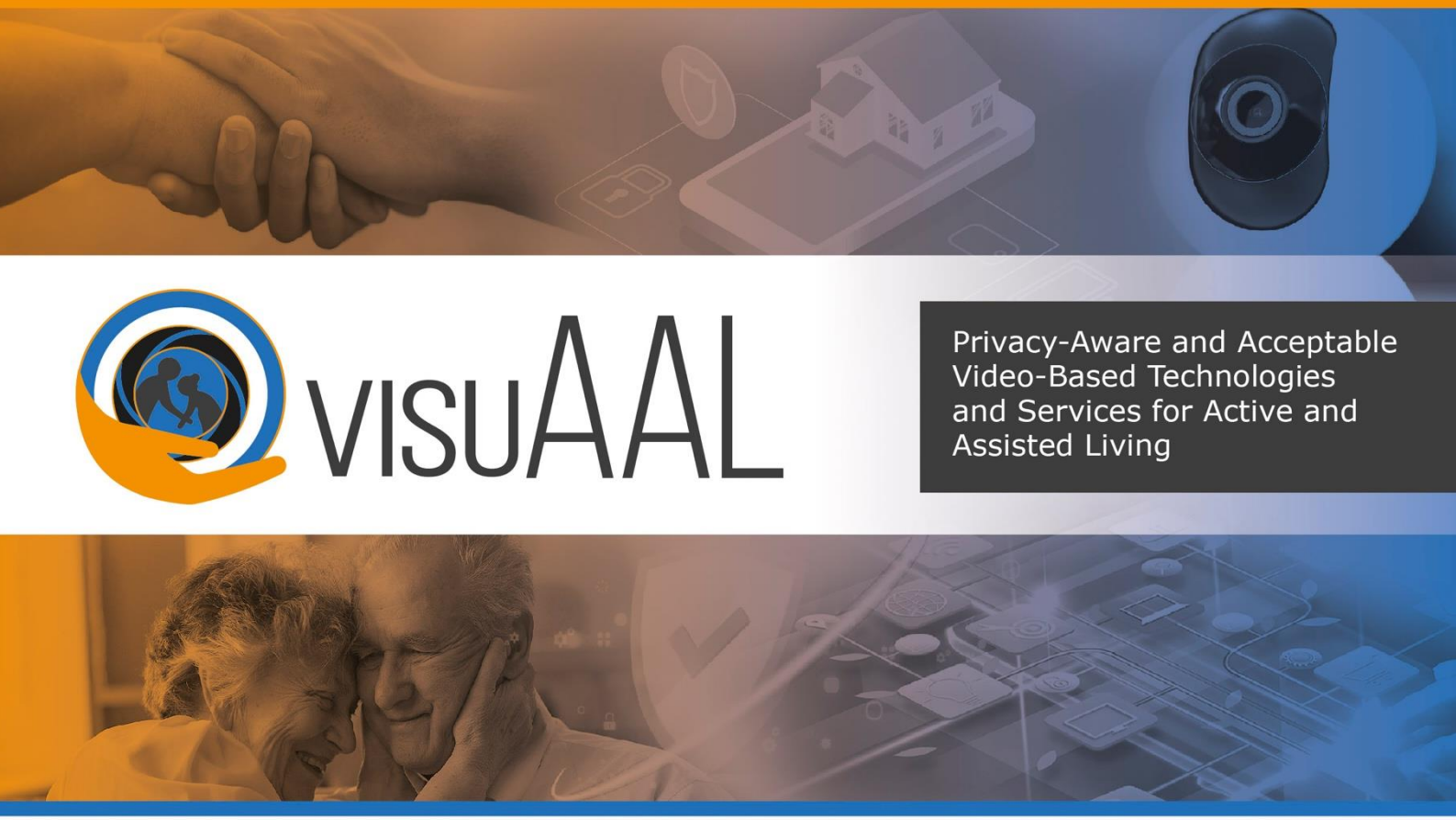

visuAAL

Privacy-Aware and Acceptable Video-Based Technologies and Services for Active and Assisted Living

D1.4. Empirical profiles for privacy-aware and acceptable research and innovation in video-based technologies for healthcare and AAL

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- Draft (D): describes planned contents and main structure of the different sections. Document is between 0% - 50% completed.
- Intermediate (I): document is approximately between 50% - 100% completed. It is the previous step before it could be released.
- Released (R): document is 100% completed, reviewed, and authorized for release by the partner responsible of the deliverable or the WP leader.

