scenario. These three questions addressed participants` first impression of the scenario, connections they could draw to privacy and their ideal imagination of this technology in line with their privacy preferences. Each topic was discussed extensively and only when participants clearly signalled that the visualization map was complete for them, the interviewer proceeded. Like this, maps varied in complexity meaning that the number of objects within the maps varied depending on participants` personal understanding of the scenario. As for the subsequent task participants were asked to sort the answer boxes into meaningful groups of statements. Then, participants had to code each group or box according to the degree of importance, i.e., how important they would consider each of their statements in terms of privacy in this scenario. The interviewer then picked the statement that was rated as most important and questioned if it was interchangeable. If so, participants were encouraged to name what they considered as an adequate exchange.

The interview finished with an informal talk about participants` demographics and their experiences in care as well as regarding technology.

2.2.1 The AAL Scenario

Participants were encouraged to picture themselves as an eighty-year-old healthy but frail person living alone at their own home. Participants had to imagine that AAL technology was installed in their homes to support them and to counteract frailty due to ageing.

The type and functionality of this technology was not important, but participants were informed that the technology would have various social and functional features. Among the latter the following were mentioned: medical care support (e.g., measuring temperature, blood pressure), household assistance (e.g., turning light on and off, vacuum cleaning), monitoring (e.g., gait monitoring), memory aid (e.g., daily reminders for medicine or important events) and a social companion (e.g., motivates and provides games for physical and cognitive exercise, facilitates communication with family and friends). Hence, this technology consisted of a very extensive non-human support for both, the person in need of assistance as well as the caregivers involved.

2.3 Participants

The qualitative interview study was carried out in June and July 2021 with twelve participants who were interviewed with semi-standardized questions through videophone. The interviews lasted approximately one hour and were conducted with participants from Germany and from Switzerland (Swiss-Italian region) who were recruited from the personal network of the authors and volunteered to take part in the study. The aim was to cover young, middle-aged, and senior females and males differing in their level of technical understanding and their care experiences.

The interviews (N=12 participants, ranging in age between 23 and 82 years M=52.67; SD=22.49) were conducted and analysed. Half of them were females (50% males). Nationality was not divided as equal as gender, with interviewing five Swiss, all of them Italian native speakers and seven Germans, all of them German native speakers. As their highest educational level, seven out of all participants stated to hold an academic degree, among them one participant holding a doctorate, whereas four completed vocational training and one person holding an A-level certificate. Slightly more than half of participants (i.e., seven participants) stated having (professional or informal) care experience, three among them reported working in the medical or care sector. High levels of technical literacy were attributed to four participants whereas three were classified as having low technical literacy. The remaining five participants ranged in between. No participant reported hands-on experience and knowledge of AAL technologies.

All participants agreed to take part in this empirical study after they were transparently informed about the use of the collected data as well as the purpose and aim of this qualitative research. No compensation was given for participation.

4 RESULTS

In the following, results of the second part of the interviews will be reported. Findings from this part might be most relevant in understanding how people conceptualize privacy in an AAL scenario.

4.1 Descriptive Results

In total, maps of eleven participants were examined (P2-P12). While every mental map was equally informative the maps differed in complexity, i.e., the number of objects included in the map (see Table 1). Interestingly, P3 the most care experienced participant (59 years, MA. Nursing and health sciences, 22 objects) conceptualized the most complex map with the highest number of objects included (Figure 1) followed by the youngest, technically highly skilled participant (23 years, 21 objects). Among the participants who created the least complex map were the two oldest participants (both aged 81, low-medium technical literacy, P12 informal care experience, both 7 objects). Participants with more complex maps (P2, P3, P4, P5, P6, P9, P10) were able to group their objects into two to six categories, whereas this was not possible for the less complex maps of P7, P8, P11, and P12.

Seven participants were able to select one most important object of the map. Among these chosen objects were "*Safety*" (P2), *"The problem of camera technology"* (P3) "*Data Protection*" (P5), "*unobtrusive technology*" (P6), "*Independence*" (P7), "*Usefulness*" (P8), and "*Simple Use*" (P9). The most important object of the map was interchangeable, except for two participants (P5, P8). Participants wished to replace their most important object with "*increased quality of life*" (P2), *"social contacts"* (P3), "*even more helpful technology*" (P6), "*being cared for by skilled and nice professional caregivers*" (P7), and "*being cared for by the own two children*" (P9).

