Attitudes Towards Aging and the Acceptance of ICT for Aging in Place

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Abstract. Facing the demographic developments in the Western world, Information and Communication Technologies (ICT) designed to support older people can represent a promising approach for the overloaded health care systems. Most older adults prefer to age in place in their home environment. Assistive ICT can support older adults in staying independent, connected, and healthy and provide help in emergency situations. However, older adults represent a special group regarding the use of ICT: they are still often less experienced and cautious in adapting new technologies. Correspondingly, acceptance poses the greatest barrier for the success of assistive ICT. Older adults are not a homogeneous group, they differ in their experience with technologies, attitudes towards aging, and ideas for quality of life. In a questionnaire approach, N = 166 participants' attitudes towards aging and evaluation of two examples of ICT are assessed. The analysis shows, that technology generations differ in their opinions about aging as well as their assessment of assistive ICT. Attitude towards aging, gender, education, health status, and other attitudes form a multifaceted picture of influences on the acceptance.

Keywords: Technology acceptance · Aging · Attitudes towards aging
Information and communication technologies · Assistive technologies

1 Introduction

The demographic developments in Western countries pose tremendous social, political, and economic challenges. Germany is one of the countries where the demographic change has advanced the most. In 2014, one fifth (21%) of the population was aged 65 or older, 11% were older than 75 years old [1]. At the same time, birth rates have been inflating for decades so that less people can pay and care for the increasing number of older people. Most people enjoy a long life and stay fit for a long time, but the growing number of older people combined with more very old people leads to an increase of long-term care patients [1]. 64% of people aged 90 or older are in need of long-term care; chronic diseases, and multi-morbidity lead to high care needs (ibid.). But most older people desire to stay home as long as possible [2]. In the last decades, many technologies have been developed to assist aging in place with support of daily life, help in emergency situations as well as medical support. These can become solutions in

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addressing the rising costs and resource problems in the health care sector as well as the elderly's desire to age in place.

2 ICT to Support Aging in Place

Current developments around ambient intelligence and smart homes provide more and more possibilities to assist old and (chronically) diseased persons in their daily chores and medical treatment, enabling independent living, and improving quality of life. The term Ambient Assisted Living (AAL) is often used to describe these technologies [3]. AAL includes the use of ICT devices, services as well as holistic systems that are integrated in the home environment [4].

One of the prominent use cases of AAL are personal safety and fall detection systems, as falls and fall-related injuries represent a significant threat to the health, independence, and even life of older people [5]. Having experienced a fall often results in fear of falling which can lead to decreased mobility and reduced participation in activities [6]. Additionally, family and caregivers are impacted by the concerns about unexpected falls. After a fall has occurred, it is critical to get help fast and avoid involuntarily remaining on the ground for longer time, which substantially increases the physiological and psychological risks [3]. Personal Emergency Response Systems enable seniors to either contact an emergency center themselves via a wearable button, or are designed to automatically detect falls, e.g., camera-systems. Thus, they prevent "long lies" and provide a feeling of security for patients and their relatives [6].

Supporting health management is another promising area of AAL. For example, poor medication management is a frequent problem and can impose a serious risk especially for older people as they use more medication and more of those with a high potential for medication misuse than other age groups. Forgetting to take prescribed medication, taking the incorrect amount, or incorrect medication can lead to numerous health consequences and does not only happen to older people with cognitive or memory impairments [5]. Medication management tools and reminders can help seniors to take the correct amount of medication at proper time [7].

Despite the promising potential and increasing number of available AAL devices and systems, they are not yet widely used.

2.1 Technology Acceptance, User Diversity, and Age

Technology Acceptance by potential users is critical for the success of AAL technologies (e.g., [8]). To explain the relationship between attitudes, intentions, and use behavior and to identify the factors that influence the technology acceptance by users, several technology acceptance models have been proposed and refined in the last half century. As one of the first, the *Theory of Reasoned Action* (TRA) proposes that behavioral intentions are the central element determining actual behavior, and that these are a function of attitudes towards behavior and subjective norms [9]. As an adaptation of the TRA, the *Technology Acceptance Model* (TAM, by [10]) targets user acceptance of ICT and focused on the two key components *perceived ease of use* and *perceived usefulness* as antecedents of the intention to use a technology. The *Unified Theory of Acceptance and Use of Technology* (UTAUT, by [11]) extends the *TAM* and is the first to include user characteristics (age, gender, and experience) as influencing factors.

Research in technology acceptance by older adults has shown, that attitudes, experiences, and self-efficacy in interacting with ICT are critical factors for the acceptance and adoption [12]. For example, experiences with technologies vary very much in older adults and also other individual differences can shape attitudes, e.g., gender, education, and social background. For example, women usually report lower levels of technical self-efficacy [13], or age and gender show interaction effects regarding the acceptance of medical assistive technologies [2].

On the other hand, age itself influences technology adoption. In general, older adults' willingness to use assistive technology is high, but older adults are known to adopt new technologies slower than younger people [12]. Aging brings changes in perceptual, cognitive, and psychomotor skills that can result in difficulties with handling devices or in the acquisition of the necessary skills [14]. Differences in physiological and psychological abilities are also large as aging is an individual process and these differences can be still enhanced by diseases and chronic conditions [15], contributing to even stronger heterogeneity of technology use behavior within the group of older adults.

Additionally, experiences and social and cultural environment play a crucial role and age can be a "carrier variable" for these. Different generations experienced different technologies and interfaces during their upbringing and education years, the so-called formative period. These generation-specific experiences with technology have an effect on the usage behavior and attitudes towards technology during their whole life span [16]. For the German population, five generations were distinguished [17] according to the product types predominant during their formative period: the *mechanical generation* (born before 1939), the *generation of household revolution* (born 1939-1948), the *generation of technology spread* (born 1949–1963), the *computer generation* (born 1964–1978), and the *internet generation* (born after 1977).

Besides the individual, age-related, and generational influences, the type of technology [18, 19] and application context [20] can impact acceptance patterns. Theories of technology acceptance have mainly focused on the two key components perceived usefulness and perceived ease of use, so far. But studies have shown, that additional motives and barriers play a crucial role in the context of assistive technologies for older adults (e.g., [21, 22]). AAL technologies are designed to operate in our homes and close to our bodies, are associated with negative aspects of aging, illness, and even with surveillance. Thus, barriers regarding stigmatization, privacy, and usability are predominant. Studies show, that users acknowledge the potential of AAL technologies, but are also concerned because of barriers. Thus, trade-offs between perceived benefits and barriers are crucial for the acceptance of AAL technologies [23].

