Influence of Age on Trade-Offs Between Benefits and Barriers of AAL Technology Usage

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Abstract. An aging population due to demographic change along with rising care needs lead to higher efforts in concepts and developments of ambient assisted living (AAL) technologies aiming at a longer staying at home and more independency for older people. Although research on technology acceptance and user diversity gains in importance, real-life decisions with trade-offs between potential benefits and barriers of AAL technology usage have not been investigated so far. Therefore, the current study (n = 140) represents a conjoint analysis approach focusing on younger and older people's decisions between benefits (*safety and relief*) and barriers (*data handling and data access*) to use an assisting system in the home environment of a family member in need of care. The results revealed differences in the decision patterns of both groups indicating that data-relevant aspects were most relevant for the younger adults, while safety represented a more relevant criterion for the older participants. In addition, contradicting evaluations of both groups were found within the aspects data access and safety. The results contribute to a deeper understanding of real-life decisions regarding the use of assisting technologies focusing on age as relevant user factor.

Keywords: Ambient assisted living (AAL) · Technology acceptance · Benefit and barrier perception · Trade-off · Age

1 Introduction

An aging population and rising needs in care and support of older people characterize demographic change in western societies. This development represents tremendous challenges for health and social systems of nearly all countries as well as high burdens for care sectors and policy [1, 2]. In particular, care institutions suffer intensely from a persistent lack of care specialists in line with steadily rising numbers of older people and people in need of care [2–4].

Enabling most older people's wish of staying within the own home environment as long and as autonomously as possible requires new concepts and innovative technology development [5]. In the last decades, numerous single devices but also complex ambient assisted living (AAL) and smart home systems facilitate living at home,

J. Zhou and G. Salvendy (Eds.): HCII 2019, LNCS 11592, pp. 250–266, 2019.
https://doi.org/10.1007/978-3-030-22012-9_19

enhance safety by enabling monitoring of vital parameters or detecting falls, or act as reminders [6]. For user's acceptance and a sustainable adoption of devices and systems, a detailed understanding of diverse users' perspectives and perceptions of such technologies is necessary. Previous research has intensively investigated users' acceptance of specific technologies (e.g., [7–9]), their interaction with assisting technology (e.g., dementia patients [10]), and also their evaluations of specific benefits and barriers (e.g., [11–13]) regarding diverse technologies and systems.

In contrast, there has not been any research so far focusing on people's real-life decisions between benefits and barriers when thinking about using an AAL system in the own home environment or using an AAL system for a family member in need of care. Thus, the current conjoint analysis study was conceptualized aiming for an investigation of people's decisions between benefits and barriers of AAL technology usage. Using an online questionnaire, people (n = 140) of different ages were asked to think about an implementation of an AAL system in the home environment of a family member in need of care and to decide which aspects are most important for them (differing between relevant benefits and barriers of technology usage).

In the following, an overview of previous research in the field of AAL and user acceptance is provided. Subsequently, the applied approach is described including the selection of relevant attributes, the online questionnaire design, and the characteristics of the sample. Afterwards, the results are presented starting with (descriptive) results of acceptance as well as benefit and barrier evaluation, followed by the conjoint analysis differing between importance of attributes (benefits and barriers: safety, relief, data handling, data access) and the meaning of attribute levels (e.g., facets of safety). Finally, the results are discussed and research gaps for future work are highlighted.

2 AAL and User Acceptance

In the last decades, the number of new and innovative technologies, reaching from medical technologies or smart home technologies to supporting AAL technologies, has increased enormously. As research projects (e.g., [6, 14]) but also as commercial products (e.g., [15]), numerous single devices as well as more complex systems have been developed and are available on the market.

Concomitantly, the awareness and importance of (future) users' acceptance of innovative assisting technologies have increased as well. In this regard, a high number of studies have already focused on perception and acceptance of AAL and smart home technologies understanding the needs of user-centered technology development [7]. Most of the studies have focused on diverse stakeholders' acceptance or behavioral intention to use different types of assisting technology as well as on their perception of potential benefits and barriers of technology usage. This way, the perspectives of e.g., professional caregivers (e.g., [9, 11]), family caregivers (e.g., [8, 16]), older people suffering from dementia (e.g., [10]), or older predominantly healthy people (e.g., [13, 17]) have been investigated.