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1. Introduction

Aging with dignity and according to personal preferences is a desirable goal which becomes increasingly more challenging to achieve. This is caused by the demographic change and a resulting gap between more people in need of care and fewer healthcare providers (Börsch-Supan et al., 2015; Pickard, 2015). To mitigate this gap Ambient Assisted Living (AAL) technology is considered one promising solution (Blackman et al., 2016; Calvaresi et al., 2017; Peek et al., 2014). Through various environmental and wearable sensors, the latter technology is embedded into a person´s daily living environment to provide support for activities of daily living and prevent risky incidents. As a contribution to more safety, well-being, and autonomy for people in need, for example, activity patterns, changes in mobility as well as vital signs are tracked and monitored through AAL (e.g., Blackman et al., 2016; Choukou et al., 2021; Rashidi & Mihailidis, 2013). Generally, a combination of different technologies and sensors is used for AAL which increasingly includes visual sensors such as RGB or depth cameras (Climent-Pérez et al., 2020). Abundant sensory information can be gathered with these video-based technologies which makes these sensory devices particularly advantageous. In fact, other sensors such as pressure mats or haptic sensors could be replaced by a camera as any specific activity in a room may be monitored effectively with one single visual sensor (Cardinaux et al., 2011; Climent-Pérez et al., 2020). From a technological and economical viewpoint this increase of camera and video technology as part of AAL monitoring is quite reasonable. From a user point of view however, health monitoring with visual sensors is rather rejected due to major concerns which prominently include privacy issues as a main barrier of technology acceptance (e.g., Arning & Ziefle, 2015; Beach et al., 2009; Offermann-van Heek & Ziefle, 2019).

2. Acceptance of video-based aal and the role of privacy

2.1. (Technology) Acceptance

Acceptance is a complex and multi-dimensional phenomenon but broken down to a few words its core meaning relates to approval, acknowledgement or adoption of an object, fact, or instance (e.g., Kollmann, 1998; Lucke, 2013). Hence, acceptance can also be an expression of an attitude which is understood as active willingness and not reactive acquiescence (Dethloff, 2004). Technology acceptance assumes a subject of acceptance which refers to an object of acceptance (Hüsing et al., 2002). Furthermore, technology acceptance involves various phases and happens over time (Peek et al., 2014). In research, technology acceptance is traditionally measured with the Technology Acceptance Model (TAM) (Davis, 1989) and/or the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2012). The variables that are at the centre of these established models, are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) which revealed to explain 40% - 70% of an individual´s intention to use technology in several contexts including healthcare (for an overview see Davis et al., 2020). Even though these models are robust and quite powerful, one major critique consists in their inability for context-specific evaluations of technology acceptance. Specifically, when it comes to technology acceptance by older adults, biophysical (e.g., cognitive, and physical decline) and psychosocial (fear of illness, social isolation) factors are disregarded in research using these models (Chen & Chan, 2011).

Contributing to a sound understanding of older adults´ acceptance mechanisms of AAL technology, a recent conceptual model has been developed by Jaschinski et al. (2021). The authors (2021) based their model on the Theory of planned behaviour (Ajzen, 1991) with "intention" defined as "*indication of a person´s readiness to perform a given behavior*" as a core construct of the theory (Ajzen, n.d., 1991). Based on the determinants of intention, Jaschinski et al. (2021) included appropriate belief antecedents for AAL acceptance in their conceptual model. These multidimensional variables consisted of

- ***Attitude towards using AAL*** (= "*the degree to which […] [using AAL] is positively or negatively evaluated"* (p.3)),
- ***Social Norm*** (referring to subjective norm defined by (Ajzen, n.d., 1991) as *"perceived social pressure to engage or not engage in a behavior"*, namely AAL usage (p.3)),
- ***Personal Norm*** (= *"people´s self-based standards or expectations for AAL use that flow from one´s internalized values"* (p.3)) and

- ***Perceived behavioural control*** (= *"people´s perceptions of their ability to […] [use AAL]"* (p.3)).

