Emotions and Attitudes of Older Adults Toward Robots of Different Appearances and in Different Situations

Stephanie Lehmann(✉), Esther Ruf, and Sabina Misoch

Institute for Ageing Research, OST Eastern Switzerland University of Applied Sciences, Rosenbergstrasse 59, 9001 St. Gallen, Switzerland
stephanie.lehmann@ost.ch

Abstract. The demographic change and the decrease of care personnel lead to the discussion to implement robots to support older adults. To ensure sustainable use, the solutions must be accepted. Technology Acceptance is dealt with in different models, but little attention has been paid to the emotions that older adults have toward service robots that support every day or care activities. The simulated robot study examined the positive and negative emotions and the attitudes of 142 older adults toward robots in different situations and with robots of different appearances. The situation influenced both emotions and attitudes. The older adults expressed more negative emotions and a more negative attitude in a care situation. In terms of appearance, less uncanniness and higher usage intention for the human-like and android robot were reported. The results contribute to a deeper understanding of robot acceptance and should be considered in the development of service robots for older adults in the future. Furthermore, the results should be validated in vivo with existing robots.

Keyword: Robot · Emotion · Attitude · Older adults

1 Background

1.1 Development of Technological Solutions to Support Older Adults

The development and use of technologies for older adults to support them and their caregivers are supported by various social trends. Above all, demographic change is leading to an increase in the elderly population [109]. In the European Union in 2018, the age group 65+ accounted for 19.7% of the total population with big differences between countries. Italy with 22.6% was at the highest end and Ireland with 13.8% at the lowest. What all countries have in common is the increase in the older population, especially as baby boomers reach retirement age [29]. Since many older adults wish to live independently in their familiar environment as long as possible [69], solutions are needed to support older adults in their private home. This can have a positive effect for their quality of life [100], which is in line with the aims of Ageing in Place [45]. Furthermore, solutions are needed to support nursing staff in care facilities, since the

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expected shortage of skilled nursing staff [121] is another major factor that is expected to lead to an increased use of technology and robotics.

Considering that worldwide more than two billion people will potentially need digital technologies by 2050 [122], these could support the well-being of older adults. It is assumed that robots will play an increasingly important role by maintaining the independence and well-being of older adults [92, 124]. They have proven benefits and can contribute to improving the quality of life of older people [9, 91], and they could contribute to maintaining the quality of care [10]. Robots offer the potential to support and relieve the burden on both older adults and their caregivers and they can also be used for prevention and rehabilitation purposes to avoid or reduce the need for assistance [42]. Promising areas of application of robots for social and daily healthcare of older adults are reported [2, 3]. The field of robotics in nursing is developing rapidly to meet the need for assistance in caregiving [65]. However, to realize the successful implementation of robots for older adults, user acceptance is essential, as so far little acceptance is reported for robots in care for older adults [114].

1.2 User Acceptance

Several models of Technology Acceptance portray the "Intention to Use" as an operationalization of acceptance. They vary in their differentiation, in the number of influencing factors, and in the field in which they were developed and tested. The basic Technology Acceptance Model (TAM) [21] has been developed further over time to the TAM 2 [111], TAM 3 [110] and the Unified Theory of Acceptance and Use of Technology model (UTAUT) [112]. Misoch, Pauli and Ruf [77] provide a critical discussion of Technology Acceptance models regarding their predictive power in relation to older adults. The Almere model [46] refers specifically to assistive robots for older adults. Extended to the context of service robots it developed into the Service Robot Acceptance Model (sRAM) [120].

Most of these models focus on cognitive (especially evaluative) and social factors. Emotions triggered by robots that support daily activities are considered rather globally (e.g. as "fear" dimension [124]) and unspecifically (e.g. as "emotional involvement" and "potential threat" [78]). Emotions of users are investigated at most concerning empathy with robots [95]. Some authors, such as Goher, Mansouri and Fadlallah [41] found the criterions "Ease of Use" and "Usefulness" to be the main factors for technology acceptance among older adults. However, in the study by De Graaf and Allouch [23], only the factor "Enjoyment" and not "Utility" indicates the actual use of a robot. Therefore, emotions of older adults should be given more emphasis in the consideration when interacting with a robot, as emotions and attitudes influence their reactions [14]. Although the integration of emotions in robot systems attempts to make robots empathetic, the emotional reactions of humans toward robots have not yet been explicitly investigated [94].

1.3 Emotions in Interaction Toward Robots Used for Older Adults

When robots perform tasks usually performed by humans and come into direct contact with humans for an intimate task it can evoke powerful emotions. Thus, embedding robots in new everyday situations can be emotionally challenging. Different types of robots can be used to support older adults and nursing staff. A distinction is often made between service type and companion type robots, although not all robots can be categorized strictly in either one of these two groups [16].

Robots referred to as service type robots are used as assistive devices with functionalities to support independent living. When it comes to the level of acceptance of these robots, studies usually focus on two aspects: types of social functions, that are important to accept the device in the living environment; how social functions can facilitate the usage of the device. Emotions that are triggered by these types of robots in older users were not the primary focus of research. It is expected that in assistive situations, the use of robots can lead to unclear expectations [19] and unrealistic ideas [8].

In contrast, emotions and reactions of older adults interacting with the second type, the so-called companion robots, are well studied [e.g. 1, 48, 72]. These companion robots are made to evoke explicitly positive emotions and are used as aids in therapy.

Nomura, Kanda and Suzuki [83] combine perspectives on societal attitudes and psychological reactions toward robots in their Negative Attitudes toward Robots Scale (NARS). In human-robot-interaction, communicative behavior is affected by the attitudes toward robots and anxiety related to robots [84].

1.4 Appearance of the Robot and Situation of Human-Robot Interaction

There are additional factors, such as characteristics of the robot or environmental factors, that can influence acceptance. The appearance of robots has been discussed as an important factor promoting or inhibiting acceptance [14, 35]. As robots are judged by users based on their appearance, it can trigger positive feelings toward the robot and thus lead to greater acceptance [49]. The appearance of a robot can be divided into different categories, for example in functional, zoomorphic, anthropomorphic, or cartoon-like [54]. With the idea that positive human-robot interaction is increased by human resemblance, humanoid robots are built in industrial contexts [e.g. 57]. Anthropomorphic robots also seem to reach higher levels of acceptance in settings with social interactions with a robot. Human-like shape and behavior have advantages when a close interaction between a robot and a human is necessary, and better performance in human-like tasks is assumed when a robot resembles a human [49]. Socially assistive robots that have human-like characteristics tend to promote acceptance and use [59]. However, there are varying findings when it comes to preferences on human-like robots. Broadbent [13] reports that older adults expressed a preference for non-humanlike robots, as they did not want them to replace humans. Other researchers found that older adults prefer discrete, small robots as well as human- or pet-like robots over large humanoid robots [15, 108, 123]. However, the "Uncanny Valley" hypothesis [80] states that the more human-like the appearance of the robot, the more accepted it is, unless it does not resemble a human too much. An abrupt decline in acceptance has been observed as soon as reaching a certain level of human resemblance in a robot. Android robots can be perceived as frightening when their movements are too mechanical and therefore do not match human appearance [68]. This gap in acceptance is subject of much debate, and mixed or inconsistent findings concerning the existence of the uncanny valley and its explanations are discussed [e.g. 47, 55, 66, 75, 104].

An important point regarding the appearance of a robot is that it cannot be considered independent to the situation of its use. Studies show that not only the appearance of the robot but also the situation in which a human-robot interaction takes place has a decisive influence on acceptance [22, 26, 39, 77]. The robot must fit the respective field of application or the task performed [13, 93], and the shape and capabilities of a robot should be congruent. Robots with a human-like appearance are attributed to have personality, emotions, and intentions [53]. This potential humanization leads to robots being considered as "trustworthy" and useful for trustful tasks.

Research from the fields of human-robot interaction (HRI), human-robot proxemics (HRP), and human-robot spatial interaction (HRSI) show that personal space is a major issue in human-robot interaction (for a summary see [63]), and the spatial area in which a robot moves during interaction is determined by the situation and its tasks. The robot should stay outside the intimate zone and within the personal or social zone of a person [56, 115]. If robots support daily activities of older adults, they are usually outside the intimate zone. This is different when robots support care activities which usually include touch in the intimate zone. Care workers were reserved toward robots in tasks that involve human touch [88].