Most studies have in common that perceived benefits and barriers of using assisting technology were evaluated separately and isolated from each other. Independent from the investigated user group, enabling a longer staying at the own home, a feeling of

increased safety, and enabling a more autonomous life for older people or people in need of care represent the most relevant benefits of using assisting technology (e.g., [7, 11, 13]). On the other side, the perception of barriers has been expressed differently with regard to diverse user groups. While family caregivers expressed in particular concerns about maintaining home security [8], professional caregivers mentioned especially concerns about data security, privacy, and perceived control in professional everyday [9, 11]. In addition, more detailed research found that – among professional caregivers – technology depends on the respective care area [12]. In contrast to the caregivers' perspective, concerns expressed by older people referred to dependency on technology and a lack of personal contact (e.g., [13, 17]).

Besides investigations of diverse user groups' perspectives, acceptance and perception of assisting technologies can also impact by individual factors of users, e.g., gender, previous experience, attitude towards technology, or education (user diversity). With regard to demographic change and an aging population, age-related factors such as the biological age, perceived age, or attitude towards aging (e.g., [18]) have been considered as relevant parameters for technology acceptance [19]. Some studies have already revealed significant influences of age and chronic illness on the acceptance of a vital signs monitoring system [20] and electronic safety devices [21]. With regard to evaluation of assisting health technologies, effects of age have not been found for the perception of benefits, while older adults showed higher ratings of barriers to use assisting technology compared to younger adults [22].

To sum up, previous studies have intensively investigated technology acceptance of diverse user groups, separate evaluations of benefits and barriers, and influences of age as relevant user factor. Hence, knowledge about real-life decisions, in which several advantageous and disadvantageous factors have to be weighed against each other, is missing regarding usage of AAL technologies in the own home environment. In addition, it is unclear if age – which has been proven to be a relevant factor for technology acceptance – has an impact on decisions between benefits and barriers of AAL technology usage. Therefore, the current study aims at an investigation of exactly these two research gaps applying a conjoint analysis differing between younger (<50 years) and older adults (50+).

3 Empirical Approach

The following section gives an overview of the study's empirical approach, starting with a description of the applied methodology "conjoint analysis". Then, the selection of attributes and attribute levels as well as the experimental questionnaire design are described. Further, information on the collection, processing, and analysis of data are provided, before the sample of the study is illustrated.

3.1 Applied Methodology

To examine the trade-off between perceived benefits and barriers of using AAL systems and technologies from the perspective of caring relatives, a conjoint analysis (CA) was carried out. The method of conjoint analysis emerged in the 1960s from the

psychological measurement theory of the American mathematical psychologist Luce and the statistician Tukey [23]. The CA is used to measure preferences and allows a holistic examination of decision-making situations, in which selected attributes are weighed against each other [24]. Since its introduction to market research in 1971 by Green and Srinivasan [25], conjoint measurement is considered as one of the most frequently used methods for market segmentation, product planning, and pricing in marketing [26]. Nowadays, CA is also used in other disciplines such as social sciences and acceptance research (e.g., [21]), health and care research (e.g., [27]), or in environmental science (e.g., [28]).

In contrast to common methods in social science such as surveys, CA is based on a decompositional procedure. In CA, overall assessments of holistic concepts, referring to products or scenarios, are determined. For this purpose, different alternatives ("choice sets") are presented to the participants, which usually consist of three to five attributes and vary in specific characteristics of the attributes – called attribute levels. Participants are then asked to select the combination of attributes levels matching their preferences most closely. On the basis of these preferential decisions, information about an attribute's importance for the overall assessment can be gained in relation to all other investigated attributes. In addition, statements can be made about the relevance of individual attribute levels within the attributes. Nowadays, numerous variants of conjoint analysis exist. The form used in the present study is the choice-based-conjoint analysis (CBC), as is it a widely used approach and allows an investigation of complex decision processes in which various attributes influence the final decisions [24].

3.2 Relevant Attributes and Levels in the Field of AAL Acceptance

The most important step in the conception of a conjoint study is the definition of relevant attributes and levels that are evaluated in the choice tasks [29]. Relevant influencing factors for the acceptance of AAL technologies were selected on the basis of a literature analysis. Thereby, the following four attributes with each four different levels were identified and included in the consideration. For an overview, all attribute levels and their visualizations are depicted in Table 1.

As a first relevant aspect, the type of data access by third parties was identified to be an important barrier for AAL technology usage. Numerous studies have shown that concerns about limited individual privacy have a negative impact on the assessment of AAL (e.g., [30, 31]). An important role in dealing with health data refers to the question with whom data concerning AAL technology usage should be shared [32]. Therefore, data access was integrated in the current study as privacy-relevant potential barrier of using AAL technologies. Within the attribute levels, it was differentiated between *trusted persons* (selected by the person who is using AAL technology), a *circle of relatives* (consisting of several people), *medical experts*, and *emergency services*.

