Service Robots: Emotions of Older Adults in Different Situations

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Abstract: Against the background of demographic change and an expected shortage of skilled nursing staff, consideration is being given to whether robots will play a greater role to assist older adults in daily life activities and care personnel. Many models of Technology Acceptance do not focus on emotions of older adults triggered by service-type robots that support daily activities or care activities. The present simulated robot study investigated emotions of 142 older adults towards different robots in different situations to contribute to a deeper understanding of the acceptance of robots. The situation in which a robot interacts with a human affected the emotions of the older participants differently: in the service situation, less negative emotions were expressed than in the care situation. These results should be considered when developing service robots for older adults. The results should be validated with existing robots in real life.

1 INTRODUCTION

The rising amount of technical innovations being developed to support older adults at home and nursing staff in care institutions can be attributed to several trends in industrial societies. Amongst these are demographic changes (Vaupel, 2000), an expected shortage of skilled nursing staff (World Health Organization, 2015), and the fact older adults wish to live independently at home for as long as possible (Marek and Rantz, 2000), with positive effects on their quality of life (Sixsmith and Gutmann, 2013). Against this background it is assumed that robots will play an increasingly important role in the area of service and care for older adults, maintaining their independence and well-being (Ray, Mondada and Siegwart, 2008; Wu et al., 2014). A robot is a programmable machine that can take over tasks (semi-)autonomously (Savela, Turja and Oksanen, 2018).

In their review, Agnihotri and Gaur (2016) report promising applications of assistive robots for social and daily healthcare of older adults. If robots which support tasks usually performed by humans are to be used, the consideration of user acceptance is essential as in Europe, low acceptance rates for robots by older adults are assumed (Payr, Werner and Werner, 2015).

Many models of Technology Acceptance are characterized by behavioral or technology-oriented approaches. They focus on cognitive (especially evaluative) and social factors such as attitudes and previous experiences (e.g. Theory of Reasoned Action (TRA); Fishbein and Ajzen, 1975), the perceived/experienced usefulness or simplicity of use (e.g. Technology Acceptance Model (TAM); Davis, Bagozzi and Warshaw, 1989) and other social factors (e.g. Unified Theory of Acceptance and Use of Technology Model (UTAUT), Venkatesh, Morris, Davis and Davis, 2003).

In the overall construct of Technology Acceptance, emotions triggered by robots that support daily activities are considered marginally, globally (e.g. as "fear" dimension in Wu et al., 2014) and unspecifically (e.g. as "emotional involvement" and "potential threat" in Mollenkopf and Kaspar, 2004).

It is questionable whether utilitarian factors can sufficiently explain robot acceptance of older adults. Goher, Mansouri and Fadlallah (2017) claim that the two primary factors that influence adoption of technology by older adults are ease of use and usefulness. In contrast, in a laboratory-based user interaction study De Graaf and Allouch (2013) found that only “enjoyment”, and not utility, explained the actual use of a robot. This shows that it is important

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to pay attention to emotions of older adults interacting with robots, as these emotions and attitudes influence their reactions (Broadbent, Stafford and MacDonald, 2009a). While emotions and their integration into robotic systems are receiving a great deal of attention, the investigation of people's emotional reactions towards robots are largely neglected (Rosenthal-von der Pütten, Krämer, Hoffmann, Sobieraj and Eimler, 2013. Emotions of users are often studied in terms of empathy *with* a robot (Rosenthal-von der Pütten et al., 2014) rather than emotional reactions *towards* robots.

In the field of robotics, negative emotions towards *communication robots*, which can lead to an avoidance of communication, were investigated (Nomura, Kanda, Suzuki and Kato, 2004; 2008). Reactions and emotions of older adults towards *companion robots,* animal-like robots such as the seal PARO (e.g. Abbott et al., 2019; Hung et al., 2019; McGlynn, Kemple, Mitzner, King and Rogers, 2017), that are made to evoke explicitly positive emotions and are used as aids in therapy, are well studied. Emotions of older adults towards *service-type robots,* which should support tasks of daily life, have hardly been considered so far.

