A Game of Wants and Needs
The Playful, User-centered Assessment of AAL Technology Acceptance

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Abstract: The use of Ambient Assisted Living (AAL) technologies presents one option to face the challenges of recent and rising care needs due to demographic change. User acceptance of those technologies plays a major role for a successful rollout and sustainable technology usage. Empirical research approaches (e.g., online questionnaires) in this area are often impersonal and abstract for the participants. In contrast, the current study aimed for a playful qualitative user study approach in which people empathize with different necessities of support and evaluate desired technologies and respective usage motives as well as barriers. The paper presents first research results of the new undertaken research approach, which was tested with six older participants (aged between 50 and 81 years of age). The results show that the playful approach enables a personal assessment of different assistive technologies and technology-related usage motives and barriers when a prototype testing is not feasible.

1 INTRODUCTION

Demographic change causes high burdens for the care sector as more and more older people are in need of care (Walker & Maltby, 2012). As the majority of older adults prefers to age in place and live independently as long as possible (e.g., Wiles et al., 2011), more and more technological solutions are developed aiming for support and assistance of older people and people in need of care in their everyday lifes. The term, Ambient Assisted Living (AAL) refers to the use of technologies to assist an older person in aging-in-place, supporting living independently, staying active, remaining socially active and mobile (Blackman et al. 2016). Industry and research institutions are currently working on different types of AAL technologies as well as holistic AAL systems. Prominent use cases are smart home functions (e.g., sensors for control of lighting, heating, doors, and windows) and the support of communication with friends, family and caregivers, fall detection, and other health care applications like medication reminders.

The number of available AAL systems and research projects is high (Memon et al., 2014). Although these technologies have the potential to facilitate everyday life and quality of life of older adults, they are not yet widely used. One of the crucial barriers against adoption of AAL technologies is the technology acceptance of the potential users (Merkel, 2016).

Research on technology acceptance in various contexts has been mostly dominated by the Technology Acceptance Model (TAM) (Davis et al., 1989) and its derivatives. These models might explain technology adoption sufficiently in a variety of contexts. Regarding assistive technologies for older adults, studies have shown that additional motives and barriers play a significant role (e.g., Jaschinski & Allouch, 2015, Peek et al., 2014). Potential users see the advantages and necessity of assistive technologies, but are at the same time concerned (e.g., regarding privacy violations, feelings of isolation). Thus, it might not be sufficient to evaluate the ease of using a system and the perceived usefulness, as traditional models suggest. For the decision to use an AAL system, the trade-off between the perceived barriers and benefits in the individual context is decisive (van Heek et al., 2017).

Much of the published research regarding technology acceptance of AAL uses qualitative methodologies like interviews and focus groups (Peek et al., 2014). In these studies, the participants typically evaluate one system that is described via a presentation or scenario, or the participants can interact with (a prototype of) that system. These

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studies have identified a vast amount of motives and barriers for older adults to use assistive technology. Most prevailing barriers against AAL technologies are general concerns regarding privacy intrusion, a low usability of the system, and high purchase and maintenance costs as well as the lack of perceived benefits (Jaschinski & Allouch, 2015; Peek et al., 2014). Perceived benefits include the increased safety, independence, and the release of burden to family and caregivers.

Wilkowska et al. (2015) conducted a comparison of methodological approaches to measure privacy concerns in an assistive environment. In a hands-on experiment, the importance of privacy aspects decreased in comparison to questionnaire studies and focus groups. Thus, the method does considerably influence the results and the evaluation of benefits and barriers of a novel technology.

In this publication, we report a new qualitative research approach. In a real-life situation, older adults need not only choose whether to use a technology. With more and more technologies on the market (Merkel, 2016), they also have to choose between different technology options (and non-technological alternatives). Our hypothesis is, that confronting participants with the choice between technology options can reveal additional insights into older adults' decision-making processes, trade-offs, and their evaluation criteria in choosing a technology. It is a more realistic decision situation than evaluating one system without knowing the technological alternatives. Just like the differences in relative importance between the questionnaire study, focus groups, and hands-on-experiment in Wilkowska et al. (2015)'s design, the importance of barriers and benefits may shift with choice between technology options. This is done in this study with a game-based interview approach, in which details are visualized and printed onto playing cards as a memory aid.