Regarding the results from previous research, the following hypotheses have been examined in this study:

(1) Appearance of the robot: although inconsistent results in the literature, it is assumed that human-like to android robots will trigger more negative feelings in older adults.
(2) Situations when interacting with a robot: it is assumed that situations that require interaction in the intimate zone will evoke more negative feelings in older adults.

The present study aimed to investigate more comprehensively the emotions and attitudes of older adults toward robots of different appearances and in different situations. It aims to be a contribution to a better understanding of the acceptance of robots in this field, with the ability to lead to a sustainable use of robots. The study only refers to service type robots. According to the categorization of assistive robots for older adults by Broekens, Heerink, and Rosendal [16] the main function of service robots is to support daily activities. Companion robots (e.g. pet-like robots), whose main function is to improve health and psychological well-being, or other robot types, are not considered.

2 Methods

2.1 Design

A vignette methodology to collect emotions and attitudes toward robots was used. In vignettes, hypothetical situations are described, and participants are asked to put themselves into the hypothetical situation and to respond [6]. In human-robot interaction studies, this method has been used successfully and is a common methodology in psychology and sociology experiments [17, 31]. Video trials are used and regarded as a valid methodology [46].

Table 1. Study sample.

	N = 142 older adults
Age	73.2 years (SD = 6.1, range 58–87)
Gender	54.2% female
Marital status	71.1% married/living with partner
Nationality	97.9% Swiss
Education	65.5% tertiary level 23.2% secondary level 8.5% obligatory school education 0.7% no school leaving certificate
Living environment	98.6% private household
Household size	64.8% two-person household
Residential area	53.5% more rural
Interest in technology	21.8% very interested 50.0% interested 26.8% not interested 1.4% not interested at all
Technology experience	76.1% experience with technology use in professional life
Experience with robots	24.5% contact with a robot before

N = Number.

2.2 Participants

Via different existing networks of the Institute for Ageing Research (IAF), older adults who had to be German-speaking and aged over 60, were recruited in Eastern Switzerland. They were offered several possible study dates. A total of 11 study dates took place between September to December 2018 in three different Swiss cantons (St.Gallen, the Grisons, Lucerne). Table 1 shows the characteristics of the sample.

2.3 Measures

A questionnaire was developed to collect the emotions and attitudes of older adults toward robots. For emotion items, various existing scales were compiled based on a literature search. Table 2 shows the scales and basic emotions (overview in [86]) that were considered. Single emotions were added mentioned by older adults and the research team during a feasibility test in September 2017. A list with 79 positive, 12 neutral and 116 negative emotions was the result (see Fig. 1).

After this first compilation of a list with 207 emotion items, final items were selected separately by two researchers based on eight criteria (Table 3).

From the resulting list of 34 positive and 45 negative items, further individual items were sorted out based on content considerations when not fitting, being already covered by other items, or being too vague. The result was a two-page list with 30 positive

Table 2. Scales and basic emotions for questionnaire development.

Scale
German version of positive and negative affect schedule [12]
State-Trait-Anxiety Inventory [44]
SEK-ES–questionnaire for emotion-specific self-assessment of emotional competencies [25]
Jennifer Monathan "liking" questionnaire [79]
Emotional reactions to domestic robots [97]
Property list at the subscale level [52]
Feeling scale – Revised version (Bf-SR) [113]
Multidimensional state questionnaire (MDBF) [103]
Basic Emotions [4, 27, 37, 43, 50, 51, 71, 81, 85, 87, 89, 107, 118, 119]

Table 3. Criteria for item selection.

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) 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

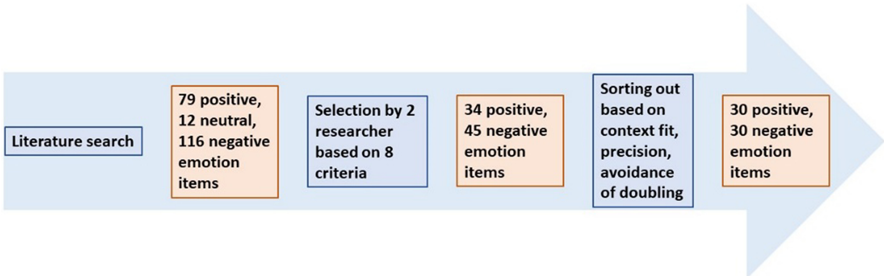

Fig. 1. Selection process of emotion items.

and 30 negative emotion items, presented as adjectives and displayed in random order. A dichotomous answer format ("rather yes" or "rather no") was chosen to allow the participants to fill in the questionnaire rapidly and easily. Figure 1 shows the selection process of the emotion items.

In addition, questions of robot acceptance were chosen based on the Almere model and the robot-acceptance questionnaire in the version by Heerink, Kröse, Evers and Wielinga [46]. Of the 41 items, six were selected which suited the context of the present study best. Two questions from the construct "Anxiety" (ANX), one from "Attitude toward Technology" (ATT), one from "Intention to Use" (ITU), one from "Perceived Ease of Use" (PEOU) and one question from "Perceived Usefulness" (PU) and translated into German and adapted. The answer format followed a five-point scale from 1 "do not at all agree" to 5 "agree completely".

Items following the recommendations from the review by Flandorfer [35] and items from previous questionnaires of the authors were chosen to collect sociodemographic data. Three further questions were included in the questionnaire which were described in the literature in the context of robots: Experience with technology from previous professional life ("Yes/No"), interest in technology on a four-level scale from "very interested" to "not at all interested" and the question "Have you ever dealt directly with a robot" from Nitto, Taniyama and Inagaki [82] to compare the Swiss population with the German and Japanese population.

Care was taken to ensure that the question formulations and answer categories of the questionnaire were age-appropriate (according to the recommendations of Lang [62]). Nine older adults (four men and five women 60+ years old) pretested the questionnaire. The final questionnaire consisted of four pages and could be completed in about 15 min.

2.4 Material

The vignette was presented in a video format supplemented with pictures of robots of different appearance. For the variation of the situation, two different video stimuli were selected. Each film showed a different situation of interaction with a robot. The video stimuli were tested beforehand in a feasibility test in September 2017. One situation showed an older woman in a retirement home sitting at a table with other older women, illustrating the service situation (S1). In this situation, the robot Care-O-bot 3 [36] moves toward the woman with a cup of water and then invites her to drink, which she does. The other situation showed a middle-aged bedridden woman, her arms and legs being washed by the robot Cody [40] without other people visible, illustrating the care situation (S2). Both video stimuli were cut to one minute in length, to accurately illustrate the relevant interaction. To avoid distractions through verbal descriptions they were shown without sound.

Because assistive robots have a wide range of different looks [22], pictures of robots with varying degrees of human resemblance were selected based on the most used classification of different authors: machine-like, mechanical-human-like, human-like, and android [24, 67, 116]. Pictures of high quality and that depicted meaningful representations in the context of nursing care for older adults were selected. The pictures were shown without product names of the robots. Pictures of the following robots were selected: Lio for machine-like appearance [30]; Kompai for mechanical-human-like appearance [106]; Romeo for human-like appearance [7]; Otonaroid for android appearance [76].

2.5 Procedure

Several participants took part in each of the 11 study sessions, which always followed the same pattern. After an introduction and explanation of the study, the participants were shown the first video (S1) and were asked to put themselves in this situation as if they were experiencing it themselves, imagining the appearance of the robot based on the picture given after the video. One of four images of a robot were given to the participants, resembling either machine-like (A1), mechanical-human-like (A2), human-like (A3) or android (A4). After the first completion of the questionnaire, the participants were given another picture of the robot and had to fill in another questionnaire. This procedure was repeated with the second video (S2) (Fig. 2 shows the procedure of the study sessions). According to a predetermined scheme ensuring all possible combinations occurred equally, each participant evaluated four randomly composed vignettes (see Table 4). Participants reported emotions and attitudes for each of the four vignettes with the questionnaire. Each participant was set apart in a classroom and filled in the questionnaire on his/her own and in silence. No joint discussion or audible comments were allowed during the study appointments.

Table 4. Combination of appearance and situations [96].

