Domestic Robots for Homecare: A Technology Acceptance Perspective

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Abstract. In times of the demographic change and the increasing need of novel concepts to meet the requirements of older adults' care in the near future, health care robots could be a potent solution to meet shortcomings in the health care sector. Even though the potential of robotic home care assistance is promising, the question if older persons would accept a robotic assistance at home is still underexplored. Adopting a three-step procedure, older adults' perceptions towards home care robots are empirically explored. In a first step, focus groups were accomplished to understand older persons' perceptions on benefits and barriers. Second, a survey study was applied to determine acceptance criteria, the perceived usefulness and the extent and types of concerns toward a domestic robot in homecare. Finally, in a further survey study, specific care situations in the home care settings had to be evaluated in a third study, thereby comparing preferences for a human care persons vs. a robotic care assistant. Outcomes reveal both, age-sensitive as well as age-insensitive findings. While overall a positive attitude towards home care robots was found, serious concerns in terms of fear of loss of control and connection to family members are prevailing. Outcomes contribute to an understanding of social factors in the development and implementation of accepted home care solutions and might be helpful to develop age-sensitive information and communication concepts.

Keywords: Domestic robots · Technology acceptance · Demographic change · Older adults · User centered design · Smart home

1 Introduction

As a matter of fact: the profound demographic change and the growing aging population is a serious challenge for most industrialized nations in the world [1]. They all have to master the need to develop efficient, sustainable and humane solutions of medical care of the growing number of aged persons in times of overstrained health care systems and dwindling number of caregivers [2]. Demographic and financial constraints lead to a serious bottleneck, in which not enough caregivers for the growing number of patients remain. A critical shortage of public resources, doctors, nurses, and other healthcare personnel will

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arise within the next decades [3]. In situations, where persons cannot be treated in institutional settings alone anymore, individual and personalized care in the home environment plays a more and more important role [4, 5].

Along with this change an increased need exists for intelligent medical technologies covering diagnosis, treatment, and care, which enable seniors to live independently at home [6–9].

In the last decade, a huge number of innovative smart health care technologies have been developed that promise to deliver significant improvements in access to care, quality of care, and the efficiency of the health sector [3, 10, 11], thereby representing possible solutions to the soaring requirements of novel care concepts and bridging temporal and spatial gaps between patients and physicians.

The developments in the health care sector aimed at different implementation concepts, and the spectrum of emerging technical applications covers a broad variety of developments, reaching from internal technologies (implants for monitoring physiological signals) over devices integrated into clothes (wearable technologies) to healthcare robots or smart home technologies, which support older people in keeping up independent living [4, 12–14].

Even though the progress in these technical developments is significant and promising, still the social part of the developments is underexplored. Social and emotional aspects of humans' technology acceptance as well as the detailed study and the willingness of understanding individual usage motives and barriers have not been fully understood. Technology assistance—especially in the home-care and rehabilitation sector—can only fully deploy its huge potential for graying societies, if acceptance issues are considered and the willingness of older users to accept technical devices as care authorities in their homes. Usable systems and devices that meet users' expectations as well as respect their requirements to keep their individuality, dignity and their intimacy at home will be critical success factors [15–18] for a successful roll-out and a broad acceptance of such systems.

In this paper we concentrate on the social perception of domestic robots for the care of older persons at home. In the next section we describe the current state in the technical development of robot variants and also refer to recent acceptance studies which have been carried out to study human-robot interaction. On this base we develop the research question and the logic of empirical procedure undertaken in this study.

2 Robots for Healthcare

In the last years, many research projects and technical developments in research and industry have emerged to develop, implement and test health care robots in different settings, ranging from laboratory studies to field test or even in realistic settings such as senior homes [19, 20]. The majority of healthcare robots for older people are still in the development and validating test phases, even though some of them are already commercially available. Regarding the functionality, a huge range of functions and care situations has been addressed [21, 22].

In their overview article, Broadbent et al. [19] categorize health care robots into three large groups—all of them are designed to enhance the life quality of older people and to support their independent living at home. One type of robot is providing physical assistance,

the second type of robot monitors health states and provides medical safety. The third category of healthcare robot offers social contact, entertainment or companionship [19]. In addition, there are also telepresence systems [23], which support social connectedness and communication of older adults with their family members and care personnel.

The Care-o-bot, which was developed at the Fraunhofer Institute in Germany [24], for example, is a robotic assistant that supports persons in their daily living at home, offering drinks, laying the table, waters plants and switches on the TV or the radio and is able to even call for the rescue service in case of emergency. Similarly, Pearl, a mobile autonomous robot developed at Carnegie Mellon university [25], was developed to support seniors' mobility at home and to support them to take medication or to remind them of appointments at the doctors' office. Another development is the hobbit, a care robot, which has been designed especially for fall detection and emergency detection. The robot is able to picking up objects from the floor in order to prevent falls and to call the ambulance, if necessary [23]. Also, the hobbit allows multimodal interaction for users with differing impairment levels.