The perception of benefits and the perceived necessity is tied to the desires and needs of the potential users. Regarding AAL technologies, aging concepts could determine the perception of benefits and barriers of AAL technologies and research [15] showed, that the understanding of age and aging has been changing. Aging is - on the one hand - associated with health issues, loneliness, and limitation of autonomy and mobility, but more and more seniors live an active lifestyle and feel old at a later point in live. Good health, social relationships, and independence are important constituents of quality of life in older age [24] and AAL technologies have the potential to improve one or more of these areas.

2.2 Focus and Aim of the Study

Many variables have been identified in research that may influence the acceptance and adoption of ICT for aging in place by older adults. To improve the understanding of technology acceptance of assistive ICT, this study analyses individual characteristics and attitudes for their influence on the acceptance of two exemplary AAL technologies and the evaluation of benefits and barriers. The main focus is directed on differences in the evaluation by different technology generations in order to comprehend attitudes in the special groups of today's and tomorrow's older adults as potential users of AAL technologies. Additionally, the effects of gender, health status, and education as well as technical self-efficacy are explored. As wishes and ideas of life in older age may differ, also the influence of attitudes towards aging on the acceptance and evaluation of barriers and benefits are studied. The evaluation of motives and barriers of the presented technologies' adoption is presented in detail to deeper understand the reasons for differences in technology acceptance. For this explorative approach, a user-centered study was chosen. In a questionnaire study, users of different technology generations were asked about their attitudes towards ageing and evaluated two examples of AAL technologies. The detailed methodological approach is presented within the next part.

3 Methodological Approach

Within the following section, the design of the questionnaire, applied statistical procedures, and the study's participants are described. For the present study, an online questionnaire was conceptualized based on a preceding qualitative study [25] in order to reach a larger sample focusing on older people, their wishes and needs concerning life quality in older age, their attitudes towards aging as well as their perceptions and acceptance of AAL and ICT technologies in different application contexts.

3.1 Questionnaire Design

In the first part of the questionnaire, the participants were asked for demographic characteristics such as gender, age, and educational level as well as their perceived age. The participants assessed nine items referring to quality of life in older age (based on [2]). Further, the participants assessed four items belonging to a positive attitude and six items referring to a negative attitude towards aging. Addressing attitudinal characteristics, the participants evaluated their technical self-efficacy in interacting with technology (using four items; based on [26]), their disposition to privacy (using three items; based on [27]), and their disposition to trust (using three items; based on [28]).

To be able to characterize the participants, they further indicated (yes/no) if they suffer from a chronical disease, if they have to do medical check-ups regularly, and if they have to rely on medical aids (e.g., blood glucose meter, heart pacemaker). Additionally, the participants evaluated their subjectively perceived health status.

In a next step, two randomized application contexts and respective medical technologies were introduced to the participants: the first one referred to a medical emergency scenario and focused on diverse technologies that could be used for fall detection (e.g., emergency buttons, camera systems, motion detectors, and smart watches). The second application context referred to facilitating everyday life for people in older age who become forgetful or suffer from dementia by using technical reminders for drugs or appointments (e.g., smartphones, laptops, audio assistant, smart TV, or smart watches).

Following each application context, the participants were asked to evaluate the acceptance of fall detection (Cronbach's $\alpha = .840$) and medical reminders (Cronbach's $\alpha = .766$) by using each three items, perceived motives and barriers by using each nine items. To evaluate these items, the participants were asked to put themselves in a scenario of a 71-year old, who lives alone, is faced with minor health problems and a general frailness. The items and scenario are based on a preceding qualitative study [25]. Further, all items were evaluated on six-point Likert scales (1 = *min*: "I strongly disagree"; 6 = *max*: "I strongly agree").

3.2 Sample Description

A total of $n = 166$ participants filled out the online questionnaire completely. The participants were on average 51.42 years old ($SD = 16.10$, $min = 15$, $max = 88$) and 60.8% were female (39.2% male). As highest educational level, most of the participants (66.9%) reported to hold a university degree. 19.3% hold a university entrance diploma, 9.0% a completed apprenticeship and 4.8% a secondary school certificate. Asked for their perceived age, the participants indicated on average to feel younger than their real age ($M = 43.77$, $SD = 13.98$, $min = 10$, $max = 76$). In more detail, the majority (74.3%) indicated to feel younger, 22.3% to feel just as old as they are, and only 3.4% to feel older (1 to 5 years) than their real age. Regarding their subjectively perceived health status ($min = 1$, $max = 6$), the participants reported to feel very well on average ($M = 4.91$, $SD = 0.78$) and none of the participants indicated to need care. The subjective health status declined moderately with aging ($r = -.215$, $p = .005$). Considering attitudinal characteristics ($min = 1$; $max = 6$), the participants reported a moderate technical self-efficacy ($M = 4.21$, $SD = 1.16$), a moderate trust in other people ($M = 4.15$, $SD = 0.78$), and rather neutral needs for privacy ($M = 3.71$, $SD = 0.98$). Technical self-efficacy differed strongly between men ($M = 4.67$, $SD = 1.18$) and women ($M = 3.91$, $SD = 1.04$) ($F(1,164) = 19$, $p < .001$).

3.3 Data Analysis

Prior to detailed statistical analyses, item analyses were calculated to ensure measurement quality and a Cronbach's alpha >0.7 indicated a satisfying internal consistency of the scales. Afterwards, data was analyzed by correlation and MANOVA analyses. The level of significance was set at 5%. Post-hoc analysis procedures were based on Gabriel's procedure as the group sizes were unequal. For analyzing effects of age as influencing user factor, the following four technology generations were distinguished based on [17]: the first generation *Internet* referred to people aged between 14 and 36 (n = 33, 19.9%); the second *Computer generation* included people aged between 37 and 53 years (n = 49, 29.5%); the third generation - *Technology Spread* - referred to people aged between 54 and 68 years and was the largest group (n = 65, 39.2%); finally, the last group *Household Revolution* referred to n = 19 participants (11.4%) aged 69 years and older.

4 Results

In the following results section, we will first look at the factors for *Quality of Life in Older Age* and *Attitudes towards Aging*, before the general acceptance as well as motives and barriers of using fall detection and medical reminders are discussed. For each topic, first we will present the general evaluation and the differences between technology generations, before we take a short, explorative look at the influences of other user factors: age, health status, education level, and attitudinal variables such as technical self-efficacy, need for privacy, and attitude towards aging.

4.1 Quality of Life in Older Age

The respondents rated how relevant they considered different aspects for quality of life in older age. Factors regarding social life, autonomy, and health care were included. Overall, the participants showed agreement to all items related to quality of life (cf. Fig. 1). On average, *to be independent in older age* was evaluated as the most important factor (M = 5.51, SD = 0.68). Second most important was *to have a stable social network* (M = 5.49, SD = 0.74). The lowest but also still positive evaluations referred to the aspects *not to be a burden for others* (M = 4.60; SD = 1.31) and *regular monitoring of one's health status* (M = 4.29, SD = 1.16). As all factors were evaluated to be important, the dimensions social life, autonomy, and health care all contribute to quality of life in older age.