A second potential barrier of using AAL technology refers to the way the AAL technology or systems handles data. Thereby, the duration of data storage represents a frequently discussed data security-related aspect [11]. Hence, the duration of data handling was integrated as a potential barrier of using AAL technology. With regard to

Table 1. Attribute levels and their visualizations (red box marks an exemplary scenario).

Attribute	*Attribute levels*			
Data access	Trusted persons	Relatives	Medical experts	Emergency services
Data handling	Real time (no storage)	Short-term (1 week)	Middle-term (1 month)	Long-term (permanent)
Safety	Fast	Medical	Structuring	Felt
Relief of caring persons/family members	Temporal	Organizational	Financial	Emotional

the attribute levels, a distinction has been made between four storage periods: a *real time processing (no storage)* of data, a *short-term storage up to 1 week*, a *middle-term storage up to 1 month*, and *a long-term (permanent) storage* of data referring to the AAL system's usage. The various levels are accompanied by different ways of monitoring the state of health of the patient in need of care. While, for example, the real-time data acquisition only allows a situational analysis of the disease state, the long-term storage enables an analysis of acute and chronic disease progressions. These relationships were – of course – introduced and explained to the participants prior to the conjoint decision tasks.

Moving to benefits of using AAL technology, increased security represents one of the most mentioned aspects. Numerous studies proved a positive influence of the factor "gain in safety" on the acceptance of AAL technology (e.g., [7]). The high relevance of this aspect has been confirmed by a revealed higher willingness of participants to accept privacy restrictions if monitoring by AAL technology provides increased safety (e.g., [33]). Increase in safety was therefore also integrated as attribute in the current study. As diverse dimensions of safety were identified to play a role for AAL technology usage in preceding studies, the attribute levels referred to different types of safety: *fast safety* referring to fast assistance in emergencies, *medical safety* by checking and monitoring of medical parameters, *structuring safety* by reminding and organizational functions, and *felt safety* related to perceived safety and the feeling that the persons in need of care is not alone.

As an additional benefit of using AAL technology, the relief of caring persons and family members by means of using AAL technology has been identified. Relevant studies have indicated that participants show an increased willingness to adopt AAL

technologies if technology usage has the potential to relieve the burden on caregivers (e.g., [34]). Similar to the safety attribute, diverse dimensions of relief were relevant and have therefore been integrated in the current study: *temporal relief* due to time savings (it is no longer necessary to visit the persons in need of care several times a day), *organizational relief* due to minor efforts in planning, organization, and infrastructure of everyday life, *financial relief* by saving costs of care services or costs of drives, and *emotional relief* by the knowledge that the system monitors the health state and contacts the caring relatives in emergencies.

3.3 Experimental and Questionnaire Design

The questionnaire consisted of different parts. The first section addressed demographic data (e.g., age, gender, educational level) as well as questions about the residential area and the proximity to close relatives and medical care centers. Afterwards, the participants' general attitude towards technology (five items) [35], privacy (three items), and data security (three items) (based on [36, 37]) were rated on a six-point Likert scale (min = 1: "I strongly disagree"; max = 6: "I strongly agree). In the third part, the participants' experiences in the field of health, care, and medicine were collected by using five statements which could be answered with "yes" or "no". Further, more detailed knowledge about the subjective state of health, e.g., with regard to chronic diseases or the need for regular medical check-ups, has been gained by six items (answer options: "yes", "no").

To enable that the participants emphasized with the situation of being a caregiver for a close family member in need of care, a fictitious scenario was presented in the next section of the questionnaire. The scenario focused on the integration of supporting technologies into the living environment of a person in need of care as well as on the everyday life of a family caregiver. Within a description of the daily routine, the functional scope of the technologies, prototypical usage situations, and the potential relief were described in more detail. After this, the participants were asked to evaluate possible benefits and barriers of AAL technology (each six items) as well as their acceptance (four items) and intention to use AAL (three items). Thereby, it was differentiated whether AAL technology was used for a) a relative in need of care and b) for the participants themselves. In line with the evaluations of attitudes, all statements were rated on six-point Likert scales (min = 1: "I strongly disagree"; max = 6: "I strongly agree).