When considering the acceptance of robots, important factors that promote and inhibit acceptance, such as appearance and form, are discussed (Broadbent et al., 2009a; Flandorfer, 2012). In industrial contexts humanoid robots are built, with the idea that positive human-robot interaction is increased by human resemblance (e.g. Kiesler and Hinds, 2004). Also, in social settings, anthropomorphic robots seem more accepted, on the one hand because human-like shape and behaviour have advantages when a close interaction between a robot and a human is necessary, and on the other hand because people suppose that the more a robot resembles a human, the better it performs human-like tasks (Hwang, Park and Hwang, 2013). However, too much human similarity can be counterproductive, a phenomenon known as the "Uncanny Valley" effect or "acceptance gap" (Mori, 1970). This is the seemingly paradoxical effect that the acceptance of artificial figures does not increase linearly with anthropomorphism but suffers a severe slump within the increase in human similarity: the more human-like the figure is, the more people accept the artificial figure presented – however, acceptance falls above a certain degree of anthropomorphism. Today, mixed findings concerning both the existence of the uncanny valley and its explanations are discussed in literature (Ho and MacDorman, 2017; Kätsyri, Förger, Mäkäräinen and Takala, 2015; MacDorman and Chattopadhyay, 2016; Miklósi, Korondi, Matellán and Gácsi, 2017; Strait et al., 2017).

Studies show that in addition to the appearance of the robot, the situation in which an interaction takes place has a decisive influence on acceptance (Decker, 2010; Eftring and Frennert, 2016; Gaul et al., 2010; Misoch, Pauli and Ruf, 2016). Situations in which service robots perform tasks that are usually performed by humans are likely to evoke emotions, especially when the service robot comes into direct contact with humans in an intimate task. In assistive situations, the use of robots can lead to unclear expectations (Compagna and Marquardt, 2015) and unrealistic ideas (Baisch et al., 2018). Equally, embedding robots in new everyday situations can be emotionally challenging.

Research on human-robot interaction (HRI), human-robot proxemics (HRP), and human-robot spatial interaction (HRSI) shows that personal space is a major issue in human-robot interaction (for summary see Lauckner, Kobiela and Manzey, 2014). Most research has shown that robots should stay outside of a person's intimate zone and within their personal or social zone (Kessler, Schroeter and Gross, 2011, Walters et al., 2009a). The spatial area in which a robot moves during interaction is determined by the situation and its tasks. If a robot supports tasks in everyday life, it is usually further away from the person than if it supports care activities. A robot interacting in a care situation in the intimate zone could evoke more negative feelings and therefore it is assumed that interaction with a robot in a service situation triggers less negative feelings.

Nursing activities usually include touching the patient and, in their survey, Parviainen, Turja and Van Aerschot (2018) found that care workers were reserved towards the idea of using autonomous robots in tasks that typically involve human touch. This shows that different situations might cause different levels of positive or negative emotions, depending on the appearance of the robot and the situation it is used in.

So far, research on Technology Acceptance has hardly considered the emotions of older adults towards a service type robot depending on a specific situation.

1.1 Aim

The aim of the present study was to investigate the emotions of older adults towards different robots in different situations to contribute to a better understanding of the acceptance of robots.

2 METHODS

The present study is a simulated robot study, conducted as a vignette study. A hypothetical situation is constructed based on vignettes, and the participants put themselves into the situation displayed (Atzmüller and Steiner, 2010).

The study refers exclusively to *service-type robots* whose main function is to support daily activities, according to the categorization of assistive robots for older adults by Broekens, Heerink and Rosendal (2009, p. 95). *Companion robots* (e.g. pet-like robots), whose main function is to enhance health and psychological well-being, or other robot types, were not considered in this study.

2.1 Material

2.1.1 Videos

Two videos with different situations showing human-robot interactions were selected and tested beforehand in a feasibility test (September 2017). The service situation shows an older woman in a retirement home sitting at a table with other older women. The robot *Care-O-bot 3* moves towards the woman with a cup of water and then invites her to drink, which she does.

The care situation shows a middle-aged bedridden woman, her arms and legs being washed by the robot *Cody* without other people visible. The videos were cut to a minute in length, to accurately illustrate the relevant interaction and were shown without sound in order avoid distractions through verbal descriptions.