Table 1: Descriptive statistics regarding the number of objects within the maps.

Descriptive Statistics		Participants
Mean	14,36	
Median	12	
Mode (bimodal)	7	P7, P11, P12
Mode (bimodal)	12	P8, P9, P10
Max	22	P3
Min	7	P7, P11, P12

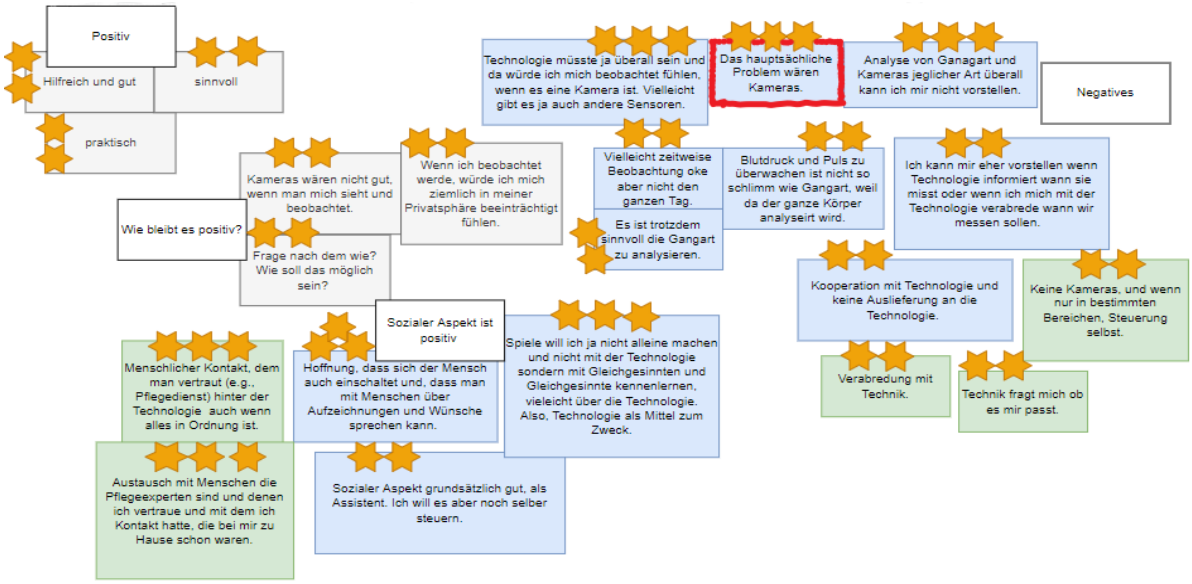

Figure 1: Exemplary schematic visualization of P3`s mental map (in German language). The yellow stars represent the coding for importance (3 stars = very important). The box framed in red corresponds to the most important object.