2 METHOD

The development of the method was led by the goal to identify barriers and benefits of AAL technologies that hinder usage in practice. Our hypothesis is, that the reasons to (a) decide whether to use technology at all for one use case differ from the reasons why (b) a specific technology is chosen from alternatives. An additional research question is, whether the criteria for technology choice deviate between scenarios of different necessity of support.

The interviews were audiotaped and transcribed verbatim. The theoretical foundation of the analysis was the qualitative content analysis by Mayring (2010). Three coders viewed the whole material. The study was carried out in German. For the publication, selected quotes were translated to English.

Figure 1: Example of the interview procedure.

2.1 The Interview Procedure

After a short introduction, the interviews started with questions about attitudes towards aging, the desire to age in place, and attitudes towards technology (e.g., *"What does quality of life mean to you?"*, "*Do you like to be supported by technology in your everyday life?"*). The goal of these questions was to let the interviewees put themselves into the situation of aging and to relate to technologies that already support their everyday life at present. Short questions regarding prior knowledge of and experience with AAL and smart home technologies followed.

In the main part (see Figure 1), two rounds of "the game" were played, each round with the precondition of a different scenario of the participant in older age. The written and visualized scenario was laid on the table as a memory aid. After introducing the scenario, a first use case and the matching technology options were explained (see Figure 2). To be more realistic and to support memory, images of the technologies were printed as playing cards with a description of the technology's characteristics on the back. The participants were then questioned *"Which of the technologies would you prefer to use in the given scenario?"* and were asked to explain their reasoning to the interviewer. A sketch of an apartment was acting as the game board, to which the interviewees could put those technologies that they wanted to use. Additionally, the participants were asked to indicate the most decisive reason for acceptance from nine cards. This forced choice for one main benefit should provoke a more active discussion about the reasons for acceptance. In a second step, the interviewees chose the most rejected technology in a similar

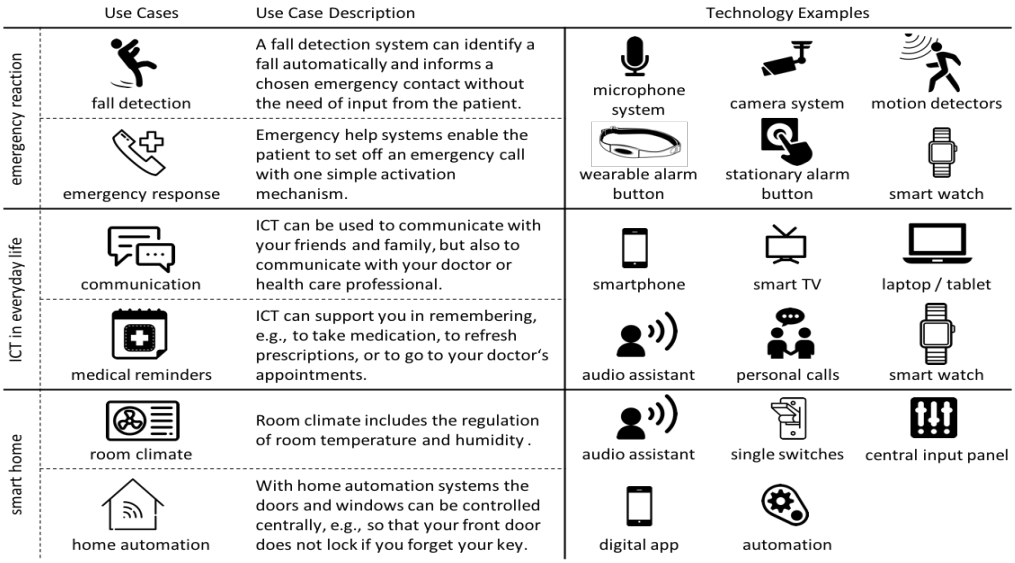

Figure 2: Overview of use case and technology descriptions (technology options do not presume to be complete).

manner. This approach was repeated with each of the six different use cases and their corresponding technologies. The order of the use cases was randomized between the interviews. As the scenarios built on each other, their order was not changed.

After introducing the second scenario, the participants were asked to depict potential changes in technology choices as well as reasoning for acceptance and rejection.

At the end of the interview, the participants were asked to summarize their attitudes towards the presented AAL technologies and to indicate motives and barriers or conditions for acceptance that are most important. After the interview, a short questionnaire was applied assessing demographic data, experience with ICT and AAL, as well as technical self-efficacy (using an abridged scale by Beier (1999)).