2.1.2 Pictures

For the visual stimuli, pictures of robots with varying degrees of human appearance were selected based on the most used classification of different authors: machine-like, mechanical-human-like, human-like, and android (DiSalvo, Gemperle, Forlizzi and Kiesler, 2002; MacDorman and Ishiguro, 2006; Walters, Koay, Syrdal, Dautenhahn and Te Boekhorst, 2009b). The aim was to have images of high quality of the robots, and images that depicted meaningful representations in the context of nursing care for older adults. The following images were selected: for machine-like appearance: Lio (F&P PersonalRobotics, 2019); for mechanical-human-like appearance: Kompai (TelepresenceRobots, 2019); for human-like appearance: Romeo (Automation and Control Institute, 2019) and for android appearance Otonaroid (Miraikan, 2019). The pictures of the robots were shown without product names.

2.1.3 Questionnaire

To develop the questionnaire, various existing emotional scales were compiled based on a literature search. Items from eight scales and the basic emotions of 14 authors were considered: the German version of positive and negative affect schedule (Breyer and Bluemeke, 2016), the State-Trait-Anxiety Inventory (according to Spielberger in the long version of Grimm, 2009), the SEK-ES – questionnaire for emotion-specific self-assessment of emotional competencies (Ebert, Christ and Berking, 2013), the Jennifer Monathan «liking» questionnaire (Monathan, 1998), the Emotional reactions to domestic robots (Scopelliti, Giuliani and Fornara, 2005), the Property list at the subscale level (Janke and Debus, 1978), the Feeling scale - Revised version (Bf-SR) (Von Zerssen, 2011), the Multidimensional state questionnaire (MDBF) (Steyer, Schwenkmezger, Notz and Eid, 1997), and the Basic Emotions (Arnold, 1960; Ekman, Friesen and Ellsworth, 1982; Frijda, 1986; Gray, 1982; Izard, 1971; James, 1884; McDougall, 1926; Mowrer, 1960; Oatley and Johnson-Laird, 1987; Panksepp, 1982; Plutchik, 1980; Tomkins, 1984; Watson, 1930; Weiner and Graham, 1984 (overview in Ortony and Turner, 1990)). Single emotions mentioned by older adults and the research team during a feasibility test and workshop were added. This resulted in 79 positive, 12 neutral and 116 negative emotion items.

Items were then selected separately by two researchers based on the following criteria: (1) deletion of the category "neutral" because it was too unspecific; (2) ensuring comparability with other studies; (3) avoidance of doubled / too similar items; (4) the same number of positive and negative items; (5) focus on "real" emotions and not “attitudes” or “evaluations”; (6) state emotions instead of trait emotions; (7) comprehensibility; (8) frequently occurring items. The results were discussed and a list of 34 positive and 45 negative items was compiled. Subsequently, further individual items were sorted out based on content considerations. Four positive items were sorted out because their content did not fit (e.g. "in love"). 15 negative items were sorted out because their content did not fit, because they were already well covered by other items or because they were judged too vague. The resulting 30 positive and 30 negative emotion items were converted into adjectives, even if the basic emotion was a noun. The resulting 30 positive and 30 negative emotion items were displayed in random order with the answer selection "rather yes" or "rather no” on two pages of the questionnaire. The dichotomous answer format was chosen because frequencies were to be determined and so that participants can rapidly and easily treat the emotion lists.

Further items which were described in the literature in the context of robots were integrated into the questionnaire: acceptance, technology experience, prior experience with technology and robots, attitudes, and willingness to interact. The following scales were considered: Robot familiarity and use questionnaire (Mitzner et al., 2011), Robot Attitude Scale (RAS) (Broadbent, Tamagawa, Kerse, Knock, Patience and MacDonald, 2009b; Nomura et al., 2008, p. 3), God-Speed questionnaire (Bartneck, Kulic, Croft and Zoghbi, 2009), Robot-acceptance questionnaire (Wu et al., 2014), Negative Attitude Towards Robots Scale (NARS) (Nomura, Kanda, Suzuki and Kato, 2006). NARS and RAS were often used in other studies. However, these questions relate strongly to emotional robots or to communication with a robot. Therefore, they proved inappropriate for the present study. The robot-acceptance questionnaire in the version by Heerink, Kröse, Evers and Wielinga (2010), which is based on the Unified theory of acceptance and use of technology (UTAUT) model fit. Six of the 41 items were selected, which proved to be predictive for acceptance in studies or fit into the context of the present study.