Beyond these more or less functional robots, there are also social robot prototypes, as Aibo (http://www.sony-aibo.com), the robotic dog, or Paro the little seal from Japan (http://www.parorobots.com) that have been designed as social companions able to be much more than only a functional helper. Both robots have in common that they deliver social values which might be especially helpful for persons with only limited access to family members and persons with dementia [26, 27]. Like the Paro, the Hug [28] has a soft and warm surface and is equipped with sensors that react to physical pressure. By this, nonverbal communication behavior (sending and receiving hugs) between older adults and family members is enabled.

With the ever-increasing functionality, ability, and reach of health care robots, the question of technology acceptance and social aspects of human robot interaction is focused. On the one hand, the influence of robot attributes, form and personality on acceptance is under study [29] as well as the influence of user characteristics, e.g. cognitive abilities, gender, experience with technology, age, culture on the willingness to interact with the robot at home [30–33]. While most of the studies concerned with acceptance of robot assistance concentrate on older adults, there is a scarcity of research papers reporting on the different attitudes and preferences of all the different persons involved in the care process, as e.g. staff and residents of senior homes as well as family members and relatives of residents which could have different perspectives on the usefulness of health-care robots [34, 35]. A recent study in this context [35] showed that the concerns and the perceived benefits strongly depend on the respective perspective. Interestingly, the residents were more positive towards robotic assistance than the family members and the staff. While the staff was mostly concerned about the job loss, residents and family members feared the loss of personal care. The benefit reported by all stakeholders was the gain in time that allows increasing the care and communication quality with the residents. The target functions of the robots was seen in the detection of falls and getting quick help as well as support in lifting and monitoring locations.

Even though technology development in the homecare robotic sector is fast developing and the potential of robotic assistance in the field of domestic care of older persons at home is widely acknowledged, the research and technology development is mostly technology

driven. The question if and if so, older persons would accept a robotic assistance at home—given that robotic assistance would be feasible and affordable—is still a research topic that needs deeper understanding [31, 35–37].

In addition, the general acceptance for or against a domestic robot is only one side of the coin. The willingness to allow a domestic robot to support us in sensitive and quite private care situations at home is another issue that needs to be examined in the older age group. This is an urgent research duty, as the integration of users in the technology development is indispensable for the success of the technology in the roll-out phase and therefore a mandatory requirement for sustainable solutions.

3 Research Questions and Purpose of the Study

Based on the acceptance-related research so far, the goal of this study was to explore all the acceptance-relevant criteria that people apply to the vision of using a domestic robot at home. In order to gain deeper insights, a three-step empirical procedure was applied.

In a first step, focus groups with users of all ages were run in which users discussed freely about potential benefits and drawbacks of having a robot at home. The argumentation patterns were recorded and used to develop the questionnaire instruments, which were used to quantify acceptance patterns in the next step. Focus groups allow a deeper understanding of mental models and hidden drivers for or against a novel technology as it might be the case in home car robots for which only very single persons might have experience with.

Second, a quantitative survey study was run, in which users of all ages evaluated the benefits and barriers of using a domestic robot. Also, they evaluated conditional usage criteria and prerequisites that should be given to reach positive acceptance or at least tolerance. Outcomes allow to quantify the relative benefits and barriers to estimate the overall willingness to adopt homecare robots.

While in the second study quite general benefits and barriers of domestic robots were explored, the third study addressed specific actions and daily assistive functions a robot could do to be an accepted helper at home. Here, the focus was laid on sensitive care situations which might be accomplished by a domestic care robot. In order to compare the relative acceptance, participants evaluated both, the acceptance of a home care robot doing these tasks and a human care person.

For the analysis, we took an aging perspective, thereby determining if users of different ages and technology education might have a different perspective on the acceptance of a domestic robot.

4 Study 1: The Focus Group Approach

4.1 Participants

Three focus groups were run, in which younger and older adults volunteered to take part. Overall, 27 persons in an age range between 22 and 65 years took part. 60% were females. Participants were recruited from the social network of the authors. All of them were open to novel technologies, from different backgrounds and educations, but did not have

experience with using a robot by themselves. Participants were not gratified for their efforts.

4.2 Procedure and Instruction

In the beginning of each focus group, the topic was introduced to participants by giving them a scenario in which the role and the functions of the domestic robot was characterized in a functional and neutral way. The household robot was introduced as an assistive device that can support persons in their independent living at home, in the following areas: (1) Tasks of housekeeping (Fetching and passing household items, laying the table, using the microwave, cleaning, controlling heating, light, front door, shutters) (2) Personal assistant (safe mobility in the house, communication and exchange with the environment but also as a support to get help in emergency situations, reminder of appointments and intake of medication). Participants were instructed to freely comment on these functions and to envisage to have such a robot at home. The focus groups lasted around 1.5 h and were carried out on university campus. Data were collected by note-taking by assistants who were not involved in the discussion.