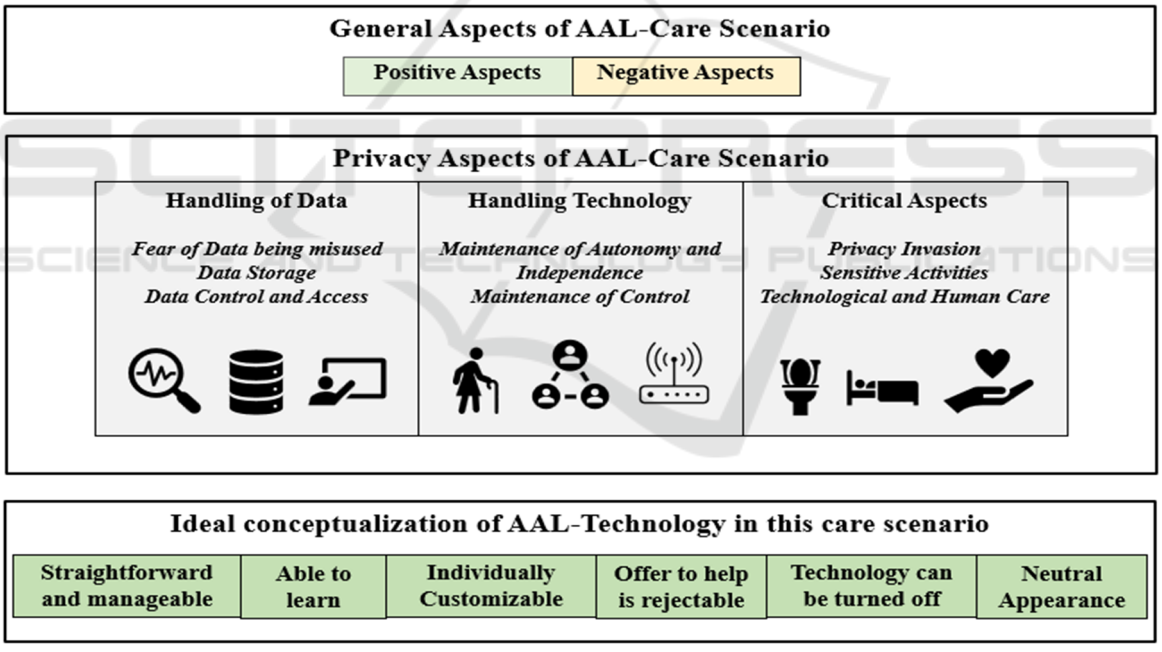

Figure 2: Illustration of categories.

4.2 Qualitative Findings

Results from the thematic analysis of the single maps revealed three major categories, “General Aspects of the AAL Scenario”, “Privacy Aspects of the AAL Scenario” and “Ideal Conceptualization of AAL Technology”.

These three broad classifications were further divided into several major and minor subcategories. Allocations are illustrated in Figure 2 and details are described in the following.

4.2.1 General Aspects of the AAL Scenario

Positive Aspects. Overall, participants mentioned more general positive than negative thoughts on the AAL scenario. Indeed, all participants but one (P4)

had a positive first impression, meaning that the first word they mentioned had a positive connotation.
In general, the AAL technology in this scenario was considered as "*helpful for oneself*" (P3) and "*for relatives"* (P4) as well as "*useful"* (P8) and "*important for life"* (P12).

In addition, some participants even shared more excitement when asked about their general impression:

> *"For me it is fascinating if I fall down, and the system calls an emergency service."* (P5)
> *"I am enthusiastic, […] it lights my thoughts. Without the technology no one knows about my health, and I can only guess if I am not well. Just thinking that with this technology there is someone, is a great relief."* (P10)

Negative Aspects. As what can be identified as general negative aspects or concerns regarding the AAL technology, only a few were mentioned. Participants feared that interaction with AAL devices would make them particularly aware of their frailty or in the extreme case be the cause of further health decline and frailness.

> *"Every day you are reminded of your frailty, you are always reminded that you can´t do certain things anymore and you have the feeling that you are dependent on this thing. […]."* (P2)
> *"I am afraid that I am no longer challenged. Basically, it is like diminishing self-esteem from the outside"* (P4)

4.2.2 Privacy Aspects of the AAL Scenario

Handling of Data. Participants frequently raised the issue how data is handled in this scenario and discussed it in various lights. Thoughts concerning this topic can be divided into three subcategories that are ***Fear of Data being misused***, ***Data Storage*** and ***Data Control and Access***.

Fear of Data being misused. Participants were aware that the AAL technology records most of their everyday activities and health information which makes the resulting data highly sensitive. Participants feared fatal consequences if this data would get in wrong hands.

> *"A film is a data, a photo is a data, a state of health can also be another piece of information and I wouldn´t want many others to know that I have a certain illness. I mean inappropriate dissemination of data. You have to understand who is on the other side, […] if one looks for a specific purpose regarding health okey, but if one looks to make fun of me then it becomes almost a crime."* (P10)

Data Storage. How data is stored was only a matter for participants with high technical understanding. Indeed, to express preferences, one might need to know how and where data can be stored as well as what implication the storage location has for data security. P5 for instance preferred data to be stored locally rather than in a cloud.