The review by Flandorfer (2012) and previous questionnaires of the authors served as a basis for sociodemographic items. In addition, the item "Have you ever dealt directly with a robot" by Nitto, Taniyama and Inagaki (2017) was added to be able to compare the Swiss population with the German and Japanese population.

The question formulations and answer categories of the questionnaire were age-appropriate (according to the recommendations of Lang, 2014). In total, the questionnaire was four pages long and could be completed in about 15 minutes. The questionnaire was pre-tested (with four men and five women 60+) and was then finalised for the study.

2.1.4 Recruiting

German-speaking older adults aged over 60 were recruited in Eastern Switzerland. Possible participants were asked via different existing networks of the Institute for Ageing Research (IAF), FHS St.Gallen, University of Applied Sciences, and were offered several study dates. Finally, 11 study dates took place in the period of September to December 2018 in three different Swiss cantons (St.Gallen, Graubünden, Lucerne).

2.1.5 Study Procedure

Several participants took part in each study appointment. Each participant filled in the questionnaire alone and in silence in a classroom. No joint discussion or audible comments were allowed during the study. The participants first saw a short video sequence of a service situation (S1) without sound, in which a robot reminds a resident to drink and brings the respective resident water. Since assistance robots in the service and care sector cover a broad spectrum of different designs from very technical to very human-like (Decker, 2010), the participants were shown one of the four images (machine-like robot (1), mechanical-human-like robot (2), human-like robot (3) and android robot (4)) after the video sequence. The emotions caused by the situation were then recorded with the self-constructed questionnaire on emotions. After completing the first questionnaire, the participants received a different picture of the robot for the same service situation and were again asked about their emotions. This process was repeated with the video sequence of a care situation (S2). The sequence of the pictures varied randomly for each participant. Through this procedure each participant processed four randomly distributed vignettes, whereby the order of the displayed vignettes varied according to predetermined scheme, which ensures that all possible combinations occurred equally (see table 1).

Table 1: Variation of the vignettes.

Appearance A	Situation S	
(A1-A4)	Service situation (S1)	Care situation (S2)
A1: machine-like	A1 x S1	A1 x S2
A2: mechanical-human-like	A2 x S1	A2 x S2
A3: human-like	A3 x S1	A3 x S2
A4: android	A4 x S1	G4 x S2

2.1.6 Analyses

The data from the questionnaires were manually entered in a SPSS data mask. A 5% check of the sample was carried out. After quality control and data cleansing, the data were evaluated with the IBM SPSS Statistics 26 program. The results are presented descriptively: M for mean value, SD for standard deviation or n for sample size and % for frequencies, according to the scale level. For differences in the scores of positive and negative emotions for different situations t-tests were calculated. In order to investigate the influence of different situations and different appearance of the robot on positive and negative emotions a one-way analysis of variance (ANOVA) was calculated in each case.

3 RESULTS

3.1 Participants

A total of 142 older adults participated with an average age of 73.2 years (SD=6.1, range 58 to 87). 54.2% of the participants were female. 71.1% lived with a partner (married/living with partner). Except for three persons (from Germany, Great Britain, no details), all participants were Swiss. 65.5% of the participants had completed tertiary education, 23.2% upper secondary education, 8.5% compulsory schooling, and 0.7% had not completed any schooling. Except for two persons (in retirement homes), all participants lived in a private household (98.6%), which consisted predominantly of two persons (64.8%). The current residential area was reported to be more rural by 53.5%, and more urban by 46.5%. 50.0% rated themselves as interested in technology, 21.8% as very interested, 26.8% as rather not interested and 1.4% as not interested at all.