4.3 Results

Overall, the discussion was vivid, revealing both, positive as well as negative aspects. As the perception of assistive domestic robots was not age-sensitive, revealing similar benefits and barriers across ages, results are reported alongside three categories which have been formed out of the argumentations.

Accepted usage contexts: A first category dealt with visions of using contexts in which such a robot would be welcome. In the first place, the robot was perceived as a relief in everyday life for handicapped or disabled persons which need assistance (stairs, moving around) with the goal to be more flexible in old age. In addition, the robot was perceived as a possibility to get things efficiently done, whenever care costs are too expensive or people are lazy or oblivious, but also for time savings for busy people. But the robot was also seen helpful as a social companion, if no relatives are living nearby, for entertainment reasons or just for having fun. The use of a robot was also seen positive in a situation in which an older person lives with the relatives, and the robot is then helping to have both the independency of being cared for but still the presence of family members for personal contact.

Fears and barriers: When it comes to the barriers, the discussion centered around three main topics:

One referred to the vision that the robot is not controllable anymore and decides for humans even if they do not want this. Here, it was obvious that the fears were nurtured by irrational scenes and movies in which robots took over the control and "got crazy". In this context, it was also discussed that participants have concerns of data protection and privacy loss and that third parties could have access to their physiological data or emotional states ("Occurrence of wrong functions through potential manipulations which I do not understand as old person").

The second type of barriers referred to usability issues. In this context, participants (especially the middle-aged and older ones) were concerned about the ease of handling the robot, the unpredictability of technical errors and system failures ("short circuit", "system crash", "attrition of parts", "unreliability") but assumed that the robot would be also complicated to program and use ("too many functions at once", "missing maintenance service"). They also assumed that the robot would be too slow to react and that the robot would be too bulky and difficult to maneuver in the apartment.

The third type of barriers regarded the dependency on the robot and the feeling to be at the mercy of the robot. In this context, participants not only mentioned the unlikable personality (the interaction was assumed to be "impersonal", "cold", "sterile", "imbalanced"), but also suspected that the presence of the robot would prevent family members to stay in contact, thus the robot was made responsible for social isolation and for a "life without life quality". Singularly, also health concerns were raised in terms of probable electric shocks that could occur when persons have wet hands and when robots mingle with water.

4.4 Discussion

Overall, discussions regarding the acceptance of a domestic robot were fruitful and participants—independently of their age and gender—were very engaged, seeing both, benefits and drawbacks. Positive perceptions were prevailing about the usefulness of such a robot in case of being old and needing help, but also for daily assistance whenever people are lazy, busy or oblivious.

When focusing on the barriers, concerns raised seemed to be triggered by movies in which robots are taking over the control over the world and human beings having nothing to do against it. Here three types of (mis-)information might be responsible for the types of concerns raised: The vision of a robot made from steel, that must be cold, technical, impersonal and bulky and could provoke electricity issues (shock, smog).

The vision of robot care which makes people lonely either because relatives would then not care for the older persons any more (as the robot is doing this), or the general vision that technical assistance is the opposite to human assistance. Finally, the vision of being helpless in terms of complexity of functions, problems with using and handling the interfaces and technical errors. Apparently, the everyday experience with technical failure in devices might have triggered the usability issues raised by participants.

5 Study 2: Determining Benefits and Barriers Towards a Domestic Robot

5.1 Participants

Overall, 260 participants, in an age range of 20–88 years completed the online survey. The sample was split into three age groups. In age group 1 (younger), there were 92 participants, 51% women, from 20–30 years of age ($M = 24.7$, $SD = 3$). Age group 2 (middle-aged) consisted of 101 persons in an age range of 40–65 years of age ($M = 51.5$, $SD = 6.2$),

with 45% men and 54% women. Finally, in age group 3 (older group), there were 69 persons, 57% women (41% men), in an age range from 66–88 years ($M = 75.8$, $SD = 6$). Participants were asked via email to take part in the study. Completing the questionnaire took about 30 min. Younger persons were mostly students from different fields of study, the middle-aged and older age group came from different professional fields (e.g., engineers, administrative officers, secretaries, teachers, nurses, architects and craftsmen). All of them reported to use ICT for private and business purposes regularly and were quite technology affine. Neither of them had experience with using a robot.

5.2 Questions in the Survey

The survey contained the following sections: The first part of the questionnaire dealt with demographical data like gender, age and educational level.

In a second part, the general usefulness of a domestic robot was asked for. Participants had to answer the following questions (see Table 1):

Table 1. Items to the questions: "Do you think … Items had to be answered on a 4-point Likert scale (1 = no, 2 = probably not, 3 = probably, yes 4 = yes).

Do you think…
that the use of the devices could increase your life-quality?
to use a home robot to live longer independently at home?
that the home robot is generally useful?
that the use of the devices will make your life easier?

