Dynamic interplay between general experience and robot-specific expertise at older adults' first encounter with a robot: Role for robot acceptance and implications for robot design

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S. Baisch, T. Kolling, B. Klein, J. Pantel, F. Oswald, M. Knopf. Dynamic interplay between general experience and robot-specific expertise at older adults' first encounter with a robot: Implications for robot design. Gerontechonology 2018;17(4):215-231; https://doi.org/10.4017/gt.2018.17.4.003.00 **Background** Robot acceptance by older adults has been shown to vary widely, hence the question arises how to foster robot acceptance in this target group. Most older adults have little experience with and knowledge about robots. Therefore, general experience acquired during a lifetime in robot-related domains and the provision of robot-specific expertise can be valuable resources to improve older adults' initial anxiety and attitude towards a robot. **Aim** Previous studies have only considered the role of general experience and increasing robot-specific expertise separately. The current study investigates their dynamic interplay at older adults' first encounter with two social robots. Additionally, the study assessed the role of the robots' design (zoomorph vs. mechanoid appearance and functions) for the relationship between different domains of general experience (animal and technology experience) and robot acceptance. **Methods** In this study, N = 27 older adults (aged 65 - 81 years) were introduced consecutively to two social robots, i.e., the zoomorphic robot Paro and the mechanoid robot Giraff. A stepwise introduction procedure was used to gradually increasing robot-specific expertise. Anxiety and attitude towards the respective robot, as predictors of robot acceptance, were assessed repeatedly throughout the introduction procedure. Technology and animal experience were assessed as relevant domains of general experience. **Results** General experience was beneficial for the older adults' initial levels of anxiety and their attitudes towards both robots, with relevant domains of general experience varying according to the robots' designs. With increasing robot-specific expertise, attitude ratings improved and the relevance of general experience for anxiety and attitude decreased. Older adults with less general experience profited particularly well from increasing robot-specific expertise. **Conclusions** As general experience and robot-specific expertise are important resources for robot acceptance, the need for a more thorough consideration of these aspects in robot development and implementation research is discussed.

Keywords: robot expertise, general technology experience, attitude towards robots, robot-related anxiety, social robots, robot acceptance

INTRODUCTION

In the future, robots will become more and more common in our daily lives. Particularly social robots, i.e., robots able to express emotions and to interact in a social manner with humans, will offer help with daily routines. Facing an aging population, specific interest has recently been taken into developing assistive robots to support the older members of society. Although often only prototypes, a wide variety of robots are already available to date to support older adults with the accomplishment of everyday living tasks, healthcare, and psychosocial needs.

The willingness of older adults to accept such robots in their homes, however, seems to vary widely (e.g., Giuliani, Scopelliti, Fornara, Muffolini, & Saggrese, 2003; Frennert & Östlund, 2012; Beer, et al., 2012). As these interindividual differences remain largely unexplained, analyzing relationships between characteristics of older robot users and robot acceptance is necessary in order to identify facilitators and barriers to robot acceptance.

Experience with robots and robot-related domains as a resource for robot acceptance

A user characteristic known to play a relevant role in the acceptance of new technologies is experience, defined as the familiarity and knowledge regarding the technology of interest (Sun & Zhang, 2006). Empirical evidence from research on computer use and acceptance by older adults supports the relevance of experience for robot acceptance (e.g., Gonzáles, Ramírez, & Viadel, 2015; Jay & Willis, 1992). These findings also suggest that anxiety and attitude towards the technology of interest are particularly prone to the effects of experience. However, it has to be noted that current theoretical models of robot acceptance (e.g., Heerink, Kröse, Evers, & Wielinga, 2010) treat both anxiety and attitude towards a specific robot not as measures of acceptance per se, but as predictors of robot acceptance.

In robot acceptance research, the role of two types of experience, i.e., robot-specific expertise and general expertise in robot-related domains, as a resource for low anxiety and a positive attitude of older adults towards robots have been considered.