This model achieved to account for 69% of the variance in behavioural intention to use AAL technology and illustrates the relative importance of various acceptance factors, with the attitude towards AAL technology as the most important predictor of acceptance. This model is pioneering as the first theory-driven quantitative framework for understanding acceptance of AAL and is specifically targeted to the early stages of AAL acceptance given that AAL hasn´t been adopted on a larger scale yet.

AAL technology research has been emerging the past forty years (Blackman et al., 2016) but the adoption of video based AAL in the healthcare sector is still in its early stages (Climent-Pérez et al., 2020; Wilkowska et al., 2022). Therefore, a large amount of user studies on AAL acceptance concentrated on the decision-making process during the question whether to adopt or reject (video- based) AAL. The pro-and counterarguments that contribute to this decision-making process are labelled in the literature as benefits, or facilitators, and barriers (Jaschinski & Allouch, 2015; Peek et al., 2014; Yusif et al., 2016; Zander et al., 2021). These benefits comprise increased safety, perceived usefulness, increased independence, reduced burden for family caregivers, mobility, and support with daily activities whereas the related barriers concern privacy implications and maluses of personal data by unauthorized parties, lack of control over technology, false alarms, obtrusiveness, low ease of use, high costs, and, last but not least stigmatization with respect to frailness and dependence at older age. These benefits and barriers are traded-off against each other to decide whether to accept /adopt (video-based) AAL or not and various user studies depicted how each factor is weighted (Offermann-van Heek et al., 2019; Offermann-van Heek & Ziefle, 2019; Schomakers et al., 2020; Schomakers & Ziefle, 2022). These findings suggest that safety and increased security are usually the most important benefits contributing to successful AAL acceptance. Privacy concerns have a significant negative impact on this trade-off process and are thus considered as the most relevant barrier (Garg et al., 2014; Lorenzen-Huber et al., 2011; Maidhof, Ziefle, et al., 2022; Offermann-van Heek & Ziefle, 2019; Schomakers & Ziefle, 2019) .

In general, AAL acceptance and the trade-off process has been investigated for several AAL technologies (e.g., ultrasonic whistles (Biermann et al., 2018) , pressure mats (Tyrer et al., 2006), cameras (Arning & Ziefle, 2015; Maidhof, Hashemifard, et al., 2022).

However, studies examining different user groups (people in need, caregivers) specifically on their opinions about visual sensors report a rather hesitant and doubtful attitude for such monitoring in the own home environment - despite an overall acknowledgement of the general benefits (Arning & Ziefle, 2015; Berridge et al., 2019; Bourbonnais et al., 2019; Himmel & Ziefle, 2016; Lapierre et al., 2015; Londei et al., 2009; Wilkowska et al., 2020, 2021; Ziefle, Himmel, et al., 2011; Ziefle, Röcker, et al., 2011). Arning & Ziefle (2015) identified medical safety as the most decisive factor in the process to decide for or against video-based monitoring for oneself. But an increase of the latter wasn't sufficient to increase acceptance of video monitoring in the own home. Rather positive acceptance evaluations for camera monitoring were given for other public spaces such as a shopping mall, a marketplace, or a train station. Indeed, findings suggest that video-based technology acceptance decreases the more private and intimate the space is that should be monitored (Arning & Ziefle, 2015). This trend is highlighted by a longitudinal study (Himmel & Ziefle, 2016; Ziefle, Himmel, et al., 2011) which assessed acceptance of home home-integrated Information and Communication (ICT) technologies including hands-free equipment, positioning system and cameras in 2011 and 2015. Both assessments show that independently from the home area, integrated cameras were the least accepted monitoring technology. Nonetheless, usage would be rather granted in the living room but not in the bed- and bathroom due to the intimate character of these spaces. The authors further observed that, despite persisting fear of losing one´s dignity and privacy concerns among all participants, older and ill participants accepted visual systems more than healthy participants (Himmel and Ziefle, 2016). Similarly, people with disability would accept visual monitoring more than healthy people (Beach et al., 2009). Furthermore, Ziefle, Röcker, et al. (2011) report that video-based monitoring would be accepted if technology was helpful and if data protection was guaranteed. Participants further underline the importance of privacy and trust in the system which is also in line with recent findings from Otten & Ziefle (2022).