Table 2. Items to the questions: "I would accept the usage of a domestic robot, if…. Items had to be answered on a 4-point Likert scale (1 = no, 2 = probably not, 3 = probably, yes 4 = yes).

I would accept the usage of a domestic robot if…
I can retain my independence
I can spare my relatives from intensively caring for me
I can live with dignity in independency for a longer time
I can avoid familial disputes concerning my care
I do not have to be a burden to anyone
I do not become dependent on other people
I do not have to bear the ignobility of strange care persons
I can save care costs

In a third part, the reasons for using the robots were explored (see Table 2). Participants had to affirm/deny the following items on a 4 point Likert scale.

Finally, we assessed the concerns participants have when using a domestic robot. Again, participants answered the items by confirming or denying the respective items (see Tables 3 and 4) on a 4-point Likert scale.

Table 3. Items to the questions: "I am worried that… Items had to be answered on a 4-point Likert scale (1 = no, 2 = probably not, 3 = probably, yes 4 = yes).

I am worried that…
the device sends too many error messages and that no one takes me seriously anymore
the purchase or maintenance of the device costs too high
the device has a technical defect and fails
I am not my own master anymore
my family would have too much control over me
I might look older or sicker than I am actually, when I use the device
my doctor has too much control over me

5.3 Results

Data was statistically analyzed by ANOVAs. The level of significance was set at 5% level. Due to the higher inhomogeneity of the older sample significance levels of $\alpha = 0.1$ are reported as marginally significant.

Results are presented according to the structure of the questionnaire, i.e., first we report the ratings with respect to the usefulness of the domestic robot, then acceptance criteria and barriers. For each of the sections, descriptive data with the focus on the age groups are reported as well as the inference statistical testing of differences.

5.3.1 Usefulness of Domestic Robots

Participants had to firstly answer how they generally evaluate the usefulness of a domestic robot. In this context, they were given four questions which they had to answer on a 4-point scale (1 = do not agree at all, 4 = do fully agree). Statistical testing showed a significant age effect ($F(2, 253) = 2.6, p < .05$). In Fig. 1, descriptive outcomes with respect to the three age groups can be seen.

When asked if home robots increase life quality, the younger group showed the highest confirmation ($M = 2.9, SD = 0.8$), followed by the middle-aged group ($M = 2.6, SD = 0.9$) and finally the oldest group, who showed the lowest confirmation in this regard ($M = 2.4$,

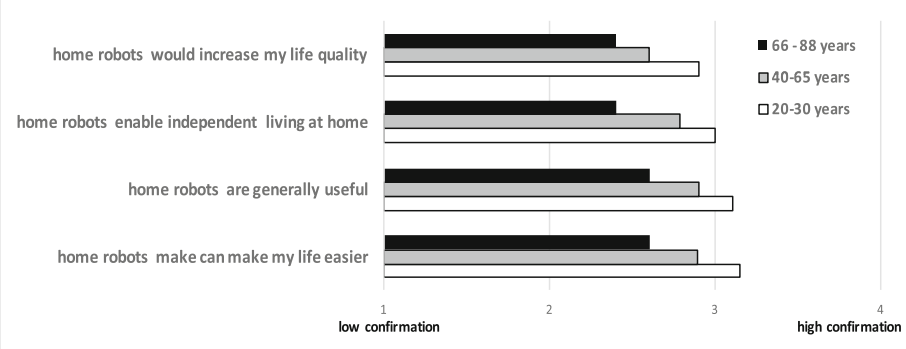

Fig. 1. Rated usefulness of domestic robots (means) in the three age groups

SD = 0.9). A very similar pattern was found for the question if domestic robots would enable independent living at home.

While the younger group shows the strongest affirmation (*M = 3, SD = 0.8*) to this statement, the middle aged (*M = 2.8, SD = 0.9*) and the older participants *(M = 2.4, SD = 0.9)* are more reluctant.

Asked if home robots would be generally useful, again affirmation to that vision is strongly age-sensitive. The younger group (*M = 3.14, SD = 0.8*) is convinced that this is the case, while the middle-age (*M = 2.9, SD = 0.8*) and the older group (*M = 2.6, SD = 1*) are not so positive.

Finally, the vision that domestic robots would make things easier was evaluated with the very same answering pattern, with the youngest showing the highest confirmation (*M = 3.2, SD = 0.7*), followed by the middle-aged persons (*M = 2.9, SD = 0.9*) and the oldest group (*M = 2.6, SD = 0.9*).

5.3.2 Acceptance Criteria for Using Domestic Robots

In a second part, participants were asked to answer eight different reasons that could be in favor of accepting a domestic robot at home. Answers again had to be given on a 4-point scale (high numbers indicate high confirmation). Again, age had a significant effect on the acceptance (*F(2, 253) = 2.3, p < .05*).