2.1.1 The Scenarios

Two scenarios were presented to the participants. The first scenario "moderate need for support" asks the participants to imagine themselves as 71 years old, living alone with small health problems, feeling "somewhat overtaxed with the daily chores". The second scenario "higher need for support" premises upon this, as 10 years have passed and the participant is now in need for domestic part-time care. In both scenarios, the family is described as not able to support the participants enough, and details of health and age-related problems are given.

The scenarios were chosen to appeal to most older adults as no specific disease was chosen but a general, age-related frailness and forgetfulness. The scenarios were visualized with the drawing of an older adult with the gender matching that of the interviewee.

2.1.2 The Use Cases

The applied use cases (see Figure 2) were conceptualized to differ in their application frequency (emergency cases vs. daily use), severity of consequences (emergencies vs. facilitation of everyday activities), and context (medical vs. non-medical). Further, use cases were chosen that are not bound to specific diseases, and thus, were applicable within the scenarios. In order not to overwhelm the participants, two use cases per application area were chosen in which the technology examples stayed the same.

2.1.3 The Technology Examples

The technology examples (see Figure 2) were chosen to be easily comprehensible and familiar to the participants. The technology options were described abstract enough to be widely applicable and familiar to the participants (e.g., "a camera system"), but to differ in important characteristics, e.g., perceived privacy invasion, reliability, and performance in the given use case.

2.2 The Sample

For this first stage of method-development, we conducted six interviews with adults between 50 and 81 years who were recruited from the social network of the interviewer. The participants' mean age was

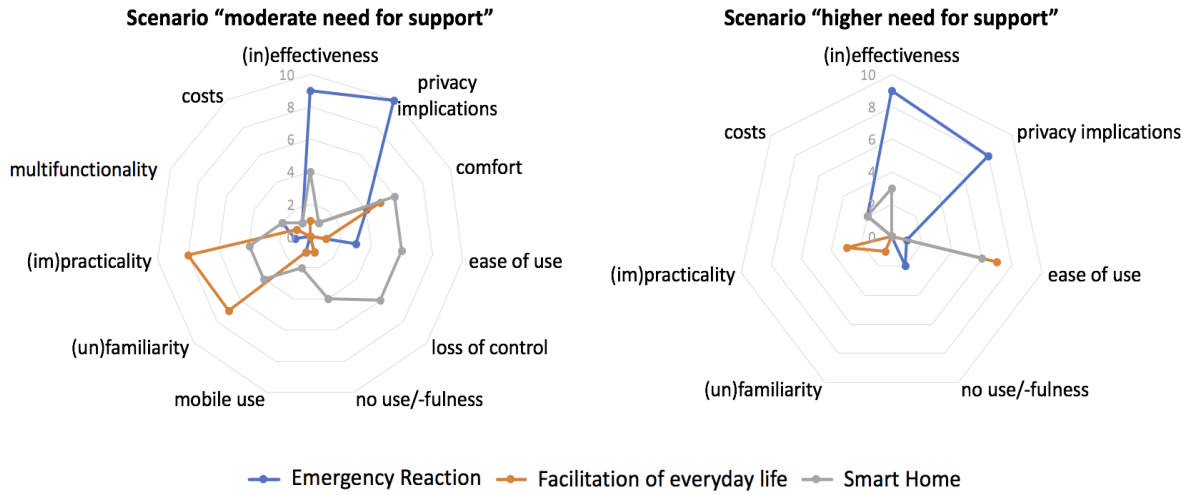

Figure 3: Number of mentions of the different topics in scenario "moderate need for support" (left) and scenario "higher need for support" (right).

59.3 years (SD = 13.0; Median = 52.5), four participants were female, and two were male.

Education level, (previous) occupation, and living circumstances (living alone or with family/spouses) varied between the participants. All participants use some common ICT technologies at least daily, and the reported levels of technical self-efficacy differed between low (1.5) and very high (4) (min=1, max=4, M=2.5, SD=0.9). Knowledge and hands-on experience with AAL technologies was very low (n=1). Further, the sample consisted of predominantly healthy older adults as only two out of six participants indicated to suffer from a chronic disease. Contrary to expectations, this was not true for the two oldest participants. All participants were German native speakers and no compensation was given for participation.

3 RESULTS

In the following, we first focus on the barriers and benefits in the first scenario, before addressing the change in motives when the necessity of technology use changes with the introduction of the second scenario, thus, when voluntary use of the technology changes into a vital use of the technology. Finally, we examine the methodological implications of this approach.