Firstly, robot-specific expertise, i.e., experience with and knowledge about specific robots, is limited in younger people and even more so in older adults (e.g., Ezer, Fisk, & Rogers, 2009; Mitzner et al., 2011; Broadbent et al., 2010). Due to this floor effect, no association between experience with robots and robot acceptance has been found to date (Broadbent et al., 2010; Ezer et al., 2009). Fostering robot-specific expertise by introducing older novice users to robots could provide a mean to further increase robot acceptance in the target group. Current research findings on this topic, however, are rather inconclusive, and studies are difficult to compare. Some studies show no change in older adults' attitude and anxiety (attitude: Damholdt et al., 2015, Kuo et al., 2009; anxiety: Wu et al., 2014), whereas a trend towards a more negative attitude has also been reported (Wu et al., 2014). Further studies report significant improvements in anxiety and attitude due to increasing robot-specific expertise (Stafford et al., 2010; Broadbent et al., 2010). Differences in study characteristics might explain the discrepant findings. The available studies vary widely regarding attitude measure (general vs. robot-specific attitude), types of robots used, and frequency of exposure to the robot (repeated vs. single exposure), as well as sampling (healthy vs. cognitively impaired older adults, living independently vs. retirement home residents). Consequently, it remains yet unclear whether increasing robot-specific expertise is beneficial for older adults' anxiety and attitudes towards robots.

Secondly, due to the lack of robot-specific expertise, older adults can be assumed to rely on general experience in robot-related domains, e.g., general technology experience, when confronted with a robot for the first time. On the one hand, the beneficial role of general experience for radical innovations such as robots has been doubted (see Dewar & Dutton, 1986). On the other hand, people are generally known to use their experience in related domains to guide their behavioral, emotional and attitudinal reactions towards a new object, i.e., a robot, when no specific expertise is available (e.g., Gentner & Smith, 2012; Gentner & Markman, 1997). Since older adults have lived through several decades of technological development, it seems obvious that older adults use their technology experience to apply it to new technologies like robots (see O'Brian, Rogers, & Fisk, 2012). Indeed, the few available studies report positive associations between general technology experience and older adults' attitudes towards both particular robots and robots in general (Pino, Boulay, Jouen, & Rigaud, 2015; Ezer et al., 2009; Heerink, 2011). However, as general technology experience varies widely among the older population (O'Brian et al., 2012), older adults cannot be expected to benefit all equally from this resource. With regard to robot-related anxiety, no study considering the role of general technology experience was identified.

These findings indicate that general experience in robot-related domains can be a valuable resource for older adults' initial anxiety and attitude towards a robot in the absence of robot-specific expertise, i.e., before they interact with a robot for the first time. In contrast, robot-specific expertise gained through information about and interaction with the robot at first encounter with it provides the ground for later robot acceptance. During the first encounter, however, the two types of experience can be suggested to interact in a dynamic interplay. This interplay can be assumed to affect older adults' subsequent anxiety and attitude towards the robot. However, no study was found to investigate the role of both general experience and robot-specific expertise simultaneously.

Furthermore, the role of the robot's design, i.e., the combination of appearance and function, has not yet received much attention in robot acceptance research. So far, research has concentrated on the role of general technology experience for older adults' anxiety and attitude towards robots, but there is no reason to assume that this is the only relevant domain of general experience in this context. Rather, relevant domains may depend on the robot's design. Since the first encounter with a robot sets the course for its future acceptance, research is needed in order to clarify the role of general experience and robot-specific expertise as resources for robot acceptance as well as the role of the robot's design in this context.

The dynamic interplay of robot-specific expertise and general experience at older adults' first encounter with a robot

When meeting a robot for the first time, older adults develop from novices mainly lacking the robot-specific expertise to somewhat more experienced robot users. In this process, pre-existing general experience coincides with emerging robot-specific expertise. As a result, both types of experiences can be assumed to affect each other, leading to moderating effects on the older adults' anxiety and attitudes towards the robot.

Firstly, it can be suggested that increasing robot-specific expertise affects the role of the general experience for older adults' anxiety and attitude towards a robot. By definition, increasing robot-specific expertise is associated with the acquisition of a more complex and sophisticated base of knowledge about and experience with the robot (cf. Greca & Moreira, 2000; Thorndyke & Hayes-Roth, 1979). In fact, it has been shown that interacting with a robot can affect people's subsequent mental representation of it after a single interaction (e.g., Kiesler & Goetz, 2001; Andonova, 2006; Fischer & Lohnse, 2007). Consequently, increasing robot-specific expertise does not only induce changes in the older adults' anxiety and attitude ratings, but also results in a decreasing need to use the general experience to guide reactions towards the robot. Thus, the relevance of general experience in robot-related domains for older adults' anxiety and attitude towards robots can be suggested to decline with increasing robot-specific expertise. However, to our knowledge, no study has investigated this assumption to date.