Data Control and Access. Participants agreed that the fewer people have access and control of the data, the better. However, some preferred giving access to a small circle of trusted people others favoured a care service. Participants shared the reasons for these preferences. P6 argued for granting access to a small circle and gives an example of an "*uptight granny*" who does not want to show the data to anyone even though it might be helpful. Therefore, she says, that it is nonetheless important that a small circle of trusted people has access to the real data because otherwise– as she put it, "*you might end up cheating yourself*." (P6). Others, such as P7, would prefer to give access mostly to a care service to avoid being a burden for family members and informal caregivers.

> *"Regarding data access and monitoring, I think it should be a care service. If something extreme happens, relatives can always be taken on board. [...] Smaller issues might arise frequently, and a care service reacts quickly and maybe comes over. I don´t want the relatives to worry a lot and then be obliged to keep checking."* (P7)

Handling Technology. Participants pictured ways they would interact with such integrated AAL devices. They discussed to what extent the degree of autonomy and independence changes and potentially diminishes in such a scenario. In addition, they explored latitudes and limits of technology in terms of keeping or giving up control over oneself. These thoughts can be summarized into two categories, namely ***Maintenance of Autonomy and Independence*** and ***Maintenance of Control.***

Maintenance of Autonomy and Independence. As a first impression, participants felt that such AAL technology would take away a lot of independence and control from them and would not consider their remaining cognitive and physical abilities required in daily life. One participant having this opinion (P8) stated that decisions on giving up autonomy and independence highly depend on, "*the will to extend my life*" (P8) considering beliefs and values on life and destiny one has at that point in time. Others concentrated on the meaning of independence and autonomy discovering that there might be two sides of the same coin.

"On one hand something is taken over but then you keep your independence longer […]. On one hand deactivated, on the other hand, increased autonomy. It is perhaps a paradox" (P4)
"I would feel being taken care of as well as being independent […] I don´t always need someone to come by all the time but I can actually handle it myself and if there is something wrong, the system takes care of it, so I am coping with everyday life" (P2)

Maintenance of Control. Participants thoughts on handling the technological devices were driven by the fear of losing control over technology and with that losing control over oneself. According to participants, AAL technology should therefore operate based on individual needs and avoid evoking feelings of being controlled.

"Technology must serve me when I need it. The machine must be at my service, and it is not I who must be at the service of the machine." (P10)
"When you are so old that you no longer know how to operate this device you even feel more controlled by the device. […]. Then, it would be important that the device is hidden so that you don´t notice it or that the device helps you to operate it to give you the feeling that it doesn´t control you." (P6)

The notion of control in this context was also viewed as control over information about oneself and with that control over the own image.

"Imagine if you say that you were doing well last week and your friend replies: ´No I don´t believe you, I know your data´. You decide what you tell your friend or how you felt, and how you generally feel about yourself. You decide what to tell and what don´t" (P6)

Critical Aspects. Three critical categories were identified that can be put under the umbrella of privacy in this AAL scenario. Namely, ***Privacy Invasion***, ***Sensitive Activities*** and ***Technological and Human Care***.

Privacy Invasion. During the process of creating the mental map, participants gave concrete examples regarding critical situations where privacy might be threatened. Interestingly, some of the participants considered this threat as rather unproblematic.

"*It doesn´t bother me in my situation […] Maybe for the younger ones it is a disturbance, but I don´t mind those things, I go around and do things as I am and there is nothing to hide -I have nothing to hide*" (P12)

On the contrary, others mentioned situations where interference of technology is not desired and considered as a disturbance of privacy. Among them P2 and P4 shared examples:

"An example: I am reading something, and I am concentrating and now technology informs me it is my turn to take my pills or whatever and I am disturbed. I think that is an invasion of my privacy." (P4)
"The more the measurement is noticeable […] thinking of a moment when I have guests over who could also see it, then I would feel that my privacy had been hurt." (P2)

Sensitive Activities. Activities that are repeatedly cited as particularly sensitive and critical to monitor are activities in the bath- and bedroom. In the bathroom, especially toileting and showering were concerning. Oftentimes, participants even either rejected the use of technology in these intimate moments or accepted it unwillingly.