3.1 Barriers and Benefits in a Scenario of "Moderate Need of Support"

Figure 3 depicts the benefits and barriers that were addressed by the participants. In the scenario of "moderate need for support" the perceived *effectiveness* and usefulness of the technologies was the most important benefit (and if missing, barrier). For example, in the case of emergency reaction, increased security is most important, and those technologies are rejected that are perceived to be *ineffective* in raising an alarm:

> *"If I fall, it would surely not be exactly next to the alarm button. So, it is no use." (w50)*

> *"The wearable alarm button, I would probably forget to wear it" (m53)*

Additionally, the participants did not always perceive the technologies as *useful*, e.g., the oldest participant does not want to be found after a fall, successfully uses alternatives, and perceives too much support as not helpful in old age:

> *"Only to live 3 weeks longer? I don't need technology for that. […] These technologies do not make life longer, they just lengthen dying. […] You have to rely on God. God will arrange that. If you die, it shall be." (w81)*

> *„I have a pocket diary that I use frequently. Everything important is in there. And for my medicine, I have this box with one compartment for every weekday. I use that all the time, and I never have problems." (w81)*

> *"I like to still use my brain. Too much support isn't good." (w81)*

In the case of emergency reaction technologies, privacy implications are the greatest barrier and a trade-off between privacy and usefulness could be observed. The participants chose the technology that they deem as most effective (in detecting the fall or

raising the alarm, respectively) and which they can still tolerate in its privacy violations.

„It is a trade-off between privacy implications, loss of control, and so on, and whether it is safer and more effective." (w50)

"I would never use a camera system, because I would feel watched, under surveillance. […] And because of the security of my data, that you never know who can get access to the videos." (w52)

Being less privacy invasive than cameras emerged as benefit of other fall detection technologies. Cameras were rejected by all participants in this scenario as too privacy invasive. Concerns about privacy and data security were also mentioned for the other technology areas, as well as missing trust in the reliability of technologies, dependence on technology, and loss of control.

"Misuse of data, data security, that you are online, you can never be sure that it has not been hacked by someone." (m53)

"Automation is out of the question for me. It would be a loss of control, too much dependence on the technology. What happens when the automation does not work correctly?" (w52)

"The audio assistant, I would not trust it to work well. Probably I just talk to someone and the temperature changes all the time without me controlling it." (w50)

As a very important theme in the context of smart home and everyday life technologies, *(im)practicality* issues emerged, e.g. to have the technologies handy, to already own compatible devices, or to be used to the devices. The perception of practicality of the different technologies varied very much between the participants, depending on their individual habits and preferences. *Familiarity* is often related to the perception of practicality, and routines should not be disturbed by new technologies:

"Because I already use a smartphone and I also enter reminders in there today. I would just do the same in older age. I wouldn't need a device, TV or tablet, that would be turned off anyway in the moment I need it. It [the new device] would then need to be running all the time. That is annoying." (m53)

Also, practicality is related to effectiveness for the desired function:

"Better than the other devices because it has the largest display. And then the personal interaction is foreground, it is the most important thing." (w50)

Mobile use is another benefit or rather condition related to impracticality.

"I would not use my laptop or smart TV, because, on the one hand, I do not sit in front of the TV all the time or use the laptop, and on the other hand, I can't take it with me. I want to be reminded wherever I am, if it is important." (w52)

Comfort is also a relevant benefit of some technologies, even for fall detection, but the perception of what is comfortable is very individual. One results of the comparison of different technological areas in one interview, is the recognition of *multifunctionality* as key benefit of integrated systems. It is not handy for older adults to use many different technology, but they rather want one system for many purposes:

"I would choose the technology that offers the most functions so that I don't need to switch technologies that often." (w52)

Another often addressed theme is the *ease of use* of technologies, that is connected to being familiar with technologies and feeling competent in interacting with them.

"I would use the laptop. Maybe because I already feel safe with it, I know how to use it and I am used to it. Other people use it to. It is just familiar." (w52)

"I could think about using an app or audio assistant, but only if they are easy to use." (w52)

Only twice *costs* were mentioned as barrier. Both times, they were weighted against the usefulness of the technology:

"To install this in the last years of your life. That's not worth the money. I would rather do something else with the money." (w81)

3.2 The Scenario with Higher Need for Support

In the second part of the game, the scenario with the increased necessity of medical technology ("higher need for support") was introduced and the participants were asked to state any changes in choice of technology and their reasoning. Only one participant stated that nothing would change.