Generational Differences: There are some significant differences in the evaluation of Quality of Life related factors between the technology generations ($F(27{,}468) = 1.66$, $p = .021$) (see Fig. 1). For the household revolution generation, *competent medical care* contributed less to quality of life in older age (M = 4.74, SD = 1.15) than it did for the internet generation (M = 5.48, SD = 0.71). Similarly, the oldest group deemed a *stable social network* significantly less relevant (M = 5.00, SD = 1.15) than the 54–68 year olds (M = 5.58, SD = 0.56) and the 37–53 years olds (M = 5.63, SD = 0.68), for whom this was the most important factor. *Competent medical care* and a stable *social network* were not as important to the technology spread generation as to the others, but to them it was more important *not to be a burden to others* in older age. The group of 54–68 years olds saw greater relevance in *access to information* (M = 5.15, SD = 0.87) than the other groups.

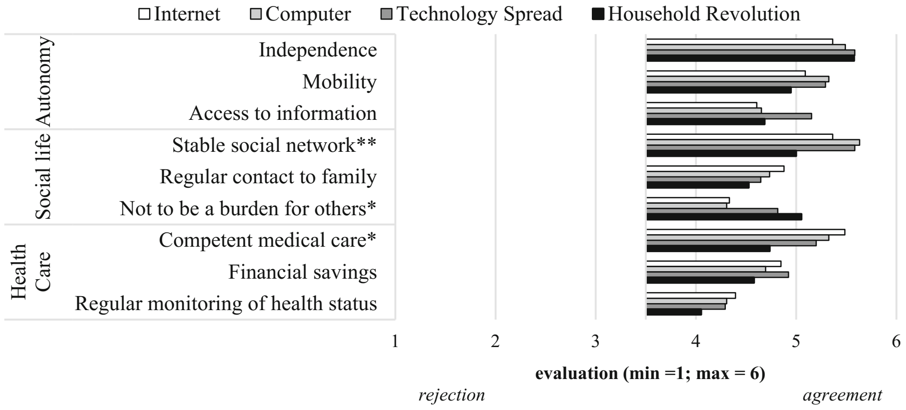

Fig. 1. "Quality of Life in Older Age" items differing between four technology generations (* = $p < .05$, ** = $p < .01$).

Other User Factors: As illustrated before, the group of the elderly is heterogeneous. Thus, in the following paragraph, gender, education level, and health status were analyzed for their influence on the evaluation of "Quality of Life in Older Age" factors. No significant effect of gender on all aspects of quality of life was observed. The results showed a tendency, that women deemed the *social network* more important than men (M_w = 5.60, SD = 0.71; M_m = 5.21, SD = 0.77) and men showed a tendency to evaluate all aspects less important than women, except for the *monitoring of health status* and *independence*. Education levels did also not influence the importance of the factors in our sample. A better subjective health status was slightly related to *independence* being perceived as more important ($r = .192$, $p = .013$).

4.2 Attitudes Towards Aging

On average, the participants had a positive attitude towards aging (M = 4.39, SD = 0.65, min = 1, max = 6). *To be able to stay in contact with friends and family* was a part of aging that was the most agreed to on average (M = 5.28, SD = 0.93). The participants also agreed with other positive aspects of aging such as *making plans* (M = 4.69, SD = 1.01), *being more relaxed* (M = 4.72, SD = 1.11), and *keep on learning* (M = 4.69, SD = 0.96). Concerns related to aging like *decreasing health* (M = 3.92, SD = 1.08) and *being less fit and lively* (M = 3.90, SD = 1.10) were slightly endorsed. In contrast, other negative aspects such as *being dependent* (M = 3.16, SD = 1.24), *being a burden to others* (M = 2.97, SD = 1.08), and *loneliness* (M = 2.89, SD = 1.19) were slightly rejected by the participants. The negative aspect to expect *less enjoyment* (M = 2.28, SD = 1.16) in older age was most rejected by all participants.

Generational Differences: Referring to the overall attitude towards aging, the group of 54 to 68 year olds (technology spread) showed the most positive attitude (M = 4.60, SD = 0.59) that significantly differed from the two younger generations (F(12,

483) = 5.47, *p* = .001). The internet generation showed the comparatively least positive attitude (*M* = 4.08, *SD* = 0.56). Positive and negative aspects of aging are examined independently, as a factors analysis showed these to be quite distinct. In a multivariate analysis of variance on the four positive aspects of aging, differences between generations are obvious (*F*(12, 483) = 2.35, *p* = .006). The generation of technology spread saw all positive factors more prevalent than the other generations. That one becomes *more relaxed* was not as much part of the picture of aging that young people have, as it was in other groups. Only for *keep on learning* no differences between the generations were prevalent. The technology generations (see Fig. 2) evaluated negative aspects of aging differently (*F*(18, 477) = 1.91, *p* = .014). Especially the youngest generation (internet generation) pictured aging going along with *becoming less fit and lively*, and sees aging more tied with *being a burden* and *being less dependent* than the other generations. The oldest generation (household revolution) rejected more than others that aging leads *to being lonely* and does not approve as much as the other generations that it comes along with *decreasing health* and *being less fit and lively*. Altogether they rejected the negative aspects of life in older age the most. The computer generation's opinion was mostly average, but for *dependence*, which they perceive as a part of aging, more than the older generations.

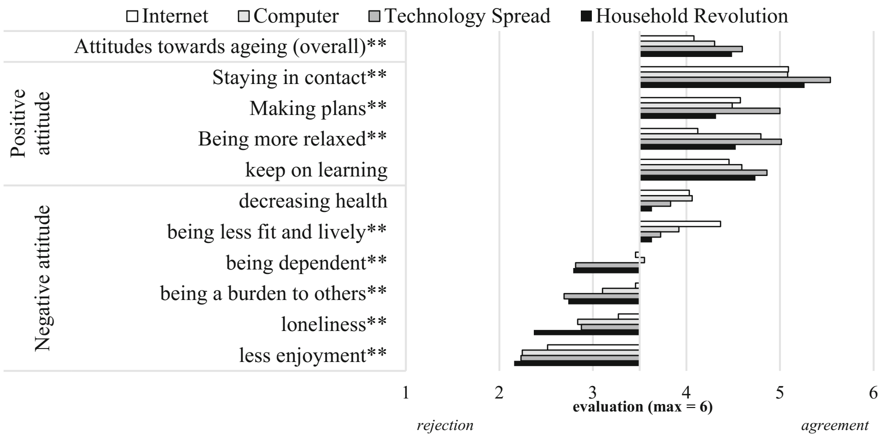

Fig. 2. "Attitude towards Aging"-related factors differing between four technology generations (* = *p* < .05; ** = *p* < .01).