76.1% already reported some experience with the use of technology in their professional lives, which included not only robots but also computers or machines. When asked whether they had ever been involved with a robot, 69.0% said they had no experience with a robot, 6.3% did not know, and those who said they had been involved with a robot before (24.5%) indicated a place at home, at work, in a workshop, at a trade fair, in a garage, at university, at a company, in continuing education courses, on a cruise ship, in the neighbourhood, in a lecture and more.

3.2 Emotions

30 positive emotions and 30 negative emotions were collected for each situation and each appearance of the robot. Overall, the three most frequently mentioned positive emotions were "awake" (75.9%), "attentive" (74.8%) and "interested" (71.9%). The three most frequently mentioned negative emotions were "tense" (49.4%), "unwell" (46.2%) and "dissatisfied" (45.0%).

The mean value of the sum score for positive emotions was M=12.72 (SD=9.70) and the mean value of the sum score for negative emotions was M=10.31 (SD=9.84). If the group of men and women is considered separately, men (M=15.15, SD=9.70) reported on average more positive emotions than women (M=10.72, SD=9.25). This difference is significant t(529.19)=5.50, p<.001. Women reported more negative emotions (M=12.24, SD=9.99) than men (M=7.97, SD=9.15). This difference is also significant t(553.84)=-5.27, p<.001.

Table 2: Positive emotions for situation and appearance.

Robot appearance	Service situation (S1)	Care situation (S2)	Both situations
A1	M=13.80 (SD=10.22)	M=08.30 (SD=07.72)	M=11.03 (SD=09.43)
A2	M=15.23 (SD=10.68)	M=10.29 (SD=09.13)	M=12.76 (SD=10.20)
A3	M=15.77 (SD=08.86)	M=10.19 (SD=09.24)	M=12.92 (SD=09.44)
A4	M=14.51 (SD=09.08)	M=13.90 (SD=10.03)	M=14.20 (SD=09.55)
Total A1-A4	M=14.82 (SD=09.72)	M=10.67 (SD=09.25)	M=12.72 (SD=09.70)

A1: machine-like, A2: mechanical-human-like, A3: human-like, A4: android, M: mean value, SD: standard deviation.

Table 3: Negative emotions for situation and appearance.

Robot appearance	Service situation (S1)	Care situation (S2)	Both situations
A1	M=08.96 (SD=09.72)	M=14.55 (SD=10.45)	M=11.77 (SD=10.44)
A2	M=07.91 (SD=09.22)	M=12.79 (SD=09.87)	M=10.35 (SD=09.83)
A3	M=07.71 (SD=08.81)	M=11.89 (SD=10.05)	M=09.84 (SD=09.66)
A4	M=08.71 (SD=09.68)	M=09.80 (SD=09.04)	M=09.26 (SD=09.34)
Total A1-A4	M=08.32 (SD=09.33)	M=12.25 (SD=09.96)	M=10.31 (SD=09.84)

A1: machine-like, A2: mechanical-human-like, A3: human-like, A4: android. M: mean value, SD: standard deviation.

Regarding the two different situations, participants expressed more positive emotions in the service situation (M=14.82, SD=9.72) than in the care situation (M=10.67, SD=9.25) (table 2). This difference is significant t(557.18)=5.19, p<.001. And, more negative emotions were expressed in the care situation (M=12.25, SD=9.96) than in the service situation (M=8.32, SD=9.33) (table 3). This difference is significant t(560)=-4.83, p<.001.

Regarding robot appearance, participants on average expressed increasing positive emotions from machine-like (M=11.03, SD=9.43), mechanical-human-like (M=12.76, SD=10.20), human-like (M=12.92, SD=9.44), to android (M=14.20, SD=9.26) appearance of the robot (table 2). Participants on average expressed decreasing negative emotions from machine-like (M=11.77, SD=10.44), mechanical-human-like (M10.35, SD=9.83), human-like (M=9.84, SD=9.66), to android (M=9.26, SD=9.34) appearance of the robot (table 3).