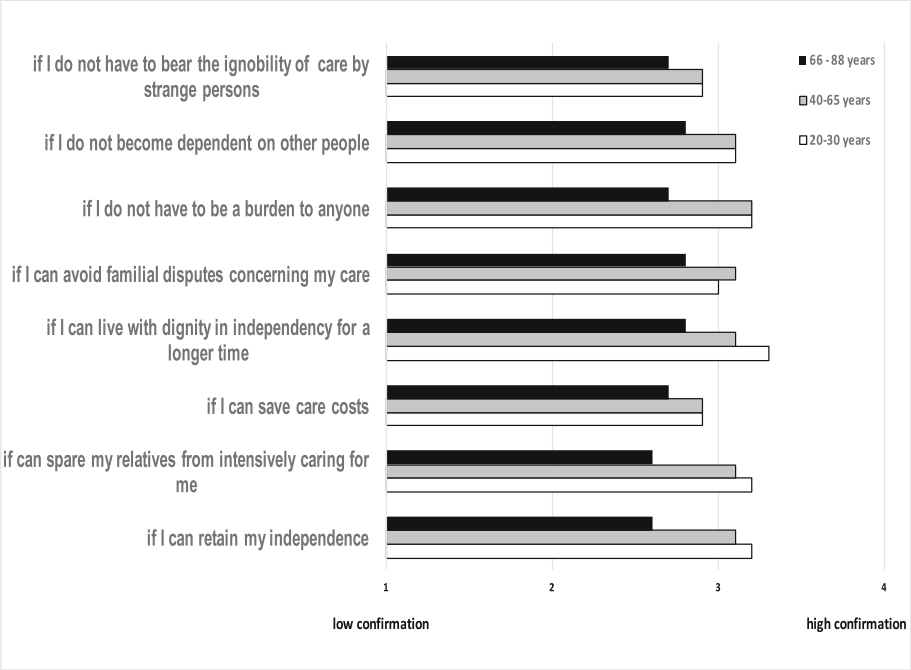

Fig. 2. Ratings of acceptance criteria (means) in the three age groups

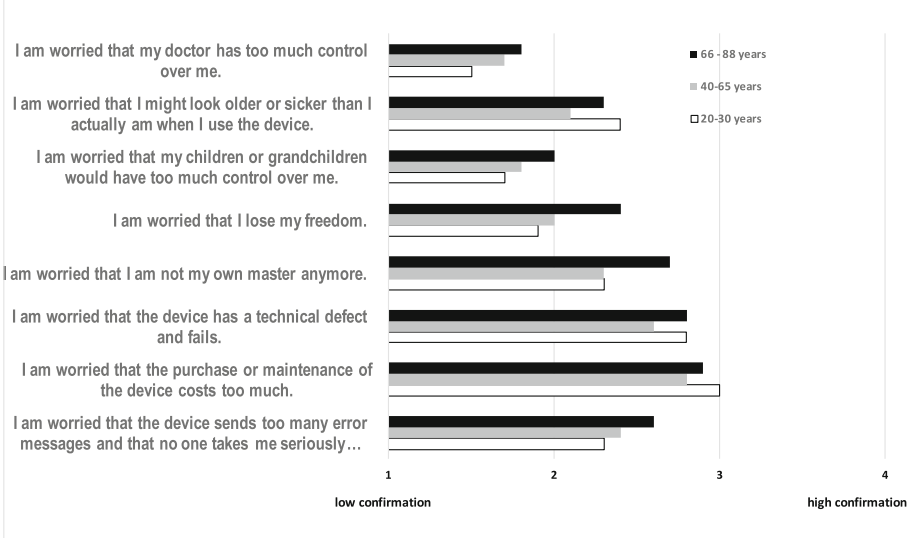

Fig. 3. Rated worries when using domestic robots (means) in the three age groups

Descriptive outcomes can be taken from Fig. 2. Overall, the younger participants are much more willing to accept domestic robots, but also the middle-aged adults which showed a similar willingness to adopt domestic robots in comparison to the younger group. Again, only the senior group showed a more reserved attitude towards the acceptance criteria.

5.3.3 Worries Towards Using Domestic Robots

In the third part of the survey, participants indicated the extent of concerns or worries they have in the context of using a domestic robot. Their answers were given on a 4-point Likert scale (high numbers indicate high confirmation).

In Fig. 3, descriptive outcomes are depicted. Again, there was a significant age effect, showing that the extent and type of worries is indeed age-specific ($F(2, 253) = 2.6$, $p < .05$). Still however, age patterns in the context of worries are less "linear" (in the sense: the younger participants are the higher the approval of the domestic robot as care authority).

Apparently, there are worries that apply also for the younger group. For example, the worry that persons would look older and sicker than they are (when using the robot), was most strongly confirmed by the younger group. The same applied for the worries that purchase and maintenance costs for the domestic robots would be high, which was also most strongly confirmed by the younger age group in comparison to the middle-aged and the aged persons.

But there were also worries which were most pronounced in the senior group. As such, the worry that older adults lose their freedom or the worry that they would not be able to master their own life was confirmed most strongly by seniors.