From a caregiver perspective, the implementation of video-based AAL may elicit stress and pressure in professional caregivers and may be seen as a sign of lacking confidence in their work, demoralizing and offending care personnel (Berridge et al., 2019). On the other hand, such implementation may contribute to more well-being at work reducing stress, as well as older adults` risk of falls (Bourbonnais et al., 2020) and, on top, may support in detecting the truth about abuse or theft allegations (Berridge et al., 2019). However, even among caregivers concerns regarding privacy violation were mentioned (Berridge et al., 2019; Bourbonnais et al., 2019, 2020; Offermann-van Heek & Ziefle, 2019).

In sum, privacy and related concerns considerably steer technology acceptance and especially during the moment of decision whether to adopt or reject video based AAL technology privacy has a considerable impact on the outcome. Given the important role of privacy, it is worth zooming into the concept and its ties to video-based AAL acceptance and current developments in computer vision.

2.2. Privacy perceptions

In the video-based AAL domain, privacy is primarily framed as a concern, something that needs to be preserved, or risks being violated. In fact, various user studies report feelings of permanent surveillance, fear of access and misuse of personal information, data sensitivity, invasion of personal space, and obtrusiveness as privacy related factors and as a barrier of video-based AAL acceptance (e.g., Demiris et al., 2009; Garg et al., 2014; Lorenzen-Huber et al., 2011; Peek et al., 2014).

However, privacy as a construct is multidimensional and differently defined in several disciplines (Burgoon, 1982; Smith et al., 2011). In the legal and economic disciplines privacy definitions are mostly value-based i.e., referring to a human right or an economic commodity (Smith et al., 2011). As part of the publications stemming from a legal perspective, Gavison (1980) points out that

> "[…] first *we must have a neutral concept of privacy that will enable us to identify when a loss of privacy has occurred so that discussions of privacy and claims of privacy can be intelligible. […]*" (Gavison, 1980, p.423).

This is an important reminder for user assessment in the AAL context where the primary focus is indeed on detecting loss of privacy and adhering to concerns of the latter.

In social science studies on video-based AAL acceptance definitions of privacy are mostly cognate-based i.e., classifying privacy as a behaviour or predisposition of the individual to behave (Smith et al., 2011). Thereby, privacy is seen as a state of mind (Alpert, 2003; Westin, 1967) or as an assertion of control (Goodwin, 1991; Milne, 2000; Westin, 1967). Within these cognate-based approaches it can be distinguished between literature explaining the mechanisms how privacy is reached and research on why privacy is needed and sought at all. Covering the latter, privacy satisfies basic human needs such as contemplation, autonomy, rejuvenation, confiding, and creativity contributing substantially to personal well-being, positive human functioning, and effective management of social interactions (Altman, 1975, 1976; Pedersen, 1979, 1997, 1999). If mechanisms to reach these needs fail continuously and privacy

concerns become true, severe mental illnesses such as depression or anxiety are potential consequences (Altman, 1975, 1976; Uysal et al., 2010).

Ideally, privacy is controlled through a boundary regulation process to reach an ideal amount of privacy, as proposed in the conceptual analysis of privacy by Altman (1976). Indeed, to reach to an optimum amount of privacy individuals attempt to shift the current achieved privacy towards the desired amount of privacy through various behavioural mechanisms such as verbal and paraverbal expressions, nonverbal movement of the body, cultural norms, and customs as well as environmental behaviours (Altman, 1976). This adjustment happens according to the circumstances at hand including personal and situational factors. The latter can be, but is not restricted to, personal factors like interpersonal skills or personality and situational factors such as physical environment including location and given barriers.

Thereby, privacy management is happening on multiple levels as outlined by Burgoon (1982). These levels are described as

- ***informational*** dimension (i.e., control over personal information),
- ***social*** dimension (i.e., control over social contacts, interaction, and communication),
- ***psychological*** dimension (i.e., control over the degree of self-disclosure of thoughts and identity) and
- ***physical*** dimension (i.e., control over physical inaccessibility).