For emotions we each calculated a one-way ANOVA with gender as covariate to assess the effects of the situation in which the robot was shown and the appearance of the robot on levels of positive and negative emotions (as measured by the questionnaire). The situation in which interaction with the robot was shown had two categories (service situation, care situation) and appearance of four categories (machine-like, mechanical-human-like, human-like, android). The level of positive emotions differed statistically significant for the different situations, $F(1,553) = 29.84$, $p<.001$, and the different appearances of the robot, $F(3, 553) = 2.88$, $p=.036$. The level of negative emotions differed statistically significantly for the different situations, $F(1, 553) = 25.35$, $p<.001$. There was no statistically significant difference in scores of negative emotions for the different appearances of the robot, $F(3, 553) = 1.86$, $p=.135$.

4 DISCUSSION

The present study intended to investigate the emotions of older adults towards robots of different appearances in different situations. Slightly more women than men took part in the study, which corresponds to the gender distribution among Swiss older adults (BFS, 2019). Several Swiss cantons could be covered, with slightly more participants coming from rural regions. However, the sample is made up of well-educated older adults and therefore does not represent the general population of Switzerland. The high percentage of well-trained study participants in studies with older adults and use of technology is a phenomenon that is quite often encountered (e.g. Dahms and Haesner, 2018; Steinert, Haesner, Tetley and Steinhagen-Thiessen, 2015). The older adults lived almost exclusively in private households, which was intended but must be considered when interpreting the results. Most participants were interested in technology, which is in line with other studies (e.g. Mies, 2011; Stadelhofer, 2000) and reflects the increasing innovation orientation in older adults (Höpflinger, 2009). In contrast to other studies (e.g. Mollenkopf, 2006; Mollenkopf & Kaspar, 2004), more participants assessed themselves as experienced in the use of technology. However, caution is required when interpreting this result, as the high percentage could be due to the formulation of the question ("Have you gained experience with the use of technology (computers, machines, robots) in your professional life"). The omnipresence computers at the workplace and the focus on the professional context could have led to distorted results. For example, "gaining experience" can refer to the fact that a computer was present, and, in contrast, housewives may have negated the question because their technical experience did not take place in a professional context. The proportion of 24.5% of older adults in this study who stated that they had ever had anything to do with a robot is within the 27% stated by Nitto et al. (2017) (persons in Germany, aged 16-69, Internet survey). The percentage of older adults who stated that they had never had anything to do with a robot (69%) is also comparable with the figures from Nitto et al. (2017), where it was 73% for Germany. Data from the Eurobarometer 2012 (from 27 EU Member States) report that 87% of EU citizens have never had a robot in their life, 12% have had experience with a robot (6% at home, 6% at work) (European Commission, 2012). In the present study, men reported significantly more positive emotions than women, and women reported significantly more negative emotions towards robots. Kuo et al. (2009) found a significant gender effect, with males having a more positive attitude toward robots in healthcare than females. In a review Broadbent et al. (2009a) report that gender has an impact on how people react to robots.

In view of the two different situations in which people interact with a robot, in the service situation, fewer negative emotions were expressed than in the care situation. A possible reason for this could be that different distances of the robot (i.e. the spatial proximity between robot and person) are accepted differently in different situations. Koay, Dautenhahn, Woods and Walters (2006) showed that people's levels of comfort varied across different distances from a robot, and that people displayed more comfort with the robot at the intermediate distance than they did at close or far distances. In the videos shown in the present study, it could be that the robot in the service situation interacts in the intermediate distance, which is more comfortable itself, and the robot in the care situation interacts at close distance, what is experienced as less pleasant. This is also shown in further studies (e.g. Seibt, Nørskov and Schack Andersen, 2016). The use of a robot is accepted, but not in personal hygiene and under the maintenance of a certain distance between robot and human being. In their systematic literature review, Savela et al. (2018) summarize that the attitudes of older adults towards robots are more often positive than negative. Other studies report that older adults showed a more positive attitude towards robots than other groups like health personnel, caregivers, relatives (Broadbent et al., 2012).