Other User Factors: No effects of gender or education level were detected for either positive or negative factors. The perception of old age going along with *still making plans* was higher with a better health status (*r* = .155, *p* = .46). Healthier participants also tied *decreasing health* more to aging (*r* = .171, *p* = .028).

4.3 Technology Acceptance of Fall Detection and Medical Reminders

As shown in Fig. 3, the acceptance of fall detection and medical reminder technologies was generally high (M_{fall} = 4.96, SD_{fall} = 1.02; M_{rem} = 5.03, SD_{rem} = 0.05).

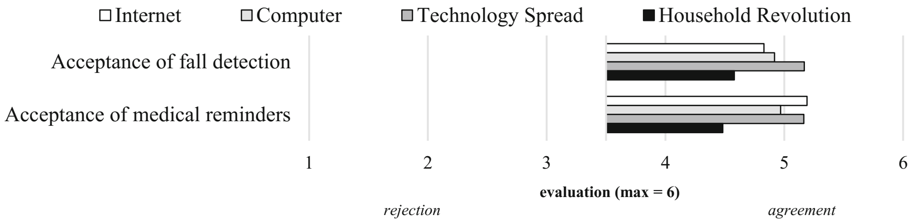

Fig. 3. Acceptance of medical reminders and fall detection differing between four technology generations.

Generational Differences: The oldest generation showed significantly less acceptance of medical reminders (M = 4.48, SD = 1.08) than the internet generation (M = 5.19, SD = 1.00) and the generation of technology spread (M = 5.16, SD = 0.81; F (3, 162) = 3.03, p = .031). A similar tendency that did not reach significance could be observed in the case of fall detection (F(3, 162) = 2.055, p = .108, n.s.): the oldest generation showed again the lowest acceptance (M = 4.58, SD = 1.23), while internet (M = 4.83, SD = 1.04), computer (M = 4.92, SD = 1.08), and in particular the technology spread generation (M = 5.17, SD = 0.85) showed higher acceptance evaluations.

Other User Factors: Technology acceptance was also influenced by other user factors (see Table 1). Women accept medical reminders less than men (M_w = 4.92, SD_w = 104, M_m = 5.21, SD_m = 0.76, F(1,161) = 4.13, p = .044). Additionally, the confidence in one's abilities in interacting with technology (technical self-efficacy) was related with the acceptance of medical reminders (r = .209, p = .007) and fall detection (r = 1.66, p = .032). Further, the acceptance of fall detection showed relationships to one's need for privacy (r = .184, p = .018) and to a positive attitude towards aging

Table 1. Correlation and inference statistical analyses of user factor influences on acceptance (n.s. = not significant (p > .05), * = p < .05, ** = p < .01, *** = p < .001

	Acceptance of medical reminders	Technical self-efficacy	Need for privacy	Attitudes towards aging	Gender
Acceptance of fall detection	.371**	.166*	.184*	.169*	M_w = 4.94, SD = 1.13, M_m = 4.99, SD = 0.82 *n.s.*
Acceptance of medical reminders		.209**		.	M_w = 4.92, SD = 1.04, M_m = 5.21, SD = 0.76 p < .05

(r = .169, p = .03). As expected, the acceptance of medical reminders was positively related to the acceptance of fall detection (r = .371, p = .0001), but only on a moderate level. These results and differing influences of user factors show, that technology acceptance differs between technologies even if the context (ICT for aging in place) stays the same.

4.4 Motives to Use Fall Detection

Additional to asking for general acceptance of the technologies, motives and barriers for using the respective technologies were assessed. Overall, a moderately high agreement to all motives was observed (M = 4.80, SD = 0.96). *To get help in a case of emergency* was the most important motive for using technology in this case (M = 5.40, SD = 1.08), followed by *staying independent* (M = 5.05, SD = 1.18). *Facilitation in everyday life* (M = 4.44, SD = 1.41) and *comfort* (M = 4.07, SD = 1.37) were the least important motives.

Generational Differences: Many differences within the evaluation between the generations could be observed (F(27,462) = 1.67, p = .020) (see Fig. 4). Taking the average of all motives, the generation of technology spread agreed most to the benefits (M = 5.07, SD = 0.79) and the generation of household revolution agreed the least (M = 4.38, SD = 1.36) (F(3,162) = 3.91, p = .010). This pattern was prevalent with all benefits, and significant differences were found for *facilitation of everyday life* (F (3,161) = 2.77, p = .044), *independence* (F(3,161) = 3.86, p = .011), *staying home* (F (2,162) = 4.54, p = .004), and *comfort* (F(3,162) = 46.825, p = .000).

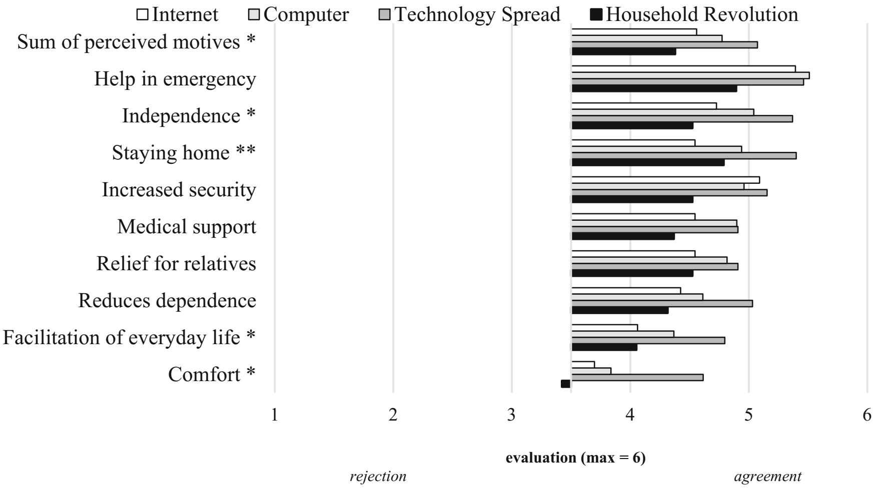

Fig. 4. Motives to use fall detection differing between technology generations (* = p < .05; ** = p < .01).

Other User Factors: The results revealed no significant effects of technical self-efficacy, gender, or health status on the evaluation of the motives to use fall detection. However, a positive image of aging was related to a positive perception of many motives (for details see Table 2). Also, a higher need for privacy was related putting more importance on *medical support, staying home,* and *comfort*. A higher education level was related to perceiving *help in emergency* ($r = -.170$, $p = .028$) and *medical support* ($r = -.205$, $p = .008$) as less important for the use of fall detection technology.