In the subsequent section of the questionnaire, participants were introduced into the experimental CA study design by providing detailed information about the attributes, their levels, and visualizations. Subsequently, the participants were asked to put themselves in the perspective of a caring relative who decided, together with the person in need of care, to use supporting technologies. Then, the participants were instructed to choose in each decision task the scenario that meets their needs and wishes most closely. As described in Sect. 3.2, four attributes with each four levels were selected for the conjoint study (Table 1). The participants had to complete 10 decision tasks in which they had to choose their most preferred scenario constellation out of four different alternatives ("choice sets"). To avoid a loss of information, the CBC was executed in a forced choice format (no "none-option"). In order to increase the

comprehensibility of the constructs, the levels in the selection tasks were displayed both verbally and visually in the form of pictograms. The uniqueness of the pictograms and semantic equivalence to the terms were positively evaluated within pretests. The number of decision tasks was limited to 10 randomized selection tasks, since the combination of all attribute levels would have led to 256 ($4 \times 4 \times 4 \times 4$) possible alternatives. This reduction of decision tasks requires a test of the design's efficiency in order to ensure validity although the possible effect that probably some attribute levels might not appear together in a set of scenario decisions. For the present study, a median efficiency of 99% and a standard error below .05 confirmed that the current design (10 choice tasks) was comparable to the hypothetical orthogonal design [38].

3.4 Data Acquisition, Preparation, and Sample

Data was collected in Germany in summer 2018 by distributing a link to the online questionnaire. Due to the randomized design of the conjoint analysis, a paper-based survey could not be realized. Participants were acquired in social networks and in online forums with a focus on age-appropriate technologies, medical technology, and nursing care. The completion of the survey took approximately 20 min. The total number of participants gained was n = 228. For the analysis, dropouts as well as dubious answers (e.g., responses with a processing time under five minutes) were removed from the data set. After the data cleaning, the total sample contained n = 140 data sets.

A total of 140 (n) participants with an age range from 17 to 86 were included in the analysis. 56.4% (n = 79) of them were female and 42.9% (n = 60) male. One participant chose the answer option "no specification" for gender determination. The average age of the volunteers was 35.4 years, the standard deviation 16.8 years. Asked for their highest educational level, 45.7% (n = 64) indicated to have a university entrance degree (qualification), 38.6% (n = 54) a university degree, and 15.7% (n = 22) a secondary school degree. Thus, the sample turned out to be highly educated. Half of the participants (54.3%, n = 76) have not yet finished their education, 35.0% (n = 49) work in their professions, and - with a clear distance - 10.7% (n = 15) indicated to be retired.

Asked for experiences with health, medicine, and care, about one third of the participants had already gained professional experience either in a medical (17.9%, n = 25) or care area (14.3%, n = 19), while 44.3% indicated to have private experiences in the areas health, medicine, and care. Further, more than a third of the participants reported that a person in their environment is in need of care (36.4%, n = 51, "private passive care experience"). 18.2% (n = 25) indicated to have already been the caregiver for a family member in need of care ("private active care experience"). Asked for their health status, 21.4% of the sample (n = 30) indicated to suffer from a chronic disease, while only 2.9% (n = 4) indicated to depend on support and care.

4 Results

The conjoint data was analyzed using Sawtooth Software [39]. First, the relative importance of the attributes was calculated based on Hierarchical Bayesian analysis (HB). Thus, statements could be made about the relevance of an attribute for the selection of a scenario in relation to all other attributes. Secondly, part-worth utilities of the attribute levels were investigated also by using HB-analysis and provide information about the (positive or negative) meaning of each attribute level for the selection of a scenario. Besides conjoint data, also other relevant criteria of the online questionnaire were analyzed using descriptive as well as inference statistical procedures.

The results are presented in the following sections starting with a description of the investigated age groups. Further, participants' evaluation of benefits and barriers as well as their acceptance of AAL technology is analyzed. Finally, participants decisions and trade-offs between perceived benefits and barriers of AAL technology are investigated.

4.1 Age Groups and Their Characteristics

In order to understand potential age-related differences in AAL technology acceptance and the decision behavior regarding trade-offs between benefits and barriers of using AAL technology, two age groups were investigated: the sample was divided into a younger age group younger than 50 years of age (n = 102; M = 26.1; SD = 6.6; min = 17; max = 48) and an older age group being 50 years of age or older (n = 38; M = 60.4; SD = 8.3; min = 50; max = 86). As illustrated in Table 2, inference statistical analyses revealed that both age groups did neither differ regarding gender nor health status. However, they differed in terms of their living circumstances and their previous experiences with care. Concerning their living circumstances, both age groups differed with regard to the highest level of education, their current occupation, and their living area. In more detail, nearly all participants of the younger group hold a university degree or at least a university entrance qualification, while the majority of the older group reported to have a secondary school degree as highest educational level. In line with this, the three quarter of the younger group reported to have not finished their education yet. In contrast, the participants of the older group reported to have a professional activity or to be in pension. Concerning the living area, the majority of the younger group stated to live in the city center, while the older group indicated to live mainly in suburban or rural areas.