These dimensions have been already applied and mentioned in research in user studies on privacy in AAL (Maidhof, Ziefle, et al., 2022; Schomakers & Ziefle, 2019) as they account for the multifaceted and pervasive nature of video-based AAL monitoring.

Furthermore, when it comes to privacy in digital environments the distinction between privacy attitude and privacy behaviour should be mentioned briefly. An attitude is *"a global and relatively enduring evaluation of a person, object or issue – a representation of whether we think the target is generally good or bad, desirable or undesirable* " (Bizer et al., 2006). Privacy concerns, common in the video-based AAL context, can be seen as one actual example of a privacy attitude. There is a common differentiation in social psychology between the availability of an attitude (i.e., present, or not in an individual's cognition) and the accessibility of an attitude (i.e., ease with which an attitude is retrieved from memory) (Bizer et al., 2006; Fazio et al., 1989; Kardes et al., 1986). The better an attitude is accessible the more likely it is that this attitude leads to a consequential behaviour. This accessibility is dependent on the context as well as on how strong the certain attitude is (Fazio, 1990; Fazio Williams, 1984). Ajzen and

Fishbein, (2004) distinguish between general attitudes towards an object and behavioural intentions (i.e., attitudes towards performing behaviours regarding an object or target). In research on privacy in video-based AAL the interest is on both types of attitudes however to a larger extent on behavioural intentions. Indeed, the overall goal of these AAL user studies is contributing to a successful adoption and actual usage of such systems. General attitudes seldomly have a strong influence on behaviour so when we compare general attitudes with specific behaviours an evaluative inconsistency occurs in measuring attitudes related behaviour, as explained by Ajzen and Fishbein (2004). If the behaviour is hard to perform or behavioural intention and behavior haven´t been evaluated at a close time a literal inconsistency happens in the measurement. Indeed, intentions may change over time according to circumstances and living situations.

Behaviour, is in turn, defined as "*an organism's activities in response to external or internal stimuli, including objectively observable activities, introspectively observable activities and nonconscious processes*" (American Psychological Association, 2022). For privacy this can refer to activities and efforts made to regulate privacy until it has reached its optimum level as explained above (Altman, 1976). These may comprise closing or opening the door, turning away or towards another person, verbally expressing wanting to be left alone or in digital environments it may comprise denying or accepting cookies, or restricting access of the personal social media profile.

In visual healthcare monitoring, privacy enhancing behaviour (PEB) has been studied which comprise behaviours that people engage in to evade or lessen privacy concerns (Broadbent et al., 2009; Caine, 2009; Caine et al., 2012). Among the observed ones were, for instance, covering up the camera with an object, turning their back towards the camera or hiding objects with their body (Caine et al., 2012). In digital environments especially information privacy plays a greater role in such and privacy research in this domain has reported a so-called (information) privacy paradox (Kokolakis, 2017). This phenomenon refers to an observed inconsistency between high concerns regarding privacy on one hand and a relatively high willingness to trade personal information for small rewards on the other. However, there is a great debate on the existence and nature of this phenomenon which may also originate from measurement differences regarding attitudes and behaviours, which have been outlined above. For an existential review on the phenomena and its controversy refer to Kokolakis (2017).

Overall, previous paragraphs have highlighted the multi-dimensionality of privacy and its strong dependence on a given context which includes situational and personal factors. In user research regarding video-based AAL it is therefore important

1) to remember and account for these individual and contextual factors,
2) to evaluate the privacy regulation mechanisms (i.e., how privacy is reached) as well as which privacy needs must be satisfied (i.e., why privacy is searched for), and
3) to distinguish between measuring general attitudes, behavioural intentions, or behavior regarding privacy.

Further explanations regarding privacy measurements will be treated in the following chapter. Technological developments of such camera-based AAL system are considering these concerns from potential users. Indeed, efforts in computer vision are made through privacy by design (Gurrin et al., 2014) and privacy by context frameworks (Padilla-López et al., 2014; Ribaric et al., 2016) to maximize privacy protection and support potential users of AAL in the way towards reaching an optimum level of privacy given certain personal circumstances. Thereby, an appeal was made to include (potential) users as soon as possible in the development stages to maximize user acceptance of the final products (Blackman et al., 2016; Climent-Pérez et al., 2020; Liu et al., 2016) which can be interpreted as a call for conducting further user studies.