Table 2. Correlation analysis results of motives to use fall detection and user factors (* = $p < .05$; ** = $p < .01$).

Motives for using fall detection	Positive attitude towards Aging	Need for privacy	Education level
Facilitation of everyday life	*.245***		
Increased security			
Independence	*.248***		
Reduced dependence	*.159**		
Help in emergency		.178*	−.170*
Medical support		.230**	−.205**
Staying home	*.208***		
Comfort	*.164**	.191*	
Relief of relatives			

4.5 Barriers of Using Fall Detection

The barriers of using technology for fall detection were partly rejected and partly accepted, resulting in an average acceptance close to the midpoint of the scale ($M = 3.44$, $SD = 0.95$). The barriers concerning *data security* ($M = 3.93$, $SD = 1.40$), *privacy* ($M = 3.94$, $SD = 1.44$), *feeling of surveillance* ($M = 3.95$, $SD = 1.49$), and *not enough human contact* ($M = 3.84$, $SD = 1.37$) were rather agreed to by all generations, except of the oldest. Factors regarding technology in general were mostly rejected: *missing trust into technology* ($M = 2.80$, $SD = 1.24$), *too much technology* ($M = 3.01$, $SD = 1.39$), *dependence on technology* ($M = 3.05$, $SD = 1.40$), and *complex interaction with technology* ($M = 3.10$, $SD = 1.42$).

Generational Differences: In a multivariate analysis of variance on all barriers, no differences between the technology generations were observed. Because of the rather small group sizes, tendencies are still reported (see Fig. 5). The generation of household revolution agreed the least on the benefits of fall detection as it was described above, but this group also rejected the barriers the most. Especially barriers regarding *privacy, feeling of surveillance,* and *data security* were rejected which are agreed upon by the other generations. Interestingly, this generation who is described as least experienced with technologies, rejected *complexity of interaction with technology* as a barrier more than the other generations.

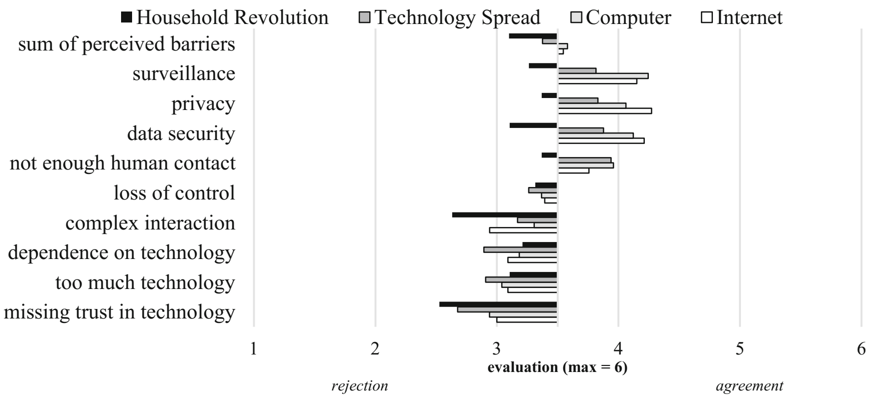

Fig. 5. Barriers of fall detection usage differing between technology generations.

Other User Factors: No significant effects of gender and education level were detected. A positive attitude towards aging did not show any relationship with the perception of the barriers, but a higher need for privacy was related with barriers regarding privacy, data security, and dependence on technology which were perceived more important. At the same time, technical self-efficacy was related to not perceiving the barriers as that much important that relate to technology itself being the problem (*not enough human contact, missing trust in technology, too much technology, and complex interaction*). Subjective health status was related to *dependence on technology* ($r = -.157$, $p = .044$) and *complex interaction* ($r = -.167$, $p = .032$), so that a better subjective health status leads to these two barriers being perceived as less important barriers (Table 3).

Table 3. Correlation analysis results of barriers of using fall detection and user factors (* = $p < .05$; ** = $p < .01$).

Barriers of using fall detection	Technical self-efficacy	Need for privacy	Subjective health status
Surveillance		.224**	
Dependence on technology		.186*	−.157*
Loss of control		.227**	
Violation of privacy		.306**	
Not enough human contact	−.164*		
Missing trust in technology	−.228**		
Data security		.386**	
Too much technology	−.210**		
Complex interaction	−.269**	.155*	−.167*

4.6 Motives to Use Medical Reminders

Again, an overall moderately high agreement was observed (M = 4.80, SD = 0.97). In this case, differences in relevance between the motives were very small. The most important motive to use medical reminders was now *autonomy* (M = 5.07, SD = 1.1), closely followed by *facilitation of everyday life* (M = 4.98, SD = 1.07), *staying home* (M = 4.95, SD = 1.34), and *medical support* (M = 4.95, SD = 1.09). *Comfort* was again the least important motive (M = 4.58, SD = 1.36).

Generational Differences: The technology generations differed in their perception of the motives of medical reminders (F(27, 465) = 1.94, p = .004) in a similar pattern as in the case of fall detection (cf. Fig. 6): Averaging all motives, the generation of technology spread again agreed most to all motives (M = 5.06, SD = 0.84) and the generation of household revolution the least (M = 4.5, SD = 1.34). The generation of technology spread perceived especially the following motives as more important than the other generations: *reduced dependence* (M = 5.11, SD = 1.01), *help in emergency situations* (M = 5.34, SD = 1.13), *staying home* (M = 5.28, SD = .086), and *comfort* (M = 4.66, SD = 1.16). *Comfort* was not a relevant motive for the oldest generation to use medical reminders (M = 3.58, SD = 1.17).

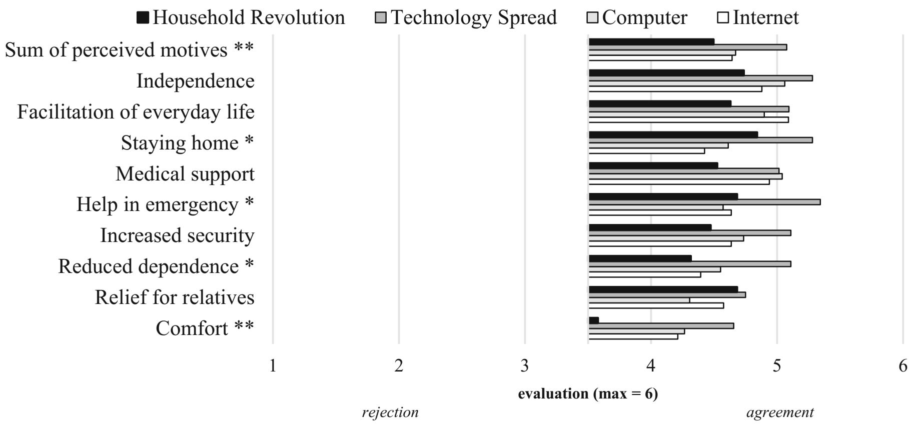

Fig. 6. Motives to use medical reminders differing between technology generations.