"I would like it if there were areas without technology for example in the bathroom or in the bedroom." (P6)
"What I don´t feel comfortable with is, for example, when I go to the toilet, knowing that I am being watched, or other intimate acts that I don´t like to do in public. […] As long as I understand this cognitively, I can accept it, even if reluctantly. But I think it becomes difficult when the mind can no longer grasp it. Then it becomes a burden." (P4)

Technological and Human Care. Despite all the positive aspects mentioned about the AAL technology in this scenario, participants talked about their hope that human care and human contact is still provided or at least complemented with technology.

"The technology is there but maybe one day a human being will come by. That is what I hope. […] Even if everything is okey every two days, once a week, you can talk to a person about these things that were recorded or about your wishes, that would be good. It doesn't matter if all the values are good, you still want to talk to someone when you are alone" (P3)
"There is no longer a person who helps you and stays with you all day long and therefore favours an exchange of social information and physical contact that a person who is alone may need. This is missing in this scenario here." (P8)

4.2.3 Ideal Conceptualization of AAL Technology

Participants shared their ideal conception of the technology in this scenario in line with privacy preferences. This means that participants were asked how they wanted the technology in this scenario ideally to be designed in terms of functionalities,

appearance, and interaction. Findings are summarized in Table 2.

Table 2: Ideal conceptualizations of AAL technology.

Ideal Conceptualization of Technology	Description
Straightforward and manageable	Technology should be simple, and it should be easy to learn how to interact with it.
Able to learn	Technology should have the ability to learn about the users, their habits, and (health) conditions.
Individually Customizable	Technology should adapt to the user´s rhythm of life and each function should be customizable and work as the user wishes.
Offer to help is rejectable	Users should have the freedom to refuse help from technology.
Technology can be turned off	Users should be able to switch the technology off anytime.
Neutral Appearance	Technology should be hardly seen, be very subtle and discreet or at least look like a design object rather than a health device.

5 DISCUSSION

The paper presented cognitive maps of potential users of AAL technology and the resultant findings regarding their opinions on living with such assistive devices. This qualitative approach aimed at understanding thought processes regarding privacy when in need of care due to age-related frailness and being supported by AAL technology.

5.1 General Findings and Privacy Criteria

Overall, and in line with existing literature (e.g., see Garg et al., 2014; Gövercin et al., 2016; Lorenzen-Huber et al., 2011; Wild et al., 2008) participants had a positive impression of themselves using AAL technology at home in older age and mentioned more positive than negative aspects.

Participants` opinions of the AAL scenario were elicited with a cognitive mapping method (3CM). Maps varied in complexity which is also reasonable according to Kearney and Kaplan (1997) and maps of experts tend to have stronger and more objects. In this study, the sample consisted of non-experts of the AAL domain, but several participants had professional care experience and/or a high general technical understanding. Participants with the least complex maps were the two oldest participants (both 81 years) both with limited technical understanding and no professional care experience. One explanation might be that older adults generally have less experience with technology compared to younger adults and therefore have less developed mental models of how to use them (Ziefle & Bay, 2004). Opposed to that, the most care experienced, technically skilled adult (59 years, MA. Nursing and health sciences) created the most complex map. The second most complex map was conceptualized by the youngest technically highly skilled participant. Even though both participants were not experts in the AAL domain they had important knowledge in related and relevant domains of care or technology respectively. In line with theoretical argumentations (Collins & Gentner, 1987; Rickheit & Sichelschmidt, 1999), this knowledge has probably helped in the creation of their compound mental maps. Previous findings have already suggested that care experience plays a role in AAL acceptance (Offermann-van Heek et al., 2019; Offermann-van Heek & Ziefle, 2019). Related to this, this study provides hints that care experiences are strongly reflected in the mental model of an AAL scenario which focuses on privacy implications.

Findings on privacy in this study can roughly be allocated to Burgoon`s four dimensions of privacy (Burgoon, 1982).