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

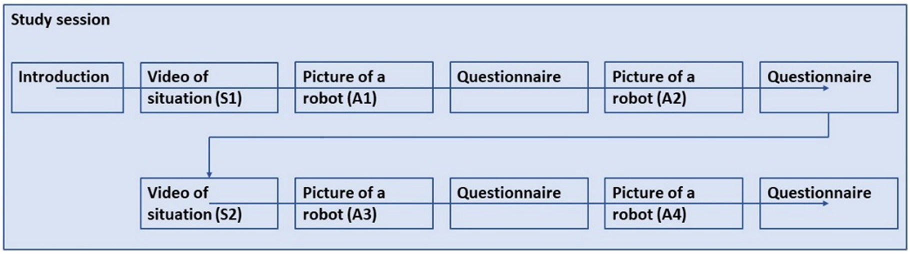

Fig. 2. Procedure of the study sessions. Order of presentation of one of the four pictures of a robot (A1–A4) varied.

2.6 Analysis

For evaluation, the IBM SPSS Statistics 26 program was used. After manually entering the data, a 5% check of the sample, quality control, and data cleansing were carried out.

The 30 positive and the 30 negative emotions were taken together to build a sum score for positive emotions and a sum score for negative emotions, respectively. M for mean value, SD for standard deviation or n for sample size and % for frequencies were reported to descriptively present the results. For mean value comparisons for the two situations in which interaction with the robot was shown (service situation, care situation), and gender comparison t-tests were calculated. For emotions and attitudes, a one-way ANOVA was calculated in each case, to compare the levels of positive and negative emotions and attitudes (as measured by the questionnaire) for the four appearances of the robot (machine-like, mechanical-human-like, human-like, android).

Multiple linear regressions were run to predict emotions and attitudes respectively. Predictors were dummy coded with situation (service versus care), appearance of the robot (machine-/mechanical-like versus human-like/android), and gender (male versus female). All variables are forced into the linear regression model (method: enter) to investigate their independent contribution. The goodness of fit of the overall model according to Cohen [18] is reported. It was checked for multicollinearity problem in the model as VIF for all variables should be <10, and for auto-correlation problem in the data as the Durbin-Watson-Test should be between the two critical values of $1.5 < d < 2.5$ [34].

3 Results

3.1 Emotions

Emotions Toward Robots. For each situation (S1, S2) and each appearance of the robot (A1, A2, A3, A4) the participants reported their agreement (yes or no) to 30 positive emotions and 30 negative emotions. Taken situations and appearances together, the mean value of the sum score for positive emotions was M = 12.72 (SD = 9.70). The mean value of the sum score for negative emotions was M = 10.31 (SD = 9.84).

When comparing men and women, men (M = 15.15, SD = 9.70) reported on average a higher mean value of the sum score for positive emotions than women (M = 10.72, SD = 9.25). This difference was significant $t(529.19) = 5.50$, $p < .001$. Women had a higher mean value of the sum score for negative emotions (M = 12.24, SD = 9.99) than men (M = 7.97, SD = 9.15). This difference was significant $t(553.84) = -5.27$, $p < .001$.

On the individual level of the emotion items the participants agreed most frequently with the positive emotions “awake” (75.9%), “attentive” (74.8%) and “interested” (71.9%). The three negative emotions the participants agreed the most were “tense” (49.4%), “unwell” (46.2%) and “dissatisfied” (45.0%).

Emotions Toward Robots in Different Situations. Analyzing the two different situations (S1, S2) separately, the mean value of the sum score for positive emotions was higher in the service situation S1 (M = 14.82, SD = 9.72) than in the care situation S2 (M = 10.67, SD = 9.25) (Table 5). This difference was significant $t(557.18) = 5.19$, $p < .001$. The mean value of the sum score for negative emotions was higher in the care situation S2 (M = 12.25, SD = 9.96) than in the service situation S1 (M = 8.32, SD = 9.33) (Table 6). This difference was significant $t(560) = -4.83$, $p < .001$.

Emotions Toward Robots of Different Appearance. The mean value of the sum score for positive emotions increased from machine-like A1 (M = 11.03, SD = 9.43), mechanical-human-like A2 (M = 12.76, SD = 10.20), human-like A3 (M = 12.92, SD = 9.44), to android A4 (M = 14.20, SD = 9.26) appearance of the robot (Table 5, Fig. 3). The mean values of the sum score for positive emotions did not differ significantly between the different appearances (F(3, 558) = 2.56, p = .054). A Bonferroni-adjusted post-hoc test showed a significant difference between the machine-like and the android (p = .037) appearance.

The mean value of the sum score for negative emotions decreased from machine-like (M = 11.77, SD = 10.44), mechanical-human-like (M = 10.35, SD = 9.83), human-like (M = 9.84, SD = 9.66), to android (M = 9.26, SD = 9.34) appearance of the robot (Table 6, Fig. 3). The mean values of the sum score for negative emotions did not differ significantly between the different appearances (F(3, 558) = 1.68, p = .171).

Table 5. Positive emotions for situation and appearance [96].

Robot appearance	Service situation (S1)	Care situation (S2)	Both situations
A1: machine-like	M = 13.80 (SD = 10.22)	M = 08.30 (SD = 07.72)	M = 11.03 (SD = 09.43)
A2: mechanical-human-like	M = 15.23 (SD = 10.68)	M = 10.29 (SD = 09.13)	M = 12.76 (SD = 10.20)
A3: human-like	M = 15.77 (SD = 08.86)	M = 10.19 (SD = 09.24)	M = 12.92 (SD = 09.44)
A4: android	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)

M: mean value, SD: standard deviation.

Table 6. Negative emotions for situation and appearance [96].

Robot appearance	Service situation (S1)	Care situation (S2)	Both situations
A1: machine-like	M = 08.96 (SD = 09.72)	M = 14.55 (SD = 10.45)	M = 11.77 (SD = 10.44)
A2: mechanical-human-like	M = 07.91 (SD = 09.22)	M = 12.79 (SD = 09.87)	M = 10.35 (SD = 09.83)
A3: human-like	M = 07.71 (SD = 08.81)	M = 11.89 (SD = 10.05)	M = 09.84 (SD = 09.66)
A4: android	M = 09.71 (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)

M: mean value, SD: standard deviation.

Influence of Situation and Appearance on Emotions. In multiple linear regression analysis, situation, appearance of robot, and gender were able to statistically significantly predict the level of positive emotions, F(3, 558) = 22.15, p = .000. The model has no auto-correlation as the value of the Durbin-Watson statistic is 1.716. The R^2 for the overall model was .106 (adjusted R^2 = .102), indicative of a moderate goodness-of-fit. Women expressed less positive emotions than men, the care situation led to less positive

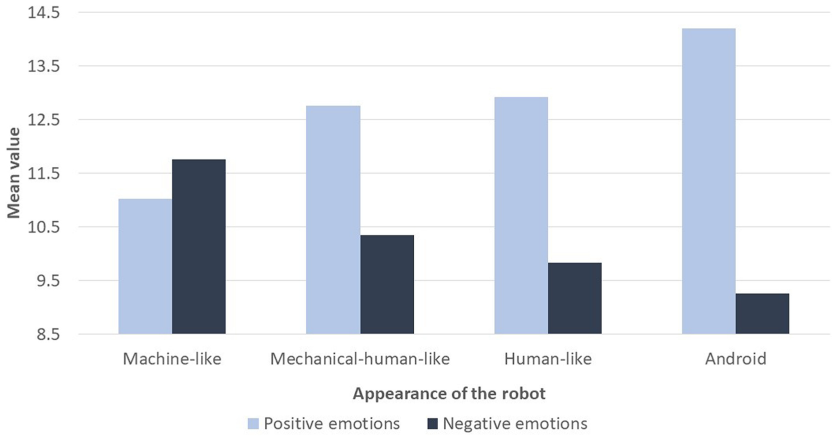

Fig. 3. Mean values of positive and negative emotions for different appearance of the robot.

emotions than the service situation, and the machine-/mechanical-like appearance led to less positive emotions than the human-like/android appearance.

In multiple linear regression analysis, situation and gender were able to statistically significantly predict the level of negative emotions, $F(3, 558) = 19.21$, $p = .000$. The model has no auto-correlation as the value of the Durbin-Watson statistic is 1.88. The R^2 for the overall model was .094 (adjusted $R^2 = .089$), indicative of a weak goodness-of-fit. Women expressed higher negative emotions than men, the care situation led to higher negative emotions than the service situation, no statistically significant influence of appearance on the level of negative emotions could be shown.