5.4 Discussion

The survey yielded both, age-insensitive and age-sensitive findings in the context of using a domestic robot at home. Independently of age, participants attested a considerable usefulness of having a domestic robot and saw a lot of reasons in favor of using them. As such, independency and the possibility to live longer in the own four walls were strong arguments, as well as not being a burden for relatives which might have the duty to care for them.

Beyond this age-insensitive positive view, the relative extent of confirmation to the respective reasons was indeed age-sensitive, as the younger and middle-aged persons were more positive than the seniors which showed more reluctance in this context. When it comes to worries, a more complex picture emerged. Especially the older group reported to have stronger concerns in the vision of losing their freedom or the ability to master their lives when relying on the support of domestic robots. Also, usability issues seem to be a strong concern of the senior group as well as the fact that assistive devices could be stigmatizing in the sense that persons look older and sicker than they factually are. Particularly, this was also a serious concern that has been raised by the younger group. Obviously, the fact that assistive devices—domestic robots—are in use is perceived as a negative stigma, rather than as a valuable assistance for specific situations.

6 Study 3: Exploring the Acceptance of Specific Functions in Robotic Assistance

In the third study, we focused on more specific functions in the context of personal care and compared the willingness of participants to accept a domestic robot in comparison to a human care person.

6.1 Sample

Overall, 304 participants, took part in the study. Due to an ad-hoc sampling method, the age distribution was quite asymmetrical with a considerably higher number of younger than middle-aged and older persons. Overall, participants were between 21 and 99 years of age, with 60% women and 40% men. Three age groups were formed: In age group 1 (younger), there were 198 participants, 51% women, from 20–30 years of age ($M = 24.3$, $SD = 2.1$). In age group 2 (middle-aged) they were consisted of 72 persons in an age range of 31–53 years of age ($M = 44.7$, $SD = 8.3$), Age group 3 (older group) consisted of 34 persons, in an age range from 57–99 years ($M = 62.3$, $SD = 9.3$).

Respondents were asked by email to take part in the study. Completing the survey took about 20 min. Again, the younger persons were mostly students from different fields of study, while he middle-aged and older age group had different educational backgrounds and professional fields. All of them reported to use ICT for private and business purposes regularly. None of them had experience with using a robot.

6.2 Questions and Design of the Study

Within the questionnaire design, there were two independent variables.

(1) One independent variable referred to the age group (comparing three different age groups)
(2) the other independent variable was the care authority, comparing a robotic care assistant vs. a human care person.

Participants had to evaluate the willingness to accept a robot as well as a human care person for the following care situations (Table 4).

Table 4. Care situations to be executed by either a human care or a robotic care assistant Items had to be answered on a 6 point Likert scale (1 = no, 6 = yes).

	Human care	Robotic care
Putting s.o. to bed		
Spoon feeding s.o.		
Giving medication		
Applying cream to the body		
Helping s.o. to wash hair		
Helping s.o. into the bath tube		
Giving s.o. a wash		
Helping s.o. to visit the toilet		
Helping s.o. to cream the face		
Helping s.o. to comb hairs		

Acceptance had to be answered on a 6-point Likert Scale (1 = not at all and 6 = in any case, yes). A dependent measurement design was applied thus participants evaluated both care authorities with respect to the willingness to accept them in the respective care situations.

6.3 Results

Data was statistically analyzed using MANOVAs with repeated measurements. The level of significance was set at 5%. Due to the higher inhomogeneity of the older sample significance levels of $\alpha = 0.1$ are reported as marginally significant. Descriptive data with the focus on the age groups are reported as well as the inference statistical testing of differences.

In a first step, we provide an overall analysis, summing up the answers across all care functions for the robot assistance and the human care person, respectively. Outcomes can be seen in Fig. 4.

The analysis revealed a significant main effect of the care authority ($F(1, 276) = 14.5$, $p < 0.001$) while there was no significant age effect. Thus, independently of age the human care person was preferred over the robotic assistant.

When looking at the single care functions (Table 5) differences showed up. We found both, situations in which humans are clearly preferred (e.g., giving s.o. medication, spoon-feeding s.o.) as well as care situations in which the robotic care assistant seems to be the "better" care authority (e.g., putting s.o. to bed; helping s.o. to visit the toilet).