Naturally, the category **Handling of Data** including its identified subcategories can be assigned to the dimension of informational privacy (control over personal information). Data contains intimate details and therefore the dimension of psychological privacy might also be relevant for this category. Findings fit in the picture on AAL acceptance of previous studies (e.g., Kirchbuchner et al., 2015; Offermann-van Heek & Ziefle, 2019) confirming data access and the fear of data misuse as relevant aspects.

The category **Handling of Technology** including its subcategories regarding autonomy, independence, and control might be most closely related to psychological privacy (degree of inaccessibility to thoughts, feelings, and intimate information) as well as social privacy (control over social contacts, interaction, and communication). Previous studies show the importance of autonomy and independence for older adults when interacting with technology (e.g., Lorenzen-Huber et al., 2011; Ulrich et al., 2020). Within the subcategory ***Maintenance of Autonomy and Independence***, several participants concluded that AAL technology enhanced and

supported independence and autonomy even though it invaded a large part of the intimate everyday life. Previous studies have called it a trade-off between autonomy and privacy (e.g., Lorenzen-Huber et al., 2011). In this study, one participant labelled it as a paradox which might be a less functional description but it emphasizes the complexity and multificacety of such an AAL scenario. Control and the feeling of being in control when using AAL is another core aspect when interacting with AAL (e.g., Schomakers & Ziefle, 2019; Ulrich et al., 2020) and has been summarized in this study in the subcategory ***Maintainance of Control***. Participants mentioned their desire to keep control over their data as well as to keep control over devices including being able to reject technological offers and being able to turn devices off completely, as results from ideal conceptulaizations show.

The category **Critical Aspects** might somehow be related to all privacy dimensions. The subcategory ***Sensitive Activities*** might be particularly bounded to the psychological as well as the physical dimension of privacy. The latter because the sensitive activities mentioned are typically done in the bath and bedroom and some participants even referred to the location. This is consistent with findings from Himmel and Ziefle (2016). The importance to complement AAL with human care and contact is emphasized in the subcategory ***Technological and Human Care***. The fact that technology should not replace human care has already been mentioned previously (e.g., Lorenzen-Huber et al., 2011). Indeed, participants want actual humans to discuss their wellbeing and at the same time participants consider human physical contact as important contribution to their wellbeing. The subcategory ***Privacy Invasion*** and several ideal conceptualizations (i.e., "Able to learn", "Individually Customizable") show that privacy within an AAL scenario is a very personal matter. Similarly, concerns especially regarding privacy are best countered with customizable solutions and individual support which partly includes human care.

5.2 Method Evaluation

The study procedure was based on the open-ended 3CM method. Participants quickly grasped the cognitive mapping approach and provided objects to be written on the cards in the form of entire sentences or single words. The main constructs assessed were "general perceptions of AAL in older age", "privacy perceptions when interacting with AAL" and "ideal conceptualization of AAL". According to Kearney and Kaplan (1997), construct validity can be examined by the following three major theoretical expectations: (1) if participants are able to distinguish between the objects they own and the ones they do not (i.e., the extent to which participants are certain that a specific object belongs in their mental representation), (2) if hierarchical relationships are shown through the creation of 5 ± 2 created categories, and (3) if participants express satisfaction with the measurement process.

These three criteria for construct validity apply to most of the sample´s maps. Nonetheless, reliable and quantifiable practices to test for these criteria during data collection were limited. Firstly, concerning ownership of the objects, no specific measures were taken to test for it. However, participants` were given time to think about further additions to the map without being pressured. Without being prompted by the interviewer, participants were also able to express when their map was completed. Secondly, theoretical expectations regarding hierarchical relationships apply to six out of eleven maps. Indeed, six participants were able to create minimum two and maximum six categories and some participants even provided headlines for each category. Lastly, most participants expressed satisfaction and enthusiasm during the mapping exercise. This was shown from participants` persistent search for additional objects and their positive comments on this mapping task during the informal talk after the interview.

Overall, within the scope of available resources and objectives of the study, reasonable efforts and measures were taken to ensure construct validity as best as possible. Furthermore, the high degree of consistency with existing findings on privacy perceptions and acceptance of AAL suggest that the method is appropriate for the assessment of the given context.