Regarding previous experiences, both groups differed significantly in terms of professional and private experiences with care. In tendency, higher proportions of participants belonging to the older group reported to have professional experiences with care, to have a person in their family circle depending on care (private passive experience), and to have already been the caregiver for a family member in need of care (private active experience). Overall, the younger group had comparably less experiences with care than the older group.

Table 2. Characteristics and inference statistical results regarding age groups.

Variables	Young (<50 years)	Old (50+ years)	P
Age (M (SD))	26.1 (6.6)	60.4 (8.3)	<.01
Gender	59.8% female (n = 61)	47.4% female (n = 18)	n.s.
	39.2% male (n = 40)	52.6% male (n = 20)	
Education	43.1% university degree (n = 44)	26.3% university degree (n = 10)	<.01
	53.9% university qualification (n = 55)	23.7% university qualification (n = 9)	
	2.9% secondary school degree (n = 3)	50.0% secondary school degree (n = 19)	
Occupation	74.5% ongoing education (n = 76)	0.0% ongoing education (n = 0)	<.01
	22.5% professional activity (n = 23)	65.8% professional activity (n = 25)	
	2.9% in pension (n = 3)	34.2% in pension (n = 13)	
Living area	54.9% city center (n = 56)	15.8% city center (n = 6)	<.01
	34.3% suburban area (n = 35)	42.1% suburban area (n = 16)	
	10.8% rural area (n = 11)	42.1% rural area (n = 16)	
Health status	19.6% chronic illness (n = 20)	26.3% chronic illness (n = 28)	n.s.
Prof. care experience	10.8% yes (n = 11)	23.7% yes (n = 9)	<.01
	89.2% no (n = 91)	76.3% no (n = 29)	
Private passive care experience	29.4% yes (n = 30)	55.3% yes (n = 21)	<.01
	70.6% no (n = 72)	44.7% no (n = 17)	
Private active care experience	11.8% yes (n = 12)	36.8% yes (n = 14)	<.01
	88.2% no (n = 90)	63.2% no (n = 24)	

4.2 AAL Acceptance

As a baseline, the participants assessed perceived benefits and barriers of the described AAL system's usage as well as their acceptance and intention to use the system. Starting with the benefits, MANOVA analyses revealed that the evaluation did not differ significantly for both age groups ($F(6,133) = 1.812$; $p = .101$; n.s.). Figure 1 shows the evaluation of all benefits for both age groups. All benefits were evaluated positively and were, thus, perceived to be real benefits of the AAL system's usage. Fast help in emergencies, increased feeling of safety, and relief of relatives represented important benefits for both groups.

Concerning potential barriers of the AAL system's usage, both age groups did also not differ significantly in their assessment ($F(6,133) = .879$; $p = .512$; n.s.). All barriers were only slightly confirmed, e.g., surveillance by technology ($M_{young} = 3.9$; $SD_{young} = 1.5$; $M_{old} = 3.5$; $SD_{old} = 1.3$), invasion of privacy ($M_{young} = 3.5$; $SD_{young} = 1.4$; $M_{old} = 3.4$; $SD_{old} = 1.3$), recording of data ($M_{young} = 3.8$; $SD_{young} = 1.4$; $M_{old} = 3.5$; $SD_{old} = 1.3$) or data sharing with third persons ($M_{young} = 3.7$; $SD_{young} = 1.4$; $M_{old} = 3.5$; $SD_{old} = 1.4$).