Other User Factors: Like the evaluation of fall detection, the results revealed relationships between a positive attitude towards aging, technical self-efficacy, and need for privacy and the motives to use medical reminders (see Table 4): a positive attitude towards aging showed a positive relationship to *independence* (r = .189, p = .015), *reduced dependence* (r = .217, p = .005), *staying home* (r = .283, p = .000), and *relief for relatives* (r = .169, p = .031). Need for privacy was positively related to *facilitation of everyday life* (r = .161, p = .04), *help in emergency* (r = .179, p = .022), as well as *comfort* (r = .166, p = .034). No relationship of the evaluation of the motives with education level and subjective health status as well as no differences between women and men were detected.

Table 4. Correlation analysis results for motives to use medical reminders and user factors (* = $p < .05$; ** = $p < .01$).

Motives to use medical reminders	Attitudes towards aging	Need for privacy
Facilitation of everyday life		.161*
Increased security		
Independence	.189*	
Reduced dependence	.217**	
Help in emergency		.179*
Medical support		
Staying home	.283**	
Comfort		.166*
Relief for relatives	.169*	

4.7 Barriers of Using Medical Reminders

Overall, the relevance of the barriers was slightly less pronounced (M = 3.19, SD = 1.06) as in the case of fall detection (M = 3.44, SD = 0.95). The most important barrier was *data security* (M = 3.69, SD = 1.55), the least important barriers was *missing trust in technology* (M = 2.67, SD = 1.24).

Generational Differences: The results revealed no significant difference between the technology generations in the perception of barriers. Still, the tendency was observed (see Fig. 7), that the oldest generation rejected the barriers more than the other generations ($F(27, 468) = 1.44$, $p = .073$) as it was also the case for fall detection.

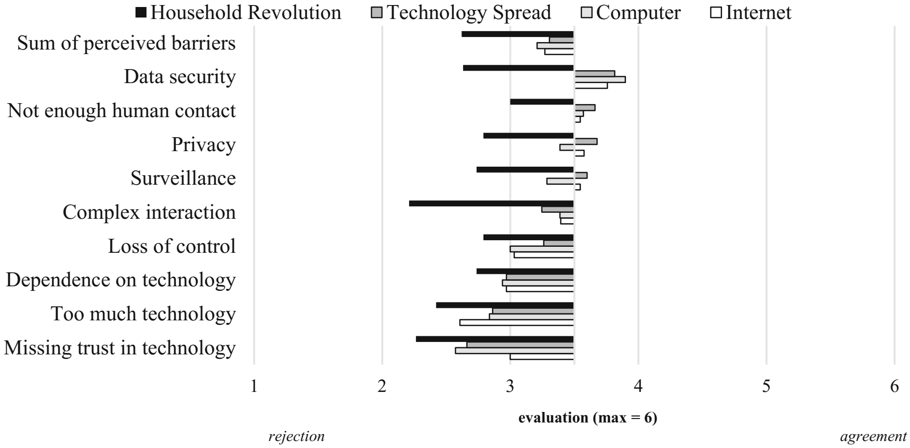

Fig. 7. Barriers of medical reminders differing between technology generations.

Other User Factors: Again, the results showed no significant effects of gender. Similar to the case of fall detection, a higher need for privacy correlated with perceiving barriers regarding *privacy*, *data security*, and also *too much technology* as more important (see Table 5). Further, higher technical self-efficacy again related to *missing trust in technology* ($r = -.206$, $p = .008$), *too much technology* ($r = -.279$, $p = .000$), *complex interaction* ($r = -.254$, $p = .001$) being all perceived as less important. Level of education correlated negatively with the perception of the barriers *not enough human contact* ($r = -.207$, $p = .008$) and *missing trust in technology* ($r = -.159$*, $p = .042$). Also, a better subjective health status correlated negatively with the agreement to the barrier *not enough human contact* ($r = -.227$, $p = .003$). Thus, the healthier participants were, the lesser was their requirement for human contact.

Table 5. Correlation analysis results of barriers of using medical reminders and user factors (* = $p < .05$; ** = $p < .01$).

Barriers of using medical reminders	Technical self-efficacy	Need for privacy	Education level	Subjective health status
Surveillance		.308**		
Dependence on technology		.19*		
Loss of control		.313**		
Violation of privacy		.366**		
Not enough human contact		.222**	−.207**	−.227**
Missing trust in technology	−.206**		−.159*	
Data security		.412**		
Too much technology	−.279**	.168*		
Complex interaction	−.254**			

5 Discussion

The present study revealed insights into attitudes towards aging and the acceptance of AAL technologies and user diversity. Differences in evaluation between technology generations of aspects of aging and the assessment of AAL technologies, as well as of the user factors gender, education, health status, technical self-efficacy, and attitudes on trust and privacy were analyzed.

5.1 Perceptions Concerning Aging and Quality of Life

Our analysis showed, that technology generations indeed differed in their perception of aspects of quality of life in older age and attitudes towards aging. The oldest generation (household revolution) attached more importance to not being a burden rather than social contacts and medical support for quality of life in older age, and rejected all negative aspects of aging very much. These participants are already in retirement age.

From these different attitudes, especially compared to the generation of technology spread, one could hypothesize that being in this age relativized wishes and concepts of aging and of how quality of life can be achieved. On the other hand, these differences could be generational, as norms and experiences with other people aging may differ to the younger generations. The generation of technology spread, that reaches retirement soon, had a very positive attitude towards aging and rejects all negative aspects but for health problems. For Quality of Life they deem a stable social network and access to information as very important. In comparison, the youngest generation, showed the least positive attitude towards aging and associated especially decreasing health and dependence on others with aging.

In this study, other user factors were analyzed for their influence on the given constructs. Gender and education level did not influence the evaluation. Subjective health status correlated weakly with the relevance of independence for quality of life and decreasing health as well as making plans as associations with aging. As subjective health status declines with age, it can be a moderator of the effects of age. On the other hand, health status itself can relativize the importance of life aspects. Those with worse health status report not to put that much emphasize on competent medical care, maybe because they have learned to live with their illness.