5.3 Practical Implications

The field of AAL connects many disciplines such as legal, technological, and social disciplines, and benefits from close inter- and transdisciplinary collaboration and communication. As such the reported findings from a social science perspective might have implications for engineers and designers as well as lawmakers working on aspects of AAL.

Especially when it comes to the perception of an "**Ideal" Conceptualization of Technology,** the insights of potential users of such AAL devices in terms of expectations and requirements towards an accepted technology in line with privacy preferences might be informative for other disciplines and

professional groups. From the results, several key principles can be outlined:

Usability. AAL users want to feel in control of technology, being able to turn it off and to manage it easily, even with little technological knowledge. This means, the usability of the AAL interface is key. Interaction with the interface should be simple and explainable in a few steps. If users know how to navigate the device, their feeling of control will be enhanced.

Framing and Information Style. Even though AAL might support crucial tasks of daily life, technological support should never be provided in an authoritarian and domineering way. Ideally, users should barely be aware of the technological support they receive. This might be accomplished with technological features that enable customization and personalization of AAL devices. Acceptance and integration of AAL in daily life becomes more natural for users if devices can quickly adapt to personal rhythms and preferences of each user. Preferences can range from technological functioning, interaction modality and data sharing to the actual design and visibility of AAL.

AAL should Match Individual (Design) Preferences at Home. Indeed, AAL does not only need to fit to users` life rhythms but also to their own home and the way users feel at home. The own four walls are a place of refuge, creativity, and wellbeing and not a healthcare facility. Despite its purpose of care and health monitoring, AAL and particularly its hardware should be designed to reflect standards of home interior.

Perception of Control should Be Considered by Legal Framing. Furthermore, this study bears another implication especially regarding legal aspects. Again, the notion of control plays a crucial role. In fact, participants, as potential users, stated to prefer being in control of technology but at the same time, they emphasized the importance of being in control of the data captured by the devices. They want to know and decide with whom, how, and when data is logged and shared. At the same time, potential data misuse and hacking are a great concern. As users might decide on data access and storage based on their personal preferences, the legal framework should enable a broad range of data elaboration methods while ensuring rights of users and allow for strict prosecuting in cases of misuse.

Those key features should be considered in future professional education not only for care personnel but also for technical designers and persons that are in charge of providing legal frameworks. The more such user aspects are considered from the very beginning of technological development, the higher will be the potential of acceptance of AAL technologies. This especially applies to the type of technology under study. In particular, camera technologies and sensors as essential parts of AAL technology might be important when it comes to perceptions of privacy. Thus, based on current research (Wilkowska et al., 2021), future studies should focus on the specificity of privacy perceptions of visual technologies at home.

5.4 Limitations and Future Research

The applied qualitative procedure was an explorative study to evaluate the methodological approach, including the 3CM Method, and its suitability to examine privacy perceptions within an AAL context. It proofed useful in getting the participants to think and reflect thoroughly about the given AAL scenario and the implications for privacy. Nonetheless, the validity of the method has limitations as outlined previously.

Related to the representativeness of the method might be the fact that the present qualitative assessment was scenario-based and did not evaluate actual technology and real-life experience and knowledge of the given domain.

Furthermore, as the study was explorative, the AAL scenario used for the creation of mental maps was very generic. Indeed, the technology described had many functions and left a lot of space to the imaginary. To attain more elaborate cognitive maps the technology presented should be more specific and its functioning should be explained more explicitly. Ideally, participants should have the opportunity to test the actual technology for a determinate period prior to the assessment of their mental representations regarding it.

The semi-structured interviews all lasted roughly one hour, and the mental mapping procedure was created in the second half. The long duration might have been challenging especially for older participants who sometimes showed difficulties in concentrating until the end of the interview. Future studies attempting to study mental conceptualizations might solely focus on the creation of the mental map without any further questions.

The present study was conducted in two neighbouring countries in Europe, namely Germany and Switzerland (Italian-speaking region). No remarkable differences between answers of participants could be identified due to nationality. For future studies, the approach of this study should be applied in other non-European countries to compare

mental conceptualizations of privacy within AAL in different cultures and certain healthcare systems.

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