3.2 Attitudes

Attitudes Toward Robots. For each situation (S1, S2) and each appearance of the robot (A1, A2, A3, A4) the participants reported their agreement on a five-point scale (1 = do not at all agree to 5 = agree completely) to six items reflecting attitude toward robots (anxiety (ANX1), “afraid to make mistakes”; ANX2, “find robot scary”; attitude toward technology (ATT), “good idea to use the robot”; intention to use (ITU), “I would use the robot”; perceived ease of use (PEOU), “robot is easy to use”; perceived usefulness (PU), “robot is useful” (Table 7).

Table 8 shows the results separated by gender. “Anxiety” and “perceived ease of use” differentiate significantly.

Attitudes Toward Robots in Different Situations. Analyzing the two different situations (S1, S2) separately, the mean value of the items differs significantly for all items except for ANX1 (see Table 9). Indicating a more positive attitude toward robots in the service situation (S1).

Attitudes Toward Robots of Different Appearance. Table 10 shows the mean values and standard deviations of attitudes toward robots for the four different appearances of

Table 7. Attitudes toward robots.

Construct (Code)	Mean (standard deviation)
Anxiety (ANX1)	M = 2.34 (SD = 1.11)
Anxiety (ANX2)	M = 2.61 (SD = 1.30)
Attitude toward technology (ATT)	M = 3.12 (SD = 1.16)
Intention to use (ITU)	M = 3.34 (SD = 1.15)
Perceived ease of use (PEOU)	M = 3.44 (SD = 0.94)
Perceived usefulness (PU)	M = 3.24 (SD = 1.16)

Table 8. Attitudes toward robots by gender.

Construct	Men	Women	T-Test
ANX1	M = 2.08 (SD = 1.00)	M = 2.56 (SD = 1.16)	t(551.39) = −5.33, p < .000*
ANX2	M = 2.37 (SD = 1.25)	M = 2.82 (SD = 1.31)	t(550) = −4.19, p < .000*
ATT	M = 3.22 (SD = 1.14)	M = 3.03 (SD = 1.16)	t(552) = 1.96, p = .051
ITU	M = 3.41 (SD = 1.14)	M = 3.28 (SD = 1.15)	t(551) = 1.32, p = .187
PEOU	M = 3.55 (SD = 0.90)	M = 3.35 (SD = 0.97)	t(551) = 2.48, p = .013*
PU	M = 3.29 (SD = 1.16)	M = 3.21 (SD = 1.16)	t(552) = 0.85, p = .395

M: Mean value, SD: Standard deviation, *: significant

Table 9. Attitude toward robots by situation.

Construct	Service situation (S1)	Care situation (S2)	T-Test
ANX1	M = 2.25 (SD = 1.11)	M = 2.43 (SD = 1.10)	t(552) = −1.93, p = .055
ANX2	M = 2.49 (SD = 1.32)	M = 2.74 (SD = 1.26)	t(550) = −2.26, p = .024*
ATT	M = 3.25 (SD = 1.19)	M = 2.98 (SD = 1.11)	t(548.38) = 2.78, p = .006*
ITU	M = 3.54 (SD = 1.10)	M = 3.14 (Sd = 1.17)	t(551) = 4.13, p < .000*
PEOU	M = 3.61 (SD = 0.91)	M = 3.27 (SD = 0.94)	t(551) = 4.23, p < .000*
PU	M = 3.44 (SD = 1.10)	M = 3.05 (SD = 1.19)	t(552) = 4.06, p < .000*

M: Mean value, SD: Standard deviation, *: significant

the robot. The mean value of ANX1 does not differ significantly between the different appearance of the robot $F(3, 550) = 0.38$, $p = .771$. The mean value of ANX2 differs significantly between groups $F(3, 548) = 4.61$, $p = .003$. A Bonferroni-adjusted post-hoc test showed a significant difference between the machine-like and the human-like ($p = .004$) and between the machine-like and the android ($p = .022$) appearance. ATT does not differ significantly between groups $F(3, 550) = 2.40$, $p = .067$. ITU differs significantly between groups F(3, 549) = 3.70, p = .012. A Bonferroni-adjusted post-hoc test showed a significant difference between the machine-like and the human-like (p = .031) appearance. PEOU does not differ significantly between groups F(3, 549) = 0.07, p = .976. PU does not differ significantly between groups F(3, 550) = 1.87, p = .133.

Table 10. Attitude toward robots by appearance.

Construct	Machine-like (A1)	Mechanical-human-like (A2)	Human-like (A3)	Android (A4)
ANX1	M = 2.43 (SD = 1.15)	M = 2.32 (SD = 1.12)	M = 2.30 (SD = 1.06)	M = 2.32 (SD = 1.13)
ANX2	M = 2.94 (SD = 1.32)	M = 2.62 (SD = 1.29)	M = 2.40 (SD = 1.21)	M = 2.49 (SD = 1.32)
ATT	M = 3.00 (SD = 1.13)	M = 2.99 (SD = 1.13)	M = 3.30 (SD = 1.22)	M = 3.19 (SD = 1.13)
ITU	M = 3.15 (SD = 1.19)	M = 3.22 (SD = 1.14)	M = 3.53 (SD = 1.09)	M = 3.46 (SD = 1.14)
PEOU	M = 3.44 (SD = 0.96)	M = 3.44 (SD = 0.95)	M = 3.46 (SD = 0.92)	M = 3.41 (SD = 0.95)
PU	M = 3.12 (SD = 1.17)	M = 3.14 (SD = 1.16)	M = 3.37 (SD = 1.15)	M = 3.35 (SD = 1.15)

M: Mean value, SD: Standard deviation

Influence of Situation and Appearance on Intention to Use the Robot. In multiple linear regression analysis, situation and appearance were able to statistically significantly predict the intention to use (ITU), F(3, 549) = 10.13, p = .000. The model has no auto-correlation as the value of the Durbin-Watson statistic is 2.03. The R^2 for the overall model was .052 (adjusted R^2 = .047), indicative of a weak goodness-of-fit. The care situation led to less intention to use the robot than the service situation. The human-like to android appearance of the robot led to more intention to use the robot than the machine-/mechanical-like appearance. No statistically significant influence of gender on the intention to use the robot could be shown.

4 Discussion

The present study examined emotions and attitudes of Swiss older adults toward robots with different appearances in different situations. As people's impression of robots is socially influenced in every country [105], it is important to have data from many different countries. As far as gender is concerned, although more women participated (54.2%) in the study, this corresponds to the gender distribution in Switzerland from the age group of 65 and over (men: 44.71%, women: 55.29%) [32]. In terms of educational level, however, the sample with a high percentage of well-educated (65.5% tertiary education) does not correspond to the general Swiss population. The distribution of the educational background in Switzerland for older adults (over 65 years) shows more people with secondary education (53%) than with tertiary education (24.2%) [33]. Often, older participants in studies of technology are well educated [e.g. 20,102]. Most participants were interested in technology (71.8% (very) interested in technology) which also is in line with other studies [e.g. 74,101] although Seifert and Schelling [99] found in their study that only

36% of the people 65+ years rather or completely agreed with the statement “I am very interested in new technical things”. The proportion of people who had contact with a robot before (24.5%) was slightly lower than in a telephone survey (26%) [38] and in an internet survey in Germany (27%) [82], in the U.S. (43%) and in Japan (31%). But higher than in the Eurobarometer (14%) [28]. A recently published study found in Switzerland 42% of participants had contact with a robot before [64]. The participants lived almost exclusively in private households, which was intended but must be considered when interpreting the results.

The present study found a significant gender effect. Men reporting more positive and women reporting more negative emotions. The gender effect was also significant in the two questions ANX1, ANX2 representing the anxiety construct (“afraid to make a mistake” and “find the robot scary”) and the question about perceived ease of use (PEOU). These findings are supported by the review of Broadbent et al. [14] were gender has an impact on how people react to robots, and is in line with the study of Kuo et al. [61] who found in the healthcare sector men having a more positive attitude toward robots than females.

The reported emotions differed significantly in the two different situations. In the service situation (S1, becoming a drink from a robot) more positive emotions and in the care situation (S2, being washed by a robot) more negative emotions were reported. Even five of the six items about attitude toward robots indicate a more positive view of the robot in the service situation (S1). Anxiety was less, positive attitude, intention to use, perceived ease of use and perceived usefulness were higher. There are several possible moderating variables for this effect. The different spatial proximity between the robot and the person in the two different situations could play an important role. Different distances from a robot can influence the level of comfort for the people, and the intermediate distance is rated the best [58]. In the service situation (S1) the robot acts in the intermediate distance and in the care situation (S2) in a close distance. This result corresponds with other studies [e.g. 98].