3. Empirical insights – integrating the users´ perspective

User studies on acceptance of AAL have been reviewed several times (Blackman et al., 2016; Jaschinski & Allouch, 2015; Liu et al., 2016; Peek et al., 2014; Queirós et al., 2015; Yusif et al., 2016; Zander et al., 2021) and, among other things, mention the benefits and barriers of adoption as outlined above. However, these studies did not look specifically at AAL monitoring with video and camera in the home environment.

Generally, user studies on (video-based) AAL aim at gathering knowledge using an empirical approach. This means that the gathering of knowledge happens through direct or indirect observation (Newhart & Patten, 2018). To avoid wrong interpretations of these observations, it is important to plan **why** observations are to be made in the first place, then, **how** to observe and **whom** to observe. All this planning happens in a systematic way and continues with data collection, data analysis, and finalizes with a research report. Strategies to go through these procedures are called research designs and include experimental and non-experimental designs which can be approached with qualitative (i.e., data expressed in words, analysed through identification themes)

and/or quantitative (i.e., data in the form of numbers, analysed statistically) methods in the data collection and analysis stage. Qualitative studies allow a deeper insight into individual argumentation lines but fail to go beyond the small use cases used in qualitative research. In contrast, quantitative studies on acceptance target a larger sample (i.e., study participants) and more users and can contrast different user groups. This allows to quantify the number of perceived benefits and barriers to use visual technologies and can even mirror individual decisions in the trade-offs between seen benefits and barriers. Independently of which design is chosen, these core questions need to be answered clearly (Newhart & Patten, 2018).

In the following, these questions will be discussed regarding the stages of data collection and data analysis in the context of user research on acceptance of video-based AAL technologies. Example studies are mostly, but not exclusively taken from AAL user research which target video and camera sensors and do not claim to systematically reflect the full range of studies.

The overall question of why has been made quite explicit in the previous chapter. Depending on the specific user studies, one or several research questions are posed which are intended to be answered through the planned empirical research process. Proceeding to the question of how and starting with the data collection phase, data is gathered in both a qualitative and quantitative manner. Qualitatively, study participants are either interviewed one-on-one (e.g., Maidhof et al., 2022; Otten & Ziefle, 2022) or in a group (i.e., focus group) (e.g., Lapierre et al., 2016; Mulvenna et al., 2017; Ziefle, Röcker, et al., 2011). To familiarize participants with the examined technology, they are sometimes shown presentations or scenarios of a specific video based AAL system during the study. On one occasion these scenarios were performed by a theatre group (Marquis-Faulkes et al., 2005) showing how creative these methods can be. Sometimes direct contact with a certain video-based technology is granted and participants can try the technology in a living lab (Caine et al., 2012), or the system is installed directly in their homes for a trial period.(Gelonch et al., 2019; Ourlasvirta et al., 2012) Quantitatively, questionnaires and surveys are used to gather data and technology contact is like the ones described above - either provided indirectly through scenarios or directly in living labs or trial periods. Once data is gathered, either qualitative in the form of spoken text or quantitative in the form of numbers it must be analysed so that valuable information can be extracted. Thus, in the data analysis phase, data can be analysed qualitatively with content analysis (Hoepfl, 1997; Kuckartz, 2014; Mayring & Fenzl, 2019) or quantitatively with descriptive and inferential statistics (Creswell & David Creswell, 2018; Newhart & Patten, 2018; Tabachnick et al., 2007). During both, qualitative and quantitative measurements, privacy is assessed in a variety of ways. In qualitative research proposals for using mental models were

made (Coopamootoo & Groß, 2014a, 2014b; Maidhof, Ziefle, et al., 2022; Oates et al., 2018). In quantitative research, there is a great number of instruments which can be reviewed for instance in (Biselli et al., 2022; Colnago et al., 2022; Preibusch, 2013; Wagner & Eckhoff, 2018).