5.2 User-Specific Perceptions of AAL and ICT Technologies

Our results showed, that the technology generations differ in the evaluation of medical technology, especially in the perception of motives to use ICT for aging in place. The oldest generation, that of household revolution shows again attitudes most different from the other generations. The general acceptance of fall detection and medical reminders was lower in this generation. These results are in line with previous research showing that older adults are slower in adapting new technologies (e.g., [12]) and accentuates again the importance of technology acceptance as a barrier against the widespread use of AAL technologies. Considering the evaluation of benefits and barriers, motives were mostly perceived as less pronounced, but barriers were rejected more rigorously than by younger generations. Especially privacy and data security related barriers were rejected stronger, showing that this is not the key barrier for the oldest generation. Thus, the elderly do simply not perceive these technologies as that helpful.

Surprisingly, complex interaction as a barrier against adoption is also more rejected than by other generations. In this study, the oldest generation is the generation of household revolution, that has already experienced many technical devices in their formative period and during their working life. In older studies, the older adults belonged to the mechanical generation, that were less experienced. Claßen [29] found, that the household generation perceives interaction with technical devices easier than the mechanical generation. Moreover, no differences in technical self-efficacy between the generations could be detected in this study. The results could be an indicator, that the gap between the now older adults and younger generations is narrowing, at least regarding usability issues as barriers. On the other hand, the questionnaire was distributed online, reaching only internet users. Hence, it could be that our sample of older adults is more technically affine than the average of their generation, explaining these results.

The technology spread generation showed the highest general acceptance of the presented technologies and the highest agreement to all motives to use them. Additionally to their positive image towards aging, this generation has much more experience with technology and uses many electronic devices and the internet in their everyday live compared to the older generation (e.g., 77% of the Germans aged 45 to 64 used mobile internet in 2016 [30]). But the internet generation - also often called the *Digital Natives* because they were surrounded and have been using electronic devices since their early childhood [31] - agreed to the motives to use technology almost as little as the oldest generation did. This shows, that experiences and habits to use technologies are not the only variables influencing the technology assessment. One could speculate that these young adults are very far away from aging and as they also show a more negative attitude towards aging, they do not see the added value of the evaluated AAL technologies.

Further, gender did only influence the acceptance of medical reminders. Women report a lower level of acceptance. At the same time, confirming previous research, e.g., [32], women indicated to be less confident in interacting with technical devices. This technical self-efficacy played a role for the acceptance of both technologies, with a higher self-efficacy relating to higher acceptance. The sample size of this study does not suffice to analyze interaction effects, but we can hypothesize that the gender effects on acceptance are mediated by technical self-efficacy.

Technical self-efficacy did not show any relation to the perception of motives, but a higher self-efficacy and a lower importance of those barriers regarding technology itself (e.g., too much technology, complex interaction, missing trust) were moderately related in both technology examples. Despite the fact, that in this study no significant relationship between age and technical self-efficacy was found, it could be one main moderating variable explaining the differences of the technology generations.

Education level was related to the perception of some motives to use fall detection and some barriers to use medical reminders, but always as just a small effect. A few barriers to use fall detection and medical reminders also showed a weak correlation with subjective health status. These results only show that there are influences, but are too weak and, in the case of health status, also too much interdependent on the other analyzed variables, e.g., age, to provide further insights into the effects.

Attitudes towards aging showed weak relationships with the acceptance of fall detection as a more positive attitude was related to higher acceptance. At the same time, a more positive attitude led to higher agreement to many motives to use fall detection and medical reminders. The results indicate that with a more positive attitude towards aging the support technology can offer is perceived as more useful. The construct is promising to explain differences in acceptance pattern and should thus be further elaborated and studied for effects on technology acceptance.

The individual need for privacy in general correlated weakly with the acceptance of fall detection. A higher need for privacy was associated with a higher acceptance. As the presented technologies for fall detection also included privacy-invasive technologies like camera or microphone systems, these results seem contradictory on a first sight. On the base of the current data, however, we cannot explain this finding. We can only speculate whether participants with a higher need for privacy rather wanted to be monitored by electronic cameras than by human nurses or focused on more privacy-maintaining technologies like wearable buttons when evaluating fall detection technologies. Need for privacy also related to some motives to use fall detection and medical reminders and showed moderate relationships with the perception of many barriers to use these technologies. As expected, especially barriers regarding privacy and data security were more important to those with a higher need for privacy. Many AAL technologies raise privacy concerns as important barriers against adoption (e.g., [19, 30]). Thus, it is important to include personal dispositions to privacy into the analysis of technology acceptance to better understand different user perspectives.

5.3 Limitations and Future Research

Our empirical research showed that technology generations and other user factors form a multi-faceted picture that influences the acceptance of ICT for aging in place and the perception of motives and barriers to adoption. But limitations should be taken into account regarding some methodological aspects and sample. For the analysis of single effects, the sample size was adequate, but no interaction effects could be examined. From a statistical point of view, most observed effects are small and, as the user factors itself are partly correlated, weak effects can be questioned or be attributed to mediating variables. Future research therefore should collect a larger sample to replicate the findings.

In this questionnaire approach, personal scenarios and pictures of the technologies were used to help the participants to empathize as much as possible with the hypothetical situation of being aged and using AAL technologies. But this cannot be compared to being in this situation as well as to have the opportunity to use technologies and get to know their different advantages and drawbacks in person. The technology examples used in this approach were simple descriptions of the function, e.g., a camera system or wearable button, simple enough to be understood by every participant. For further research, it would be helpful to study technology acceptance of specific systems. As the development of AAL technologies has come forward, research into the acceptance of specific system characteristics could help developing more accepted technologies.

The concept of attitude towards aging has emerged from this study as promising to better understand acceptance patterns of older adults. Rather than only monitoring age as a carrier variable, attitudes of aging and aging concepts reflect the "product" of individual experiences, biographies as well as societal frames which might be more insightful to understand the impact of aging. Further research extending this explorative approach is needed to develop and refine this construct, and to identify its influences on technology acceptance of different technologies for older adults.

Mirroring previous research, concerns regarding privacy and data security have emerged as most important barriers against the adoption of both exemplary AAL technologies. Additionally, it could be shown that the individual disposition to privacy influences the evaluation of these barriers. More research should be conducted to better understand privacy concerns in detail and the individual differences of potential users. The trade-offs between privacy concerns and perceived benefits seem to be crucial to the acceptance of assistive ICT and need to be studied further.

Finally, in this study differences between German technology generations were assessed. On the one hand, the perspective of Germans in the specific German culture and health care system is only one of many and could differ to other countries. On the other hand, we saw indicators that the oldest analyzed generation, that of the household revolution (aged 69 years or older), does not perceive usability barriers as relevant as seniors in older studies, that belonged mostly to the mechanical generation. Longitudinal approach to distinguish effects of age and generation are needed in order to understand technology acceptance not only of today's but also of tomorrow's older adults.