Differently than expected, the android robot did not evoke more negative emotions than the machine-like, the mechanical-human-like, or the human-like robot. Even if not significantly the mean values of positive emotions increased, and the mean values of negative emotions decreased the more human the appearance of the robot was. Even the mean values of four of the six attitude items toward robot do not differ between the different appearances. Only the anxiety item ANX1 (robot is scary) differs between the machine-like and the human-like and between the machine-like and the android appearance indicating more fear of the machine-like robot. And the intention to use item (ITU) differs significantly between the machine-like and the human-like appearance indicating a lower intention to use the machine-like robot. On one hand, this supports the “uncanny valley” hypothesis indicating a higher acceptance the more human the robot is. But on the other hand, the “valley” with an abrupt drop in acceptance when it is too human-like was not found for the android appearance. A discussion concerning the existence of the “uncanny valley” and its explanations can be found in Broadbendt [13]. In the present study, several possibilities could have affected this result. It could be questionable if the android robot was recognized as a robot. But this explanation can be rejected since it was pointed out in the study instructions and during the study that all images represent robots. Another possible explanation is the recognizable gender of the android robot. The picture shows an android robot that looks like a woman. All other robots cannot be clearly assigned to a gender. Since more women are employed in nursing homes [73], this could have evoked a congruent picture and more positive emotions. In the study of Prakash and Rogers [90], female human-looking faces were partially linked to notions of care or nursing. The independent assessment of the emotions for each vignette can be seen as an advantage of the study but it has to be considered that the participants were not asked which robot they would rather use. In any case, the findings are for example contrary to Arras and Cerqui [5] where only 19% of the participants would prefer a robot with a humanoid appearance, but they are in line with Prakash and Rogers [90] who stated familiarity as the primary reason for a preference of human-looking robots. Tasks that are typically performed by humans can benefit from this circumstance [11]. The findings are in line with Korchut et al. [60] postulating a preference for anthropomorphic appearances. Coming back to the "uncanny valley" it must be considered that in the original formulation of the hypothesis the movement of the robot also has an influence [55]. Overall, participants tended to prefer robots with more human-like appearance and attributes, which can be found in Walters, Syrdal, Dautenhahn, te Boekhorst, and Koay [117] too.

5 Conclusions

The study showed that the specific situation in which a robot interacts with a human has an important influence on positive and negative emotions and on the intention to use the robot. The appearance impacts the intention to use the robot and unpleasant feelings toward the robot. This in turn can influence the acceptance of robots. Additionally, gender also has an effect on emotions and intention to use. Therefore, when developing robots that are designed to interact with older users, it is important to consider the situation in which they will be used, and developers should consider the findings about appearance and gender effects.

Some limitations of the study should be mentioned. As stated above, the study sample is not representative of the general population. Less well-educated or less technology-oriented people should be included in future investigations. It must also be considered that previous experience with robots or prior knowledge about robots leads to a more positive assessment [5]. Since it can be assumed that in the future robotic systems will be increasingly discussed and used in our society, the proportion of people who will already have contact with a robot will increase significantly. A recent Swiss survey already showed a higher proportion of people who already had contact with a robot [64]. In addition, the personal situation of participants should be considered. Persons already in need of care might find the robot conducive to their privacy when helping with personal hygiene. Therefore, in future studies, the characteristics of the sample should be well chosen.

Subsequently, future studies should analyze the specific needs of older adults in real settings. Clearly simulated robot studies and real-world robot studies contribute to knowledge [13] and this simulated study had the advantages of high control over study manipulations, and that it could have been done quickly. The disadvantages were that people were under artificial conditions, therefore the results may not be transferable to real robots and real-world conditions.

This leads to another aspect that should be considered. Because of the study design and the fact that not all robots shown are currently available for testing in Switzerland, the participants only saw pictures of the different robots. Thus, image elements could have influenced the answers, although images were chosen carefully and as similar as possible. But the gap between appearance and movements as described for the "uncanny valley" can be especially great for the android robot. Therefore, robots seen moving in real life might evoke other emotions and attitudes. If technical development and financial considerations make it possible, future studies should be carried out with robots in real life.

Furthermore, many different looking robots exist, but the study used only one example for each category. Future studies should choose more or varying examples, especially if the robot has a gender form, both forms (female and male) must be considered.

Another fact to consider are differences in the videos shown. Both videos showed a woman as the main character but in the service situation (S1) the woman was older, clearly aged over 60 and corresponded more to the study participants what might have affected the responses. Both robots shown in the videos had no heads but could clearly be assigned to a different appearance category. The robot in the service situation (S1) looked machine-like (A1), and the robot in the care situation (S2) mechanical-human-like (A2). The different appearances could have affected the responses too, although the participants were instructed to imagine the robot shown on the picture.

The order of the videos was not varied, all participants first saw the service situation (S1) only the order of the images varied. Therefore, priming effects cannot be excluded. The order of the questions in the questionnaires remained the same too. This might have affected the responses as fatigue effects cannot be ruled out, as the participants had to complete four questionnaires.

Even when other possible target variables for acceptance like trust in robots [70] and not the intention to use can be considered, the present study emphasizes the need to consider the specific situation in which the robot will be used, the congruent appearance of the robot for the specific task and the gender of the end-user when developing robots to support older adults. As there are still unanswered questions, especially arising from the limitations of the present study, further research in this area must follow.

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References

1. Abbott, R., et al.: How do "robopets" impact the health and well-being of residents in care homes? A systematic review of qualitative and quantitative evidence. Int. J. Older People Nurs. **14**(3), e12239 (2019). https://doi.org/10.1111/opn.12239
2. Agnihotri, R., Gaur, S.: Robotics: a new paradigm in geriatric healthcare. Gerontechnology **15**(3), 146–161 (2016)

3. Allouch, S.B., van Velsen, L.: Social robots for elderly care: an inventory of promising use cases and business models. Stud. Health Tech. Inf. **270**, 1046–1050 (2020). https://doi.org/10.3233/SHTI200321
4. Arnold, M.B.: Emotion and Personality. Columbia University Press, New York (1960)
5. Arras, K.O., Cerqui, D.: Do we want to share our lives and bodies with robots? A 2000-people survey. Autonomous Systems Lab, Swiss Federal Institute of Technology, EPFL, Lausanne (2005)
6. Atzmüller, C., Steiner, P.M.: Experimental vignette studies in survey research. Methodology **6**, 128–138 (2010). https://doi.org/10.1027/1614-2241/a000014
7. Automation and Control Institute. https://www.acin.tuwien.ac.at/vision-for-robotics/roboter/romeo/. Accessed 01 Jan 2019
8. Baisch, S., et al.: Zeitschrift für Gerontologie und Geriatrie **51**(1), 16–24 (2017). https://doi.org/10.1007/s00391-017-1346-8
9. Barata, A.N.: Social robots as a complementary therapy in chronic, progressive diseases. In: Sequeira, J.S. (ed.) Robotics in Healthcare. AEMB, vol. 1170, pp. 95–102. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-24230-5_5
10. Bemelmans, R., Gelderblom, G.J., Jonker, P., de Witte, L.: Socially assistive robots in elderly care: a systematic review into effects and effectiveness. J. Am. Med. Directors Assoc. **13**(2), 114-120.e1 (2012). https://doi.org/10.1016/j.jamda.2010.10.002
11. Blow, M., Dautenhahn, K., Appleby, A., Nehaniv, C.L., Lee, D.: The art of designing robot faces – dimensions for human-robot interaction. In: Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human–Robot Interaction, pp. 331–332. Association for Computing Machinery, New York (2006). https://doi.org/10.1145/1121241.1121301
12. Breyer, B., Bluemke, M.: Deutsche Version der Positive and Negative Affect Schedule PANAS (GESIS Panel). Zusammenstellung sozialwissenschaftlicher Items und Skalen (2016). https://doi.org/10.6102/zis242
13. Broadbent, E.: Interactions with robots: the truths we reveal about ourselves. Annu. Rev. Psychol. **68**(1), 627–652 (2017). https://doi.org/10.1146/annurev-psych-010416-043958
14. Broadbent, E., Stafford, R., MacDonald, B.: Acceptance of healthcare robots for the older population: review and future directions. Int. J. Soc. Robot. **1**, 319 (2009). https://doi.org/10.1007/s12369-009-0030-6
15. Broadbent, E., Tamagawa, R., Kerse, N., Knock, B., Patience, A., MacDonald, B.: Retirement home staff and residents' preferences for healthcare robots. In: The 18th IEEE International Symposium on Robot and Human Interactive Communication, Toyama, pp. 645–650. IEEE (2009)
16. Broekens, J., Heerink, M., Rosendal, H.: Assistive social robots in elderly care: a review. Gerontechnology **8**(2), 94–103 (2009). https://doi.org/10.4017/gt.2009.08.02.002.00
17. Chita-Tegmark, M., Ackerman, J.M., Scheutz, M.: Effects of assistive robot behavior on impressions of patient psychological attributes: vignette-based human-robot interaction study. J. Med. Internet Res. **21**(6), e13729 (2019). https://doi.org/10.2196/13729
18. Cohen, J.: Statistical Power Analysis for the Behavioral Sciences, 2nd edn. L. Erlbaum Associates, Hillsdale (1988)
19. Compagna, D., Marquardt, M.: Zur Evaluation von Mensch-Roboter Interaktionen (MRI) – ein methodischer Beitrag aus soziologischer Perspektive. Working Papers kultur- und techniksoziologische Studien 3, p. 18. Universität Duisburg-Essen, Duisburg (2015)
20. Dahms, R., Haesner, M.: Prävention und Gesundheitsförderung **13**(1), 46–52 (2017). https://doi.org/10.1007/s11553-017-0610-5
21. Davis, F.D., Bagozzi, R.P., Warshaw, P.R.: User acceptance of computer technology: a comparison of two theoretical models. Manage. Sci. **35**(8), 982–1003 (1989)