In the field of AAL, the most relevant stakeholders are people in need of care (e.g., older adults) as well as familial (Elers et al., 2018; Jaschinski & Allouch, 2019) and formal (e.g., Lapierre et al., 2015; van Heek et al., 2018) caregivers. Hence, these three user groups have been examined in many studies using the methodological approaches mentioned above. The own home (e.g., Alharbi, 2018; Arning & Ziefle, 2015; Bandini et al., 2021; Wilkowska et al., 2021) as well as nursing homes (e.g., Berridge et al., 2019; Bourbonnais et al., 2019, 2020) are the places where such technologies are applied which means that many studies examine these environments.

Technologies studied in user studies range from cameras installed in the room (e.g., Himmel & Ziefle, 2016; Ourlasvirta et al., 2012; Ziefle, Himmel, et al., 2011) or wearable cameras (e.g., Gelonch et al., 2019; Harvey et al., 2016) as well as stationary and mobile robots with visual sensors (e.g., Caine et al., 2005). Technology used for video-based AAL is extensively reviewed by Climent-Pérez et al., (2020) and computer vision methods for privacy preservation in video-based AAL are further systematically reviewed and reported by Ravi et al. (2021).

4. Recommendations for best practice

4.1. Avoid ageism and stigmatisation

Even though (video)-based AAL is being developed for people in need of assistance and care – most of the time older adults - these user groups should not be stigmatized because of their requirements. Unfortunately, ageist stereotypes are still present in the research of AAL and fail to show the variety and heterogeneity of older adults which are not all frail and lonely, unable to use technology, as some stereotypes may communicate (Blackman et al., 2016; Fischer et al., 2022; Peine et al., 2014). Indeed, portraying older adults´ differing and individual needs for a successful uptake and sustainable use of assisting technology, is a crucial task of user studies. Besides, not only because of age, certain user groups may be more privileged than others on different levels as shown on the graphic visualized on the website of Dell (2014). Hence, user research in human-computer interaction, including video-based AAL, should be tackled with an intersectional approach as described by Liang et al. (2021).

Thereby, also the empirical approach and most importantly the data collection phase should match the target group studied. Notably, for studying older adults who may

suffer from physical and cognitive decline, this means using straightforward language and explanations appropriate for the interview partners, controlling for readable (big enough) font sizes and clear designs in survey or questionnaires and avoid very long assessment periods.

4.2. Balancing exploratory and confirmatory research

There is a lot of potential for user studies regarding acceptance of video-based AAL as this field is it is highly dynamic and advancing and AAL with video and camera is still in its early stages. Therefore, many user studies to date have had an exploratory character (i.e., without any previously identified knowledge and theoretical background) either examining these technological systems in general or examining one specific technology that has just been developed. Such exploratory research is adequate and needed given that the technology of the field develops dynamically, continuously, and quickly. It enables to keep up with developments and outline current trends. However, in the long run, more confirmatory research (i.e., based on hypothesis testing which come from previously conceptualized theories and knowledge) is desirable to corroborate findings. Similarly, using targeted quantitative models of AAL acceptance such as the one that has been proposed by Jaschinski et al. (2021) may contribute to more consistent research.

Furthermore, mixed-methods approaches in user studies may be particularly useful and many user studies are applying this approach already (Londei et al., 2009; Mulvenna et al., 2017; Offermann-van Heek et al., 2021; Offermann-van Heek & Ziefle, 2019; Wilkowska et al., 2020). Within these approaches qualitative and quantitative research methods are combined and thus provide a more in-depth understanding of users` opinions and thoughts (qualitative methods) as well as a quantification of these statements (quantitative methods) which allows for inferences on people´s opinion on a larger scale.

4.3. Trading-off contact with technology

Providing direct contact with a certain technology and then assessing participants´ opinions and evaluations is highly desirable for a further improvement of a specific technological device. It allows assessments of technology acceptance before and after having had contact with the technology under study (Peek et al., 2014). However, try-out periods require a lot of resources, ready-to use devices, technical staff that can install and explain the technology in a user-friendly way and that is available throughout the entire trial period. Furthermore, there must be enough people willing to participate and commit to such trial periods which may last from one day to several weeks. Usually not many participants can be recruited for these studies given limited resources and

limited willingness to collaborate. This also means that quantitative data collection and analysis is more difficult because inferential statistical methods require a certain minimum of data observation (Creswell & David Creswell, 2018; Tabachnick et al., 2007). Given this elevated number of resources and energy required for providing participants a direct contact with technology, presenting the technology with scenarios, a presentation or video can be seen as an adequate alternative. Sometimes, the technology under study is not even developed to a point that it can be used, so a scenario or presentation is the only way to evaluate users' opinions about it. Furthermore, with providing a scenario or a presentation, participants may be freer and more creative in their imagination of the technology which enables researchers and developers to uncover participants desired features or interaction modalities. Thus, when starting with a user study on video-based AAL, these factors should be carefully evaluated and the development stage of the technology should be considered. Eventually, direct contact with actual devices is desirable (Ziefle) as described in the following.