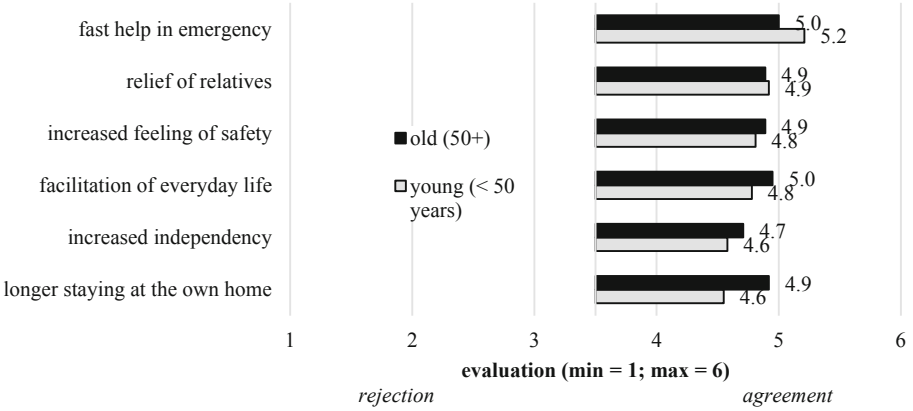

Fig. 1. Evaluation of single perceived benefits.

Asking for the participants' evaluation of acceptance and intention to use the AAL system, it was differed between using the system for a family member in need of care or for the participants themselves. Neither the acceptance of the system used for a family member ($F(4,135) = .455$; $p = .769$; n.s.) nor for the participants themselves ($F(4,135) = .170$; $p = .953$; n.s.) differed regarding the investigated age groups. Thereby, acceptance was confirmed indicated by rather high evaluations (family member: $M_{young} = 4.3$; $SD_{young} = 0.8$; $M_{old} = 4.2$; $SD_{old} = 0.7$; participants themselves: $M_{young} = 4.2$; $SD_{young} = 0.9$; $M_{old} = 4.1$; $SD_{old} = 0.8$).

The same applied to the participants' intention to use the system. The evaluations were rather positive (family member: $M_{young} = 4.2$; $SD_{young} = 0.9$; $M_{old} = 4.2$; $SD_{old} = 0.8$; participants themselves: $M_{young} = 4.2$; $SD_{young} = 0.9$; $M_{old} = 4.1$; $SD_{old} = 0.8$) and did not differ for the age groups – neither for using the system for a family member ($F(3,136) = .946$; $p = .421$; n.s.) nor for themselves ($F(3,136) = .179$; $p = .910$; n.s.).

Although the results did not show significant evaluation differences for both age groups when assessing benefits, barriers, and acceptance of the AAL system, it is questionable whether decisions and trade-offs between benefits and barriers are influenced by age.

4.3 Decision Patterns

To analyze if age had an impact on the decision and trade-offs between perceived benefits and barriers of the AAL system's usage, the conjoint study's data is considered differentiating between both age groups. Figure 2 shows the relative importance of each attribute for the scenario decisions. For the young group, the privacy-related barrier attribute *data access* was most important (27.0%), followed by *data handling* (25.7%), *relief of relatives* (24.7%), and *safety* (23.6%). For the old group, *safety* (27.8%) and *data access* (27.7%) represented the most important attributes, while *relief of relatives* (22.9%) and *data handling* (21.7%) were comparably less important.

Inference statistical analyses revealed significant differences for the attributes *safety* ($F(1,139) = 4.396$; $p < .05$) and data handling ($F(1,139) = 3.487$; $p < .1$), while *data access* ($F(1,139) = .103$; $p = .749$; n.s.) and *relief of relatives* ($F(1,139) = .079$; $p = .779$; n.s.) were not of different importance for both age groups.

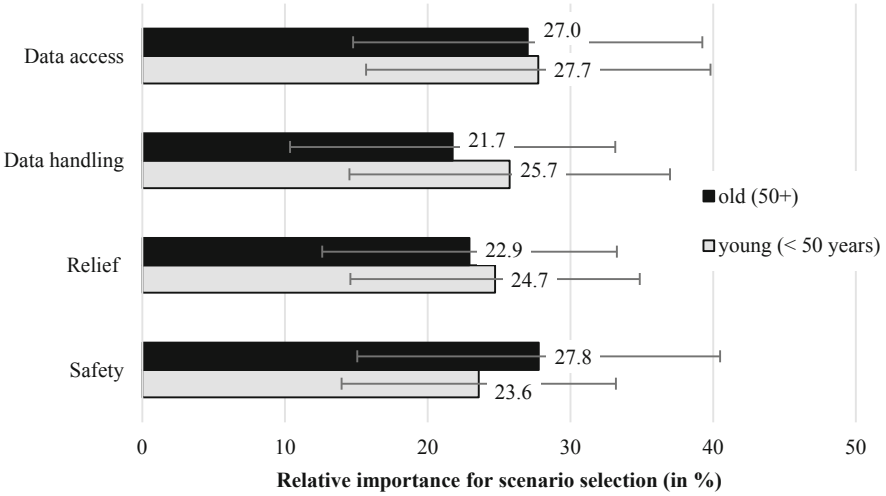

Fig. 2. Relative importance of attributes for scenario selection.