22. Decker, M.: Ein Abbild des Menschen: Humanoide Roboter. In: Bölker, M., Gutmann, M., Hesse, W. (eds.) Information und Menschenbild, pp. 41–62. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-04742-8_3
23. De Graaf, M., Allouch, S.M.: Exploring influencing variables for the acceptance of social robots. Robot. Autonom. Syst. **61**(12), 1476–1486 (2013). https://doi.org/10.1016/j.robot.2013.07.007
24. DiSalvo, C.F., Gemperle, F., Forlizzi, J., Kiesler, S.: All robots are not created equal: the design and perception of humanoid robot heads. In: Proceedings of the 4th Conference on Designing Interactive Systems: Process, Practices, Methods, and Techniques, London, pp. 321–326. ACM (2002)
25. Ebert, D.D., Christ, O., Berking, M.: Entwicklung und Validierung eines Fragebogens zur emotionsspezifischen Selbsteinschätzung emotionaler Kompetenzen (SEK-ES). Diagnostica **59**(1), 17–32 (2013). https://doi.org/10.1026/0012-1924/a000079
26. Eftring, H., Frennert, S.: Zeitschrift für Gerontologie und Geriatrie **49**(4), 274–281 (2016). https://doi.org/10.1007/s00391-016-1064-7
27. Ekman, P., Friesen, W.V., Ellsworth, P.: What emotion categories or dimensions can observers judge from facial behavior? In: Ekman, P. (ed.) Emotion in the Human Face, pp. 39–55. Cambridge University Press, New York (1982)
28. European Commission: Special Eurobarometer 460. Attitudes towards the impact of digitisation and automation on daily life (2017). https://ec.europa.eu/jrc/communities/sites/jrccties/files/ebs_460_en.pdf
29. Eurostat.: Bevölkerungsstruktur und Bevölkerungsalterung (2019). https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing/de#Der_Anteil_.C3.A4lterer_Menschen_nimmt_weiter_zu. Accessed 10 Aug 2020
30. F&P PersonalRobotics. https://www.fp-robotics.com/de/service-robotics/. Accessed 21 Jan 2019
31. Fan, L., Scheutz, M., Lohani, M., McCoy, M., Stokes, C.: Do we need emotionally intelligent artificial agents? First results of human perceptions of emotional intelligence in humans compared to robots. In: Beskow, J., Peters, C., Castellano, G., O'Sullivan, C., Leite, I., Kopp, S. (eds.) Intelligent Virtual Agents. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-67401-8_15
32. Federal Statistical Office: Ständige Wohnbevölkerung nach Alter, Geschlecht und Staatsangehörigkeitskategorie, 2010–2019 (2020). https://www.bfs.admin.ch/bfs/de/home/statistiken/bevoelkerung/stand-entwicklung/alter-zivilstand-staatsangehoerigkeit.assetdetail.13707177.html
33. Federal Statistical Office: Bildungsstand (2020). https://www.bfs.admin.ch/bfs/de/home/statistiken/wirtschaftliche-soziale-situation-bevoelkerung/gleichstellung-frau-mann/bildung/bildungsstand.html
34. Field, A.: Discovering Statistics Using SPSS, (and Sex and Drugs and Rock 'n' Roll), 3rd edn. SAGE, London (2009)
35. Flandorfer, P.: Population ageing and socially assistive robots for elderly persons: the importance of sociodemographic factors for user acceptance. Int. J. Population Res. 829835 (2012). https://doi.org/10.1155/2012/829835
36. Fraunhofer-Institut für Produktionstechnik und Automatisierung Homepage, https://www.care-o-bot.de/de/care-o-bot-3/download/videos.html. Accessed 10 Aug 2020
37. Frijda, N.H.: The Emotions. Cambridge University Press, New York (1986)
38. Forsa. Politik- und Sozialforschung GmbH: "Service-Robotik: Mensch-Technik-Interaktion im Alltag". Ergebnisse einer repräsentativen Befragung. Berlin (2016). https://www.bmbf.de/files/BMBF_forsa_Robotik_FINAL2016.pdf

39. Gaul, S., et al.: Technikakzeptanz als integraler Bestandteil der Entwicklung medizintechnischer Produkte. In: Ambient Assisted Living 2010: 3. Deutscher AAL-Kongress mit Ausstellung, Assistenzsysteme im Dienste des Menschen – zuhause und unterwegs, Tagungsbeitrag. Berlin (2010)
40. Georgia Tech: Healthcare Robotics Lab. https://sites.gatech.edu/hrl/robotic-nurse-assistant/. Accessed 10 Aug 2020
41. Goher, K.M., Mansouri, N., Fadlallah, S.O.: Assessment of personal care and medical robots from older adults' perspective. Robot. Biomimetics **4**(1), 1–7 (2017). https://doi.org/10.1186/s40638-017-0061-7
42. Graf, B., Heyer, T., Klein, B., Wallhoff, F.: Servicerobotik für den demografischen Wandel. Mögliche Einsatzfelder und aktueller Entwicklungsstand [Service robots in elderly care. Possible application areas and current state of developments]. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz **56**(8), 1145–1152 (2013). https://doi.org/10.1007/s00103-013-1755-9
43. Gray, J.A.: The Neuropsychology of Anxiety. Oxford University Press, Oxford (1982)
44. Grimm, J.: State-Trait-Anxiety Inventory nach Spielberger. Deutsche Lang- und Kurzversion. Methodenforum der Universität Wien: MF-Working Paper 2009/02 (2009)
45. Hawley-Hague, H., Boulton, E., Hall, A., Pfeiffer, K., Todd, C.: Older adults' perceptions of technologies aimed at falls prevention, detection or monitoring: a systematic review. Int. J. Med. Informatics **83**(6), 416–426 (2014). https://doi.org/10.1016/j.ijmedinf.2014.03.002
46. Heerink, M., Kröse, B., Evers, V., Wielinga, B.: Assessing acceptance of assistive social agent technology by older adults: the Almere model. Int. J. Soc. Robot. **2**, 361–375 (2010). https://doi.org/10.1007/s12369-010-0068-5
47. Ho, C.-C., MacDorman, K.F.: Measuring the uncanny valley effect. Int. J. Soc. Robot. **9**(1), 129–139 (2016). https://doi.org/10.1007/s12369-016-0380-9
48. Hung, L., et al.: The benefits of and barriers to using a social robot PARO in care settings: a scoping review. BMC Geriatr. **19**(1), 232 (2019). https://doi.org/10.1186/s12877-019-1244-6
49. Hwang, J., Park, T., Hwang, W.: The effects of overall robot shape on the emotions invoked in users and the perceived personalities of robot. Appl. Ergon. **44**, 459–471 (2013). https://doi.org/10.1016/j.apergo.2012.10.010
50. Izard, C.E.: The Face of Emotion. Appleton-Century-Crofts, New York (1971)
51. James, W.: What is an emotion? Mind **9**(34), 188–205 (1884)
52. Janke, W., Debus, G.: Die Eigenschafswörterliste: EWL; eine mehrdimensionale Methode zur Beschreibung von Aspekten des Befindens. Hogrefe Verlag für Psychologie, Göttingen (1978)
53. Janowski, K., Ritschel, H., Lugrin, B., André, E.: Sozial interagierende Roboter in der Pflege. In: Bendel, O. (ed.) Pflegeroboter, pp. 63–87. Springer, Wiesbaden (2018). https://doi.org/10.1007/978-3-658-22698-5_4
54. Jost, C., et al.: Human-Robot Interaction Evaluation methods and their standardization. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-42307-0
55. Kätsyri, J., Förger, K., Mäkäräinen, M., Takala, T.: A review of empirical evidence on different uncanny valley hypotheses: support for perceptual mismatch as one road to the valley of eeriness. Front. Psychol. **6**, 390 (2015)
56. Kessler, J., Schroeter, C., Gross, H.-M.: Approaching a person in a socially acceptable manner using a fast marching planner. In: Jeschke, S., Liu, H., Schilberg, D. (eds.) ICIRA 2011. LNCS (LNAI), vol. 7102, pp. 368–377. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-25489-5_36
57. Kiesler, S., Hinds, P.: Introduction to this special issue on human-robot interaction. Human-Comput. Interact. **19**, 1–8 (2004)