Regarding the appearance of the robot, the android robot didn't evoke more negative emotions than the machine-like, the mechanical-human-like or the human-like robot. The android robot, in fact, evoked the most positive emotions. This result seems initially surprising, regarding the "Uncanny Valley" hypothesis. However, findings concerning both the existence of the "Uncanny Valley" and its explanations are mixed (for discussion see Broadbent, 2017). As Prakash and Rogers (2015) pointed out, familiarity with the human appearance is a primary reason for why human-looking robots might be favoured over mechanical appearance. This could be especially true for older adults, particularly regarding tasks at home that typically are performed by humans (Blow, Dautenhahn, Appleby, Nehaniv and Lee, 2006). In addition, the findings must also be reconciled with Korchut et al. (2017), who postulate a preference for anthropomorphic appearances.

Our findings could have various reasons. The first question to ask is whether the android robot was recognized as a robot. Since it was repeatedly pointed out in the study instructions and during the study, that all images are robots and not humans, this explanatory approach can be rejected. Another reason could be the resemblance of the android robot to female person. All other robots cannot be clearly assigned to gender. This could have evoked more positive emotions, since more women are employed in nursing homes (Mercay and Grünig, 2016), and this could have resulted in a congruent picture for the study participants. In the study of Prakash and Rogers (2015), some of their participants opinions about female human-looking faces were linked to notions of care or nursing.

The fact must also be considered that at the beginning the participants did not have all four possible appearance options in front of them at the same time and were not asked which robot they would rather use, but each robot had to be assessed individually. However, the authors see an advantage in this study design, which is that emotions had to be assessed independently for each vignette.

In conclusion, the situation in which a robot interacts with a human can be an important factor for the emotions that older adults have, which in turn can be important for robot acceptance. Appearance seems to play a role in the sense that it can evoke positive emotions. This should be considered when developing service robots for older adults.

4.1 Limitations

In robot research, simulated robot studies and real-world robot studies are carried out. According to Broadbent (2017), both types of studies contribute to knowledge. The advantages of simulating studies are their high degree of control over study manipulations, and that they are quicker. The disadvantages when using simulated designs are that people are under artificial conditions, and therefore the results may not be transferable to real robots and real-world conditions.

In the present study, only pictures of robots were used as not all robots shown in the study were available in Switzerland at the time. Therefore, a limitation of the present study is that results might have differed if the robot had been seen in real life by respondents. Although images were chosen that show the four robot types as similarly as possible, image elements might have influenced the preferences independently of the robot. In case of the android robot, one can assume the greatest difference between the picture and the actual experience because the gap between appearance and movements as described for the "Uncanny Valley" effect could be decisive. In future, the aim is to carry out investigations with robots in real life.

Another fact to consider is that the robots and persons showed in the two video conditions were not the same. Thus, there could have been effects due to these differences: The persons shown in the videos did not have the same age. Both were women, but in the service situation, the woman was clearly aged over 60, older than the woman in the care situation. This might have affected the responses, as the person in the service situation was more in line with the age of the study participants, so that they might identify more strongly with her. Also, the robots in the videos differed. The shape of both robots had no heads, but the appearance of the robot in the service situation could be perceived as more machine-like, and in the care situation more mechanical-human-like. Although the participants were instructed to imagine the robot shown on the picture, there could be an effect that the appearance of the robot in the service video was more pleasant than the robot in the care video and this might have led to more positive emotions.

Priming effects by the video shown cannot be excluded. While the sequence of the pictures varied, all participants first saw the video with the service situation. This might have led to a priming to more positive feelings in this situation.

In the present study, only one example for each of the four categories of humanness was used. When choosing other or varying examples, the results might change, especially if the robot had been shown in a female *and* male form.

While the order of the presentation of the robots was mixed across the study, the order of the questions in the questionnaires remained the same. This may have particularly affected the responses to questions at the end of the questionnaire. In addition, as the participants saw two videos and had to complete four questionnaires, fatigue effects cannot be ruled out, even though they might be partly absorbed by the variation of the vignettes.

Finally, the composition of the study population is not representative of the general population. Although other studies report positive attitudes towards robots, a different picture may emerge if more members of less well-educated or less technology-oriented people are included. In addition, persons already in need of care who receive help with personal hygiene, might have answered differently and might find the robot conducive to their privacy. Starting from this basic analysis, future studies should increasingly pay attention to characteristics of the study sample and analyse the specific needs of older adults in real settings.

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