To understand differences in the attributes' importance, it is necessary to consider the evaluations of attribute levels. Figure 3 shows the part-worth utilities of all attribute levels indicating if an attribute level contributes – in tendency – negatively or positively to the scenario decisions.

Starting with the attribute data access, diverse decision patterns are striking for the age groups. For the young group, enabling data access for medical experts (+13.8) and a defined number of trusted persons (+11.7) contributed positively to the scenario decisions, while data access solely for emergency services (−3.1) contributes slightly negatively and for relatives (−22.4) strongly negatively to the scenario decisions. In contrast, for the older group, data access for defined trusted persons represented clearly the best (+22.3) and data access for emergency services (−27.2) definitely the worst option. Compared to that, data access for medical experts (+4.5) and relatives (+0.5) played only a marginal role for the scenario decisions.

Within the attribute *data handling*, short-term storage of data represented the best option (+14.9) for the young group, while long-term storage (−23.3) was clearly not desired. Real time processing (+5.8) and middle-term (+2.6) storage of data received slightly positive utility values. For the older group, short- (+7.9) and middle-term (+6.1) storage of data represented options contributing positively to the scenario decisions, while real time processing (−7.9) and long-term (−6.1) storage were comparably not desired.

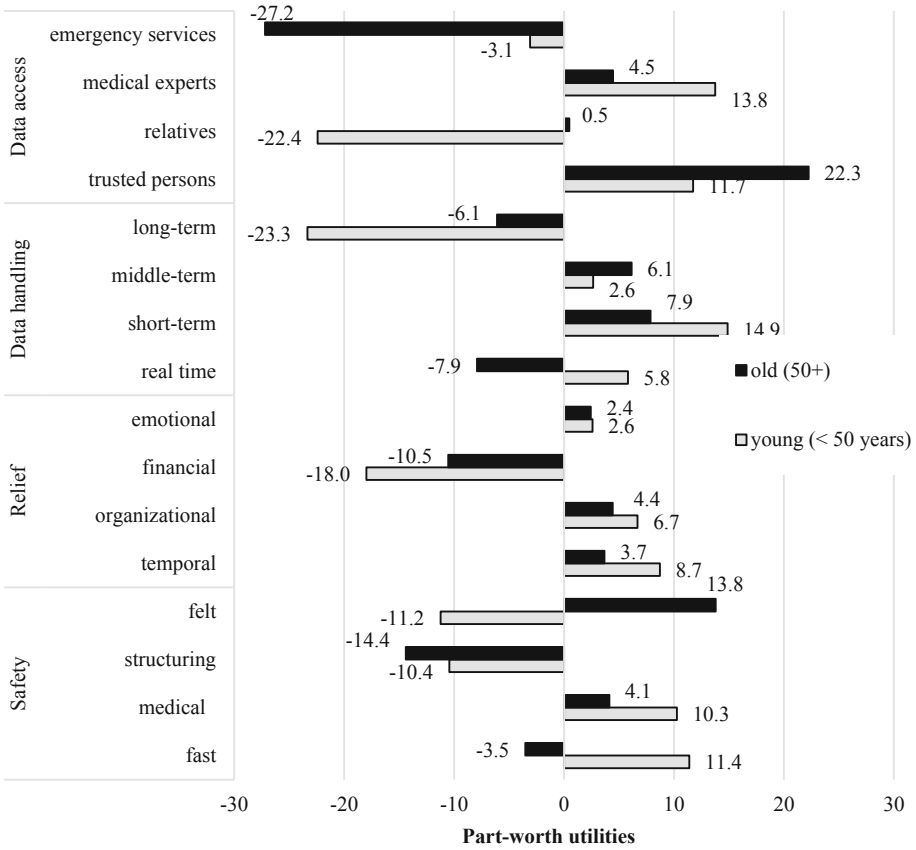

Fig. 3. Part-worth utilities of all attribute levels.

Moving to the benefits of AAL technology usage, rather similar decision patterns were found for the attribute relief of relatives. For both groups, temporal (young: +8.7; old: +3.7), organizational (young: +6.7; old: +4.4), and emotional relief (young: +2.6; old: +2.4) received positive utility values, while financial relief (young: −18.0; old: −10.5) contributed clearly negatively to the decisions. The evaluation pattern was overall stronger pronounced for the young group.