58. Koay, K.L., Dautenhahn, K., Woods, S., Walters, M.L.: Empirical results from using a comfort level device in human-robot interaction studies. In: Proceedings of the 1st ACM SIGCHI/SIGART Conference on Human-Robot Interaction, pp. 194–201 (2006)
59. Khosla, R., Nguyen, K., Chu, M.-T.: Human robot engagement and acceptability in residential aged care. Int. J. Hum. Comput. Interact. **33**, 510–522 (2017). https://doi.org/10.1080/10447318.2016.1275435
60. Korchut, A., et al.: Challenges for service robots – requirements of elderly adults with cognitive impairments. Front. Neurol. **8**, 228 (2017)
61. Kuo, I.H., et al.: Age and gender factors in user accceptance of healthcare robots. In: The 18th IEEE International Symposium on Robots and Human Interactive Communication, Toyama (2009)
62. Lang, G.: Zur Befragung und Befragbarkeit von kognitiv eingeschränkten und demenziell veränderten Menschen in Altern- und Pflegeheimen. In: Amann, A., Kolland, F. (eds.) Das erzwungene Paradies des Alters? Weitere Fragen an eine Kritische Gerontologie, pp. 207–215. Springer VS, Wiesbaden (2014)
63. Lauckner, M., Kobiela, F., Manzey, D.: 'Hey robot, please step back!' - Exploration of a spatial threshold of comfort for human-mechanoid spatial interaction in a hallway scenario. In: The 23rd IEEE International Symposium on Robot and Human Interactive Communication, Edinburgh, pp. 780–787 (2014). https://doi.org/10.1109/ROMAN.2014.6926348
64. Lehmann, S., Ruf, E., Misoch, S.: Robot use for older adults – attitudes, wishes and concerns. First results from Switzerland. In: Stephanidis, C., Antona, M. (eds.) HCII 2020. CCIS, vol. 1226, pp. 64–70. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-50732-9_9
65. Maalouf, N., Sidaoui, A., Elhajj, I.H., Asmar, D.: Robotics in nursing: a scoping review. J. Nurs. Scholarsh. Official Publ. Sigma Theta Tau Int. Honor Soc. Nurs. **50**(6), 590–600 (2018). https://doi.org/10.1111/jnu.12424
66. MacDorman, K.F., Chattopadhyay, D.: Reducing consistency in human realism increases the uncanny valley effect; increasing category uncertainty does not. Cognition **146**, 190–205 (2016). https://doi.org/10.1016/j.cognition.2015.09.019
67. MacDorman, K.F., Ishiguro, H.: The uncanny advantage of using androids in cognitive and social science research. Interact. Stud. **7**, 297–337 (2006)
68. Mara, M., Appel, M.: Roboter im Gruselgraben: Warum uns menschenähnliche Maschinen oft unheimlich sind. In-Mind Magazin 5. Medienpsychologie Teil 2: Medien, Nachrichten und wir (2015)
69. Marek, K.D., Rantz, M.J.: Ageing in place: a new model for long-term care. Nurs. Adm. Q. **24**(3), 1–1 (2000)
70. Mathur, M.B., Reichling, D.B.: Navigating a social world with robot partners: a quantitative cartography of the uncanny valley. Cognition **146**, 22–32 (2016). https://doi.org/10.1016/j.cognition.2015.09.008
71. McDougall, W.: An Introduction to Social Psychology. Luce, Boston (1926)
72. McGlynn, S.A., Kemple, S., Mitzner, T.L., King, C.A., Rogers, W.A.: Understanding the potential of PARO for healthy older adults. Int. J. Hum Comput Stud. **100**, 33–47 (2017). https://doi.org/10.1016/j.ijhcs.2016.12.004
73. Mercay, C., Grünig, A.: Gesundheitspersonal in der Schweiz – Zukünftiger Bedarf bis 2030 und die Folgen für den Nachwuchsbedarf (Obsan Bulletin 12/2016). Schweizerisches Gesundheitsobservatorium, Neuchâtel (2016)
74. Mies, C.: Akzeptanz von Smart Home Technologien: Einfluss von subjektivem Pflegebedarf und Technikerfahrung bei älteren Menschen. Untersuchung im Rahmen des Projekts «Accepting Smart Homes». Diplomarbeit., Wien (2011)
75. Miklósi, Á., Korondi, P., Matellán, V., Gácsi, M.: Ethorobotics: a new approach to human-robot relationship. Front. Psychol. **8**, 958 (2017). https://doi.org/10.3389/fpsyg.2017.00958

76. Miraikan, National Museum of Emerging Science and Innovation. https://www.miraikan.jst.go.jp/en/online/communication/profile/otonaroid.html?width=560&height=1534. Accessed 28 Jan 2019
77. Misoch, S., Pauli, C., Ruf, E.: Technikakzeptanzmodelle: Theorieübersicht und kritische Würdigung mit Fokus auf ältere Nutzer/innen (60+). In: Weidner, R. (ed.) Technische Unterstützungssysteme, die die Menschen wirklich wollen, pp. 107–115. Konferenzband, Hamburg (2016)
78. Mollenkopf, H., Kaspar, R.: Technisierte Umwelten als Handlungs- und Erlebensräume älterer Menschen. In: Backes, G.M., Clemens, W., Künemund, H. (eds.) Lebensformen und Lebensführung im Alter, pp. 193–221. VS Verlag für Sozialwissenschaften, Wiesbaden (2004)
79. Monathan, J.L.: I don't know it but I like you – the influence of non-conscious affect on person perception. Hum. Commun. Res. **24**(4), 480–500 (1998). https://doi.org/10.1111/j.1468-2958.1998.tb00428.x
80. Mori, M.: The uncanny valley. Energy **7**, 33–35 (1970)
81. Mowrer, O.H.: Learning Theory and Behaviour. Wiley, New York (1960)
82. Nitto, H., Taniyama, D., Inagaki, H.: Social acceptance and impact of robots and artificial intelligence. Findings of survey in Japan, the US and Germany. Nomura Research Institute (NRI Papers, 211) (2017). https://www.nri.com/-/media/Corporate/en/Files/PDF/knowledge/report/cc/papers/2017/np2017211.pdf?la=en&hash=A730998FD55F6D58DF95F3479E3B709FC8EF83F4
83. Nomura, T., Kanda, T., Suzuki, T., Kato, K.: Experimental investigation into influence of negative attitudes toward robots on human-robot interaction. AI Soc. **20**(2), 138–150 (2006). https://doi.org/10.1007/s00146-005-0012-7
84. Nomura, T., Kanda, T., Suzuki, T., Kato, K.: Prediction of human behavior in human-robot interaction using psychological scales for anxiety and negative attitudes toward robots. IEEE Trans. Rob. **24**(2), 442–451 (2008)
85. Oatley, K., Johnson-Laird, P.N.: Towards a cognitive theory of emotions. Cogn. Emot. **1**, 29–50 (1987)
86. Ortony, A., Turner, T.J.: What's basic about basic emotions? Psychol. Rev. **97**(3), 315–331 (1990)
87. Panksepp, J.: Toward a general psychobiological theory of emotions. Behav. Brain Sci. **5**, 407–467 (1982)
88. Parviainen, J., Turja, T., Van Aerschot, L.: Robots and human touch in care: desirable and non-desirable robot assistance. In: Ge, S.S., Cabibihan, J.-J., Salichs, M.A., Broadbent, E., He, H., Wagner, A.R., Castro-González, Á. (eds.) ICSR 2018. LNCS (LNAI), vol. 11357, pp. 533–540. Springer, Cham (2018). https://doi.org/10.1007/978-3-030-05204-1_52
89. Plutchik, R.: A general psychoevolutionary theory of emotion. In: Plutchik, R., Kellerman, H. (eds.) Emotion: Theory, Research, and Experience, Theories of Emotion, vol. 1., p. 31. Academic Press, New York (1980)
90. Prakash, A., Rogers, W.A.: Why some humanoid faces are perceived more positively than others: effects of human-likeness and task. Int. J. Soc. Robot. **7**(2), 309–331 (2014). https://doi.org/10.1007/s12369-014-0269-4
91. Pu, L., Moyle, W., Jones, C., Todorovic, M.: The effectiveness of social robots for older adults: a systematic review and meta-analysis of randomized controlled studies. Gerontologist **59**(1), e37–e51 (2019). https://doi.org/10.1093/geront/gny046
92. Ray, C., Mondada, F., Siegwart, R.: What do people expect from robots? In: Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 3816–3821. Nice (2008)