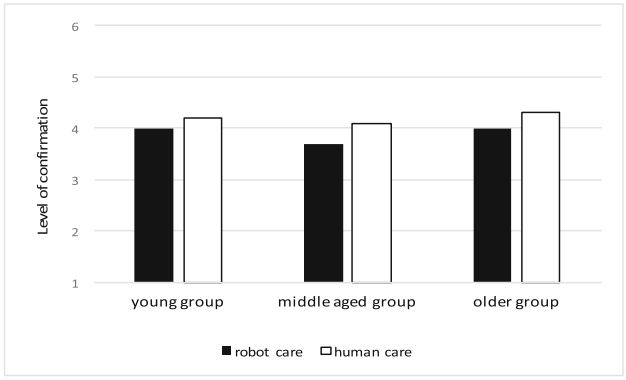

Fig. 4. The willingness (means) to be cared by a robot (black bars) and a human care persons. Answers have been summed up across the different care situations

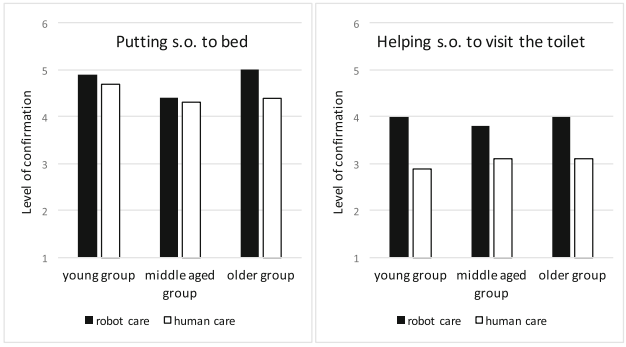

Fig. 5. Care situations (putting s.o. to bed, left side and helping s.o. to visit the toilet, right side) in which confirmation levels (means) are higher in the robotic assistance (black bars) in comparison to a human care person (white bars).

In Fig. 5, those care situations are depicted, in which participants indicated to prefer the human care. Statistical testing revealed a significant effect of care authority in the case of putting s.o. to bed ($F(1, 270) = 3, p < .1$) as well as in the case in which persons are supported to visit the toilet ($F(1, 270) = 30, p < .001$).

Figure 6 depicts, in contrast, the situation in which the human care person is clearly favored over the robot. For giving medication ($F(1, 270) = 24.9, p < .001$), statistical analysis revealed a significant effect of the care authority as well as when spoon-feeding s.o. ($F(1, 270) = 10.7, p < .001$).

In Table 5, descriptive outcomes for all care situations are given, thereby differentiating age groups and both care authorities.

Table 5. Means and standard deviations in the single care situations

Care functions	Care authority			Significance
	Age-groups	Human care	Robot care	
Putting s.o. to bed	Young (20–30)	4.7 (1.2)	4.9 (1.3)	*authority:* $p < 0.1$; *age:* $p < .05$
	Middle (31–50)	4.4 (1.1)	4.3 (1.3)	
	old (51, +)	4.4 (1.1)	5.0 (1.3)	
Spoon-feeding s.o.	Young (20–30)	4.3 (1.3)	3.9 (1.5)	*authority:* $p < 0.01$; *age:* n.s.
	Middle (31–50)	4.2 (1.1)	3.8 (1.3)	
	old (51, +)	4.3 (1.2)	3.6 (1.2)	
Giving medication	Young (20-30)	4.9 (1.1)	4.2 (1.6)	*authority:* $p < 0.01$; *age:* n.s.
	Middle (31-50)	4.6 (1.0)	3.9 (1.0)	
	old (51, +)	4.9 (0.6)	4.1 (1.3)	
Applying cream to the body	Young (20–30)	3.7 (1.4)	3.5 (1.5)	*authority:* $p < 0.01$; *age:* n.s.
	Middle (31–50)	3.8 (1.3)	3.2 (1.3)	
	old (51, +)	4.1 (1.3)	3.6 (1.5)	
Helping s.o. to wash hair	Young (20–30)	4.7 (1.1)	4.2 (1.5)	*authority:* $p < 0.01$; *age:* $p < .05$
	Middle (31–50)	4.4 (1.3)	3.8 (1.4)	
	old (51, +)	4.8 (0.8)	4.3 (1.3)	
Helping s.o. into the bath tube	Young (20–30)	3.9 (1.5)	4.5 (1.6)	*authority:* $p < 0.01$; *age:* n.s.
	Middle (31–50)	4.3 (1.3)	4.3 (1.3)	
	old (51, +)	4.7 (1.3)	4.7 (1.4)	
Giving a wash	Young (20–30)	3.5 (1.4)	3.5 (1.6)	*authority:* n.s. *age:* n.s.
	Middle (31–50)	3.6 (1.3)	3.8 (1.5)	
	old (51, +)	3.7 (1.4)	3.9 (1.6)	
Helping s.o. to visit the toilet	Young (20–30)	2.9 (1.4)	4.0 (1.7)	*authority:* $p < 0.001$; *age:* n.s.
	Middle (31–50)	3.1 (1.3)	3.7 (1.4)	
	old (51, +)	3.1 (1.4)	4.0 (1.7)	
Helping s.o. to cream the face	Young (20–30)	4.2 (1.3)	3.4 (1.5)	*authority:* $p < 0.001$; *age:* $p < 0.0\,1$
	Middle (31–50)	4.1 (1.3)	3.2 (1.4)	
	old (51, +)	4.3 (1.2)	3.4 (1.4)	
Helping s.o. to comb hairs	Young (20–30)	4.8 (1.2)	3.8 (1.6)	*authority:* $p < 0.001$; *age:* $p < 0.05$
	Middle (31–50)	4.5 (1.1)	3.2 (1.1)	
	old (51, +)	4.6 (1.1)	3.9 (1.6)	