Especially in the case of fall detection and alarm response, *privacy concerns* were overridden by the desire for safety and help.

"I would now choose the safest system, for example the motion detectors, if someone told me that it is sufficient. It depends on the effectiveness of the system. If someone

told me, the motion detector is not that reliant, I would choose a combination of microphones and motion detectors. And if the camera system is the only safe and effective option, and it is really necessary because I experienced some falls, then I would be okay with cameras." (w52)

"Now I would take everything. Cameras, microphones, motion detectors. I would take whatever makes me feel safest, where the probability is highest to help me in case of emergency." (w52)

"Then, data security, protection of privacy and so on wouldn't be as important any more as survival." (w52)

For the other two application areas, the *ease of use* becomes the central argument for technology choice.

"I would now choose the automation, then I am on the safe side. With the other systems, I could forget how to use it or forget to activate them or so. The interaction would be too complex and I couldn't trust myself to control them." (w52)

In figure 3, the topics that the participants addressed are depicted in comparison of the two scenarios. In scenario "higher need for support", the participants included fewer factors in their reasoning than in scenario "moderate need for support". This can, on the one hand, be explained by the order of the scenarios and that they had already made up their mind for the most decisive reasons. On the other hand, the relevance of the factors seemed to shift. *Being found after a fall* in the scenario "higher need for support", was much more important than *privacy implications*. In contrast in the scenario "moderate need for support", *privacy implications* overrode the *increase in effectiveness*. *Comfort* or *loss of control* may just not be important anymore in this scenario, or not enough important to be addressed.

3.3 Methodological Results

Only two participants commented directly on the game-based interview. A 52-year-old woman found the game-based approach *"a very good idea for older people with these playing cards to support their memory"*, and another 52-year-old woman said that it was *"all in all, very diverting, interesting, and felt to be very short"*. Even the oldest participants did not appear to forget details or to be overtaxed by the length of the interview. All participants participated actively and showed interest.

The wording the participants used is one indicator that the participants really put themselves into the scenarios and evaluated the technologies for their own lives. Most statements were phrased in the first person, as in the following example and the quotes above: *"If I fall, I can't reach it [the button]." (m71)* Moreover, the reasoning was larded with references to personal habits and the participant's own homes and lifestyles.

"I won't be watching TV all the time. I will be in my garden very often just like now." (w52)

"I just am a person that needs a button to touch, for haptics and the feeling of it." (w52)

The barriers and benefits for using and choosing a technology differed depending on the application areas and the scenarios, amongst other factors. Therefore, a comparison to previous studies is difficult. Moreover, qualitative studies do not aim at weighting or quantifying the relevance of the identified factors. This preliminary study with only six participants does not presume to be representative. Still, whether factors are included into the reasoning of the participants indicates at least whether they are influencing factors in the individual case.

Peek et al. (2014) conducted a literature review of studies to summarize the factors influencing acceptance of technologies for aging in place. They also provided a count of the number of articles that mentioned each factor. *High costs* and *privacy implications* are the most often addressed concerns. *Ease of use*, *ineffectiveness* and *impracticality of the medical technology* – factors that were decisive in this study – only appeared in two of 16 previous studies. The participants in this study identified many details we put into the category labelled "*(im)practicality*". These are situations, in which the technologies oppose routines or cannot exploit their full potential because of the habits or domestic situations of the participants. Additionally, issues of *ease of use*, *familiarity* with the devices, and *comfort* were often named by the participants. This shows that the participants in this game-based approach imagined the presented technologies in their own homes and lives and under the conditions of their own routines and preferences.

Another result was that the absence of one barrier became a benefit and the other way around. For example, in the case of fall detection it is a benefit for motion detectors to be *less privacy-invasive* than microphones and cameras. The participants, thus, chose the best of the given alternatives.

4 DISCUSSION

This paper presented a new game-based interview method for the assessment of AAL acceptance

criteria. This qualitative approach aimed at identifying barriers and benefits in comparison of several AAL technologies, the comparison of different use cases, and situations of differing perceived necessity for care. Visualizations, personal scenarios, and the task to choose between technology alternatives led to a situation more comparable to real decision or purchase situations than evaluating one system alone. The results of the first interviews with six older adults (aged 50 to 81 years) show that this playful approach empowers the participants to fully empathize with high-maintenance situations in older life and to evaluate technology use in these situations.