93. Robinson, H., MacDonald, B., Broadbent, E.: The role of healthcare robots for older people at home: a review. Int. J. Soc. Robot. **6**(4), 575–591 (2014). https://doi.org/10.1007/s12369-014-0242-2
94. Rosenthal-von der Pütten, A.M., Krämer, N.C., Hoffmann, L., Sobieraj, S., Eimler, S.C.: An experimental study on emotional reactions towards a robot. Int. J. Soc. Robot. **5**(1), 17–34 (2013)
95. Rosenthal-von der Pütten, A.M., et al.: Investigations on empathy towards humans and robots using fMRI. Comput. Hum. Behav. **33**, 201–212 (2014)
96. Ruf, E., Lehmann, S., Misoch, S.: Service robots: emotions of older adults in different situations. In: Guldemond, N., Ziefle, M., Maciaszek, L. (eds.) Proceedings of the 6th Internactional Conference on Information and Communication Technologies for Ageing Well and e-Health, pp. 15–25 (2020). https://doi.org/10.5220/0009324500150025
97. Scopelliti, M., Giuliani, M.V., Fornara, F.: Robots in a domestic setting: a psychological approach. Univ. Access Inf. Soc. **4**, 146–155 (2005)
98. Seibt, J., Nørskov, M., Schack Andersen, S.: What Social Robots Can and Should Do. Proceedings of Robophilosophy/TRANSOR. IOS Press, Amsterdam (2016)
99. Seifert, A., Schelling, H.R.: Digitale Senioren. Nutzung von Informations- und Kommunikationstechnologien (IKT) durch Menschen ab 65 Jahren in der Schweiz im Jahr 2015. Pro Senectute Verlag, Zürich (2015)
100. Sixsmith, A., Gutmann, G.M.: Technologies for Active Aging, vol. 9. Springer, New York (2013). https://doi.org/10.1007/978-1-4419-8348-0
101. Stadelhofer, C.: Möglichkeiten und Chancen der Internetnutzung durch Ältere. Zeitschrift für Gerontologie und Geriatrie **33**, 186–194 (2000)
102. Steinert, A., Haesner, M., Tetley, A., Steinhagen-Thiessen, E.: Prävention und Gesundheitsförderung **10**(4), 281–286 (2015). https://doi.org/10.1007/s11553-015-0510-5
103. Steyer, R., Schwenkmezger, P., Notz, P., Eid, M.: Der Mehrdimensionale Befindlichkeitsfragebogen (MDBF) Handanweisung. Hogrefe, Göttingen (1997)
104. Strait, M.K., et al.: Understanding the uncanny: both atypical features and category ambiguity provoke aversion toward humanlike robots. Front. Psychol. **8**, 1366 (2017)
105. Suwa, S., et al.: Exploring perceptions toward home-care robots for older people in Finland, Ireland, and Japan: a comparative questionnaire study. Arch. Gerontol. Geriatr. **91**, 104178 (2020). https://doi.org/10.1016/J.archger.2020.104178
106. TelepresenceRobots. https://telepresencerobots.com/robosoft's-kompai. Accessd 28 Jan 2019
107. Tomkins, S.S.: Affect theory. In: Scherer, K.R., Ekman, P. (eds.) Approaches to Emotion, pp. 163–195. Erlbaum, Hillsdale (1984)
108. Torta, E., et al.: Evaluation of a small socially-assistive humanoid robot in intelligent homes for the care of the elderly. J. Intell. Rob. Syst. **76**(1), 57–71 (2014). https://doi.org/10.1007/s10846-013-0019-0
109. Vaupel, J.: Setting the stage: a generation of centenarians? Washington Q. **23**(3), 197–200 (2000)
110. Venkatesh, V., Bala, H.: Technology acceptance model 3 and a research agenda on interventions. Decis. Sci. **39**, 273–315 (2008). https://doi.org/10.1111/j.1540-5915.2008.00192.x
111. Venkatesh, V., Davis, F.D.: A theoretical extension of the technology acceptance model: four longitudinal field studies. Manage. Sci. **46**, 186–204 (2000). https://doi.org/10.1287/mnsc.46.2.186.11926
112. Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D.: User acceptance of information technology: Toward a unified view. Manage. Inf. Syst. Q. **27**(3), 425–478 (2003)
113. Von Zerssen, D., Petermann, F.: Befindlichkeits-Skala. Revidierte Fassung (Bf-SR). Hogrefe (2011).

114. Wachsmuth, I.: Robots like me: challenges and ethical issues in aged care. Front. Psychol. **9**, 432 (2018). https://doi.org/10.3389/fpsyg.2018.00432
115. Walters, M.L, Dautenhahn K., Te Boekhorst, R., Koay, K.L., Syrdal, D.S., Nehaniv, C.L.: An empirical framework for human-robot proxemics. In: Proceedings of the New Frontiers in Human-Robot Interaction (2009)
116. Walters, M.L., Koay, K.L., Syrdal, D.S., Dautenhahn, K., Te Boekhorst, R.: Preferences and perceptions of robot appearance and embodiment in human-robot interaction trials. In: Proceedings of New Frontiers in Human-Robot Interaction (2009)
117. Walters, M.L., Syrdal, D.S., Dautenhahn, K., te Boekhorst, R., Koay, K.L.: Avoiding the uncanny valley: robot appearance, personality and consistency of behavior in an attention-seeking home scenario for a robot companion. Auton. Robots **24**(2), 159–178 (2008). https://doi.org/10.1007/s10514-007-9058-3
118. Watson, J.B.: Behaviorism. University of Chicago Press, Chicago (1930)
119. Weiner, B., Graham, S.: An attributional approach to emotional development. In: Izard, C.E., Kagan, J., Zajonc, R.B. (eds.) Emotions, Cognition, and Behavior, pp. 167–191. Cambridge University Press, New York (1984)
120. Wirtz, J., et al.: Brave new world: service robots in the frontline. J. Serv. Manage. **29**, 907–931 (2018). https://doi.org/10.1108/JOSM-04-201-0119
121. World Health Organization: World report on ageing and health. World Health Organization, Geneva (2015)
122. World Health Organization: Global priority research agenda for improving access to high-quality affordable assistive technology. World Health Organization, Geneva (2017). https://apps.who.int/iris/bitstream/10665/254660/1/WHO-EMP-IAU-2017.02-eng.pdf
123. Wu, Y.H., Fassert, C., Rigaud, A.S.: Designing robots for the elderly: appearance issue and beyond. Arch. Gerontol. Geriatr. **54**(1), 121–126 (2012). https://doi.org/10.1016/j.archger.2011.02.003
124. Wu, Y.-H., Wrobel, J., Cornuet, M., Kerhervé, H., Damnée, S., Rigaud, A.-S.: Acceptance of an assistive robot in older adults: a mixed-method study of human-robot interaction over a 1-month period in the living lab setting. Clin. Interv. Aging **9**, 801–811 (2014). https://doi.org/10.2147/CIA.S56435