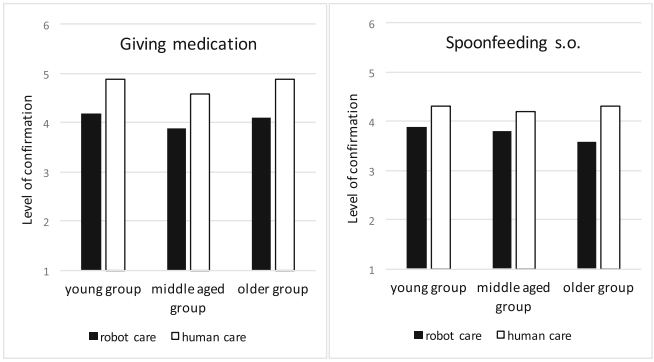

Fig. 6. Care situations (giving medication left side and spoon-feeding s.o., right side) in which confirmation levels (means) are higher in human care assistance (white bars) in comparison to robotic assistance (black bars).

6.4 Discussion

The study provided interesting insights into specific care situations and the tolerance of participants towards robotic care. Across all care situations under study there was a significant preference of human care over robotic assistance. A closer look in specific care situations however, revealed that the preference of human care over robotic assistance seems to be specific. There are care situations, as for example, the medication support or the spoon-feeding that should be in the responsibility of a human care person. In contrast, there are also care situations which are preferred to be accomplished by a robotic nurse, as e.g. putting s.o. to bed or helping s.o. to visit the toilet.

Interestingly though, no significant age effect was found showing that preferences in this context are quite age-insensitive. This is special as the acceptance of a robotic assistant was higher in younger age groups whenever general acceptance was in the focus of the study. However, whenever it comes to concrete and quite sensitive care situations, the preferences are quite stable across age groups. Surprisingly and seemingly contradicting previous findings, age is neither related to a clear preference of one over the other care authority, nor does age influence the overall extent of acceptance. Here, it should be critically kept in mind that the sample was asymmetrically young (with a larger number of younger adults) in comparison to the middle-aged and aged group. We speculate that this finding could be a result out of the asymmetrical age distribution and that age (in combination with a higher need of medical care) will influence the perception of a robotic care authority if this present sample is mirrored with significantly older participants.

7 Conclusions

In this research, we have looked at human-robot interaction in the context of caring for elderly people at home. We have seen that research in this context is mostly focused on designing the interaction of robots from a technical point of view. In contrast the willingness to accept a robot as a home care device is not easily understood. We conducted focus groups and two survey studies to understand the intricacies of robot acceptance in potential users and future users.

It is interesting to note that both qualitative and quantitative data show that the users' worries with the use of robots stems from the technological side of the equation. Risks such as technical defects and high maintenance costs are pervasive across age groups. Familiar risks—such losing control over ones' autonomy—become more palpable with age, while abstract risks—such as the fear of seeming to be more ill than one actually is—are also strongly shared by younger people. Surprisingly, loss of autonomy, when phrased as a benefit of robot use (i.e., maintaining independence), is perceived more beneficial by younger people. These seeming contradictions might be caused by differences in age-related risk perception and risk-taking personality aspects. Overall, the acceptance of a domestic robot seems to be rather high, given that no experience with such devices has been made by any of the participants.

When we look at the individual care acts that should be conducted and into the comparative analysis, we see that the subtext of the act has a strong influence on

preferences. Acts that are traditional acts of human interaction (e.g., feeding someone, or giving someone medicine) are still preferred from a human care authority. Explanations for this might come from affects related to medical mistreatment (the care person knows what he is doing and can adapt). The possible risks associated with giving medication are high while going to the bathroom or being put to bed is seemingly risk free. One can argue that participants do like human care, when it is associated with the affective nature of the caring process (feeding, hair brushing, applying skin-cream), but still prefer the non-personal care of a robot in situations of bodily exposure (taking a bath, going to the bathroom). The shame-affect caused by exposing the nude body in a possibly degrading situation to a human care person could also be a relevant explanation for this result.

Overall it is necessary to further investigate how these judgments come to be. The reasoning behind these preferences has not been surveyed and would probably need further qualitative and quantitative data for a deeper understanding. It is also crucial to incorporate the participants' health status and their own experience in caring contexts. Experience with real-life care might modulate perception of human care as well as robot care. The aim of our study was to explore untainted perceptions of human-robot interaction regarding home caring. As soon such technology becomes financially viable and readily available, perceptions are bound to change. By integrating users' perceptions into the development process, early adopters of care robots—be it out of curiosity, wealth or necessity—might benefit from technology better suited to their needs. In the long term, we will have to ask ourselves: Humans or robots? Who cares?

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