4.1 Acceptance Criteria

The acceptance criteria addressed by our participants have been reported in previous studies (e.g., Peek et al. 2014). However, the empathic, playful approach and to let participants choose between technology alternatives identified a shift of relevance of known barriers and benefits and a new angle to them. Practicality and effectiveness were the key benefits, or barriers respectively, in this study together with privacy implications. Ease of use and comfort also gained more importance than in previous reports. At the same time, the comparison between technologies leads to new benefits in a way that being less privacy-invasive or more comfortable than other alternatives become perceived benefits and barriers. Abstract motives for the decision to use technology at all in a use case, like increased security, quality of life, were mostly not named directly by the participants in this study. The focus lay on the benefits and barriers of the technology options in comparison to each other. Still, those higher-level motives and barriers could be derived from the arguments of the participants. For example, one of the decisive categories in this study was labelled (in)effectiveness, which shows that the perceived usefulness is still foreground. But if the users trust all technologies to fulfill their main function, other characteristics are important for the choice between technology.

Here, the results indicated, that AAL systems and products should put a greater focus on the practicability and match for the users' everyday life. Nowadays, many ICT devices exists also in older people's households. Still, the ease of use is a critical factor. Thus, developing AAL technologies, that work on or similar to familiar devices can be a key issue for market success.

In the context of the two scenarios, the weighting between barriers and benefits as a basis for technology choice becomes plain. While privacy implications hindered technology acceptance in a scenario of moderate need for support, in the scenario of higher need for support the increased effectiveness, and hence increased security, was the most important factor which outweighed privacy implications. This cost-benefit calculation has been labelled privacy calculus and has been extensively studied in other contexts (e.g., Laufer & Wolfe, 1977; Dinev & Hart, 2006). The privacy calculus theory could provide a good framework for further analysis of this privacy/ usefulness trade-off in AAL acceptance

4.2 Method Evaluation

The new game-based approach proved useful in providing a more realistic evaluation situation. On the one hand, the approach gets the participants to be deeper involved in the evaluation in comparison to more abstract interviews. On the other hand, the approach does not overwhelm the participants but brings them to empathize with the proposed scenarios and different necessities of support. The participants relate the technology evaluation to their own preferences, habits hobbies, routines, and domestic situations. This can not only be seen in their wording, but also in the shift towards practicality issues as important assessment criteria.

Our approach puts a different focus than common system evaluations that has been missing in AAL research until now: the distinction between benefits and barriers that lead to technology use at all and those that lead to one technology being preferred over alternatives. As the market for AAL technologies is constantly growing and hence the range of products increases, this new focus is important.

In this paper, the first results with the new game-based method were presented. The approach offers the possibility to be converted to a digital game or to be adapted to a new questionnaire approach, to quantify the results. We saw that the participants differed in their emphasis of different benefits and barriers. This raises the question, if user factors shape the perception of the factors. Also, the influence of the individuals' attitudes towards aging could contribute to understand older adults' choices and acceptance patterns.

4.3 Limitations and Future Research

The applied playful qualitative approach was a preliminary study to evaluate the method. It proved useful in getting the participants to empathize with high-maintenance situations and different necessities of support, but its representativeness is methodologically limited.

Content analysis is a useful tool for summarizing and categorizing interview data, but is influenced by

the individual coders. By engaging three coders who viewed the whole material, intercoder reliability was aimed for. Additionally, initial categories were based on the literature review, but needed to be supplemented and adapted to the context and the participants' arguments. It would be useful for future studies to expand the game structure to other technologies and use cases in order to enable direct comparisons between technologies and use cases. Additionally, it would also be possible to incorporate the characteristics of our playful approach into quantitative research, e.g., by using similar instructions, scenarios, and introductory questions within a digital version of the game.

As it was a preliminary study, the sample size was very small: future studies should aim for a replication of the playful interview approach addressing a larger sample. As previous qualitative and quantitative studies showed, that the acceptance of assisting technologies is shaped by individual characteristics of diverse user groups (Wilkowska et al., 2012; van Heek et al., 2017), a replication with a larger sample would also enable a detailed investigation of user diversity influences on a personal evaluation of technologies and motives as well as barriers to use specific technologies. As a last sample-related aspect, the present study was conducted in a single country: Germany. For future studies, this study's approach should be applied in other countries in order to compare personal evaluations of assisting technologies depending on different cultures, backgrounds, and their specific healthcare systems.

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