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References

1. Haustein, T., Mischke, J., Schönfeld, F., Willand, I., Theis, K.: Older People in Germany and the EU (2016)
2. Wilkowska, W., Ziefle, M.: User diversity as a challenge for the integration of medical technology into future smart home environments. In: Ziefle, M., Röcker, C. (eds.) Human-Centered Design of E-Health Technologies: Concepts, Methods and Applications, pp. 95–126. Medical Information Science Reference, New York (2011)
3. Cardinaux, F., Deepayan, B., Charith, A., Hawley, M.S., Mark, S., Bhowmik, D., Abhayaratne, C.: Video based technology for ambient assisted living: a review of the literature. J. Ambient Intell. Smart Environ. **1364**, 253–269 (2011)
4. Blackman, S., Matlo, C., Bobrovitskiy, C., Waldoch, A., Fang, M.L., Jackson, P., Mihailidis, A., Nygård, L., Astell, A., Sixsmith, A.: Ambient assisted living technologies for aging well: a scoping review. J. Intell. Syst. **25**, 55–69 (2016)
5. Yared, R., Abdulrazak, B.: Ambient technology to assist elderly people in indoor risks. Computers **5**, 22 (2016)
6. Chaudhuri, S., Thompson, H., Demiris, G.: Fall detection devices and their use with older adults: a systematic review. J. Geriatr. Phys. Tehr. **37**, 178–196 (2014)
7. Rashidi, P., Mihailidis, A.: A survey on ambient-assisted living tools for older adults. IEEE J. Biomed. Heal. Informatics. **17**, 579–590 (2013)
8. Merkel, S.: Technische Unterstützung für mehr Gesundheit und Lebensqualität im Alter: Herausforderungen und Chancen [Technical support for more Health and Quality of Life in Older Age: Challgendes and Opportunities]. Forsch. Aktuell, Inst. für Arbeit und Tech. (IAT), Westfälische Hochschule, University Applied Science (2016)
9. Ajzen, I., Fishbein, M.: Understanding Attitudes and Predicting Social Behavior. Prentice-Hall, Englewood Cliffs (1980)
10. Davis, F.D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Q. **13**, 319–340 (1989)
11. Venkatesh, V., Zhang, X.: Culture and technology adoption: theory and empirical test of the unified theory of acceptance and use of technology (UTAUT) in the us vs china. J. Chem. Inf. Model. **53**, 1689–1699 (2013)

12. Czaja, S.J., Charness, N., Fisk, A.D., Hertzog, C., Nair, S.N., Rogers, W.A., Sharit, J.: Factors predicting the use of technology: findings from the center for research and education on aging and technology enhancement (CREATE). Psyhol. Aging. **21**, 333–352 (2006)
13. Ziefle, M., Schaar, A.K.: Gender differences in acceptance and attitudes towards an invasive medical stent. Electron. J. Heal. Inf. **6** (2011). www.eJHI.net
14. Chen, K., Chan, A.H.S.: Review a review of technology acceptance by older adults. Gerontechnology **10**, 1–12 (2011)
15. Jakobs, E.: Alter und Technik (2008)
16. van de Goor, A.G., Becker, H.A.: Technology generations in the Netherlands: a sociological analysis. Shaker Pub, Maastricht (2000)
17. Sackmann, R., Winkler, O.: Technology generations revisited: the internet generation. Gerontechnology **11**, 493–503 (2013)
18. van Heek, J., Himmel, S., Ziefle, M.: Caregivers' perspectives on ambient assisted living technologies in professional care contexts. In: 4th International Conference on Information and Communication Technologies for Ageing Well and e-Health (ICT4AWE 2018). SCITEPRESS (2018)
19. Himmel, S., Ziefle, M.: Smart home medical technologies: users' requirements for conditional acceptance. I-Com. J. Interact. Media. **15**, 39–50 (2016)
20. van Heek, J., Arning, K., Ziefle, M.: Where, wherefore, and how? Contrasting two surveillance contexts according to acceptance. In: 6th International Conference on Smart Cities and Green ICT Systems (Smartgreens 2017), pp. 87–98. SCITEPRESS (2017)
21. Jaschinski, C., Allouch, S.B.: An extended view on benefits and barriers of ambient assisted living solutions. Int. J. Adv. Life Sci. **7**, 40–53 (2015)
22. Peek, S.T.M., Wouters, E.J.M., van Hoof, J., Luijkx, K.G., Boeije, H.R., Vrijhoef, H.J.M.: Factors influencing acceptance of technology for aging in place: a systematic review (2014)
23. van Heek, J., Himmel, S., Ziefle, M.: Helpful but spooky ? Acceptance of AAL-systems contrasting user groups with focus on disabilities and care needs. In: Proceedings of the 3rd International Conference on Information and Communication Technologies for Ageing Well and e-Health (ICT4AWE 2017), pp. 78–90 (2017)
24. Bowling, A., Gabriel, Z., Dykes, J., Dowding, L.M., Evans, O., Fleissig, A., Banister, D., Sutton, S.: Let's ask them: a national survey of definitions of quality of life and its enhancement among people aged 65 and over. Int. J. Aging Hum. Dev. **56**, 269–306 (2003)
25. Schomakers, E.-M., van Heek, J., Ziefle, M.: A game of wants and needs. The Playful, user-centered assessment of AAL technology acceptance. In: ICT4AgeingWell 2018. SCITEPRESS (2018)
26. Beier, G.: Kontrollüberzeugungen im Umgang mit Technik [Technical Self-Efficacy]. Rep. Psychol., 684–693 (1999)
27. Xu, H., Dinev, T., Smith, H.J., Hart, P.: Examining the formation of individual's privacy concerns: toward an integrative view. In: International Conference on Information Systems (2008)
28. McKnight, D.H., Choudhury, V., Kacmar, C.: Developing and validating trust measures for e-commerce: an integrative typology. Inf. Syst. Res. **13**, 334–359 (2002)
29. Claßen, K.: Zur Psychologie von Technikakzeptanz im höheren Lebensalter: Die Rolle von Technikgenerationen [Psychology of Technology Acceptance in older age: the role of technology generations]. Dissertation (2012)
30. Statistisches Bundesamt Destatis: Private Haushalte in der Informationsgesellschaft - Nutzung von Informations- und Kommunikationstechnologien [Private Household in the Information Society - Use of Information and Communication Technologies] (2017)

31. Prensky, M.: Digital natives. Digit. Immigrants. Horiz. **9**, 1–6 (2001)
32. Wilkowska, W., Gaul, S., Ziefle, M.: A small but significant difference - the role of gender on acceptance of medical assistive technologies. In: Leitner, G., Hitz, M., Holzinger, A. (eds.) USAB 2010, LNCS 6389, pp. 82–100. Springer, Heidelberg (2010)