4.4. Integration of persons that use the technology is a Must

The overall goal of successful technology adoption cannot be reached with simply providing potential users a fully finished and developed product. As mentioned above, technology adoption follows on high acceptance, including strongly perceived benefits such as perceived usefulness, ease of use of the products and increased safety. All these aspects can neither be fulfilled by a product nor forced by any marketing strategy if the product was developed without consideration of (potential) users` concerns and necessities. As described above, (potential) users do have doubts and concerns about (video-based) AAL technology (e.g., privacy concerns, lack of control, low ease of use). The extent to which these concerns lead to a technology rejection strongly depend on personal and situational circumstances. These differing contexts should be considered during the entire design process of video-based AAL. The users, comprising older adults, healthcare/medical personnel and (caring) family members should be given a chance to express their desires of their ideal technology in line with their personal motives of using such an AAL system, their physical and mental abilities, their technological experiences as well as their living circumstances. Product and process development should be subordinate to this (Ziefle, 2021) and may be realized through a design process like the one proposed by Gould and Lewis (1985) (Wilkowska et al., 2018). Thereby, the focus is put early on the users and their tasks, the design process is iterative and, lastly, product use is measured empirically (Gould & Lewis, 1985). At some point in the design process, direct contact with (demo) technology is highly recommended so users can provide detailed feedback based on real and immersive experience and interaction with the single technological devices (Ziefle, 2021).

4.5. Foster interdisciplinary collaborations

The healthcare crisis which stems from an increasingly older population in need for quality care is a global issue which requires joint efforts from different disciplines and political support. Developing and implementing (video-based) AAL in care is just one contribution towards tackling or remedying the gap between an increasing number of people in need of care and less healthcare workers available. Generally, AAL should contribute to greater well-being and ageing well but it is not the only solution. Thus, when studying (potential) users of AAL, the technological devices and their use should be placed into a framework depicting quality of life and well-being in a holistic way. It is important to understand where and how these sophisticated systems support ageing well and where they have limits. In fact, a big aspect of the studies is to explore and highlight these red lines and limits of technology.

Nonetheless, when conducting empirical research in AAL it is equally important not to get lost into the complexity and multi-dimensionality of the field. Naturally, being an empirical researcher in the field it is impossible to connect to all other disciplines and branches equally. However, for conducting successful user studies in video-based AAL it is reasonable to start connecting with technological disciplines such as computer vision scientists, and engineers, who are responsible for the development of the single products. Strengthening these ties is beneficial for both disciplines and ultimately improves the product and its uptake. Informed by technological disciplines the empirical scientist interested in the user opinion may refer to more concrete technological features or scenarios and then communicate the empirical results back to the technological partners. Another relevant discipline to connect to when conducting user studies, are the legal sciences. These legal disciplines study existing laws and legal frameworks and contribute to their improvement. It is important that these laws on technology consider opinions and preferences of all stakeholders of (video-based) AAL but most importantly of the ones that will have the most contact with technology – actual, future and potential users of AAL. In this way, user studies in the field may provide input, guidelines, and reference points for legal frameworks.

5. Conclusions

The following main points can be concluded from the previous chapters:

- Empirical user studies are important for a successful and enduring uptake of technology, including video-based AAL.
- Concerns regarding privacy are main barriers to acceptance of video-based AAL, but the desired and enough privacy is highly individual depending on contextual and personal factors.
- Social science studies can, must and should mirror legal, technological, and economic considerations. The individual, social and societal requirements, needs and wants of the stakeholders involved should be heard throughout the technological development process.
- User studies should point out individual differences in preferences, behavioural intentions, and opinions so that desired features can be implemented in technology.

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