In contrast, the decision patterns referring to the beneficial attribute safety differed strongly for both groups: for the young group, fast (+11.4) and medical (+10.3) safety represented positive options and contributed positively to the scenario decisions, while it was vice versa for structuring (−10.2) and felt (−11.4) safety. Instead, felt safety (13.8) was the most relevant attribute level for the older group and structuring safety (−14.4) represented the comparably least desired option. Fast (−3.5) and medical (+4.1) safety were – in tendency – of less importance.

5 Discussion

The current study represented a first approach to analyze decision patterns with regard to trade-offs between benefits and barriers of AAL technology focusing on a potential impact of age. In the following, the results are discussed and limitations as well as suggestions for future work are given.

5.1 Meaning of Results

Within the results section, isolated evaluations of single benefits, barriers and acceptance of AAL technology were not significantly impacted by age as user factor. These results are contrary to previous research in the field, that identified significant impacts of age on technology acceptance [22] and on the perception of benefits and barriers [18].

In contrast to the evaluations of single benefits and barriers, the results showed influences of age on the decisions between benefits and barriers of technology usage. The results suggest that the investigated barriers data access and in particular data handling were the most decision-relevant factors for younger adults (aged under 50 years). In contrast, the interplay of the benefit safety and the barrier data access was most decision-relevant for the older participants (aged 50 and older).

In more detail, contradicting evaluation patterns of data access and safety were striking. Referred to data access, the younger participants preferred data to be accessible for medical experts and defined trusted persons, and clearly not for relatives. In contrast, the decision pattern of the older participants showed that data should only be accessible for trusted persons, while data should clearly not be accessible for emergency services. With regard to the benefit safety, the fast and medical facets of safety were perceived positively by the younger participants, while they tend to reject structuring and felt safety as decision criteria. In contrast, felt safety contributed clearly positively to the decisions of the older participants, who tend to reject structuring safety as decision-relevant facet of safety. Possible explanations for these differences lie in the age group themselves: the younger participants had different life experiences and circumstances than the older participants and were in particular less experienced in care. Presumably, experiences in care lead to higher needs for felt safety as the participants are – in tendency – more familiar with concerns about their family member in need of care and with the responsibility to care for a loved person in need of care. Future studies should in particular focus on care-relevant aspects (e.g., experience in care, handling of care, attitude towards aging and care) to investigate these potential and suggested relationships in more detail.

5.2 Limitations and Future Work

Besides new insights provided by the decisions and trade-offs between benefits and barriers of using AAL technology differing between younger and older people, there are some limitations of the current study that should be considered for future research.

With regard to the applied methodological procedure, it cannot be ensured that the scenario-based approach and the estimated preferences inevitably predict actual

behavior of the participants: hence, the agreement or rejection might be higher or lower in real decisions [40]. Further, the participants were asked to empathize with the situation of having a close family member in need of care in the current study. Hence, they had to imagine to be the family caregiver and take the perspective of a caring relative. For future studies, it should be examined whether the decision profiles change for other perspectives, e.g., being the person in need of care or asking professional caregivers.

Another methodological limitation refers to the limited number of attributes that could be used within the choice-based conjoint analysis. For the current approach, the selection of attributes based on an extensive literature review and preceding studies. Nevertheless, integrating other benefit- or barrier-related aspects (e.g., independency/autonomy of people in need of care, type of recorded data) could provide interesting insights into people's decision behavior. However, extending the number of attributes would then lead to the necessity of applying different approaches such as an adaptive conjoint analysis design [41].

Discussing the sample, future research should aim for reaching a larger sample being more balanced with regard to the level of education as this study's sample was comparably high educated. Focusing on differences of user groups and the impact of user diversity, we assume that other factors besides the biological age – such as attitudes towards aging, attitudes towards care, and individual handling of care – are presumably even more relevant when it comes to concrete and "real" decisions affecting the own life as well as the life of a loved person in need of care. Future studies should therefore focus on more care-relevant individual factors referred to the investigation of real-time decisions. Further, it would be useful to investigate data-driven differences in decision patterns, e.g., by applying cluster analyses or latent class analysis [42]. As a last aspect for future work, the current study was conducted in Germany and represents a very country-specific perspective. Therefore, future research should focus on cross-national comparisons considering people's different cultures, their perspectives on aging and care, and their handling of aging within society.

Acknowledgements. The authors thank all participants for their openness to participate in the study and to share their opinions on relevant decisions regarding usage of AAL technologies. This work has been funded partly by the German Federal Ministry of Education and Research projects Whistle (16SV7530) and PAAL (6SV7955).

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