Secondly, it can be assumed that the general experience in robot-related domains affects the acquisition of robot-specific expertise. During the first encounter with a robot, older adults are assumed to base not only attitudinal and emotional reactions, i.e., initial anxiety and attitude ratings, but also behavioral reaction towards a robot on their general experience in robot-related domains. Hence, older novice robot users with different levels of general experience can be suggested to show differences in their behavior towards the robot. Differences in the human-robot interaction, in turn, may result in qualitatively different expertise gained from the interaction with the robot. Several studies with animistic robots confirm the association of general experience in robot-related domains with human-robot interaction behavior. Shibata and Tanie (2000) concluded from an interaction study that people use their general experience with animals to both form expectations about a zoomorph (animal-like) robot and to interact with it. In addition, evidence was found that former pet-owners committed more to a zoomorph interface agent (Parise, Kiesler, Sproull, & Waters, 1999) and showed more pet-directed behavior towards the robot seal Paro (Shibata, Kawaguchi, & Wada, 2012) than those who did not. Studies showing differences in robot evaluation according to differences in human-robot interaction are rather scarce, but the available literature confirms that initial expectations and interaction behavior can affect subsequent robot evaluation (e.g., Broadbent, MacDonald, Jago, Juergens, & Mazharullah, 2007; Broadbent, Lee, Stafford, Kuo, & MacDonald, 2011). As a consequence, the discrepant research findings in previous studies on the effects of increasing robot-specific expertise could be explained by sample differences in the levels of general experience, which differently affect expertise-induced changes in robot acceptance.

Relevant domains of general experience – the importance of the robot's design

As outlined above, research on the role of general experience for older adults' anxiety and attitude towards robots has concentrated on general experience with technology as the only relevant domain. However, research on categorization learning suggests that particularly novices select relevant domains of general experience based on superficial features, i.e., the outer appearance of an entity (e.g., Shafto & Coley, 2003). Social robots for older adults differ widely in appearance and functions, ranging along a continuum from mechanoid (machine-like) to animistic (imitating living beings). Consequentially, novice elder robot users may rely not only on general experience with technology to guide their reactions towards a robot but also on the general experience with living beings, depending on the robots' design. This is corroborated by studies mainly involving younger people. They show that different abilities, tasks, and personality characteristics are attributed to robots according to their outer appearance after participants saw them on pictures (Rosenthal-von der Pütten & Krämer, 2015; Hwang, Park, & Hwang, 2013). All the same, characteristics and abilities were also attributed to robots after participants watched videos of them, informing them not only about robot appearance but also about the robot's functions (Syrdal, Dautenhahn, Woods, Walters, & Kaoy, 2008; Rosenthal-von der Pütten & Krämer, 2015).

As a result, it is suggested that relevant domains of general experience extend beyond technology experience alone (Syrdal, Koay, Walters, Dautenhahn, & Otero, 2010), and depend predominantly on the robot's design. However, no study was found to examine the role of the robot's design for the association between general experience and older adults' anxiety and attitude towards robots systematically.

Study aims

In order to contribute to a better understanding of robot acceptance by older adults, the current study investigates the role of general experience in robot-related domains and robot-specific expertise for older adults' anxiety and attitudes towards robots not only separately, but under particular consideration of their dynamic interplay. Moreover, attention is also given to the role of the robot's design regarding the relevance of different domains of general experience.

To provide for increasing robot-specific expertise, a stepwise introduction procedure was conducted which allowed for the gradual provision of more knowledge and hands-on experience with the robots. To assess the relevance of the robot's design, a zoomorph robot (imitating a real animal by appearance and function) and a mechanoid robot (resembling a technological artifact by appearance and function), both targeted at supporting the fulfillment of older adults' psychosocial needs, were used.

Based on the theoretical and empirical findings presented above, we assumed that:
(1) General experience in robot related-domains will directly be associated with anxiety and attitudes towards the robots at the beginning of the introduction procedure, i.e., before participants acquire robot-specific expertise. As the relevant domain of general experience is assumed to depend on the robot's design, the following is proposed: (a) General animal experience will be associated with anxiety and attitude towards the zoomorph robot and (b) General technology experience will be associated with anxiety and attitude towards the mechanoid robot.
(2) No significant association between general experience in robot-related domains and older adults' anxiety and attitude will be found at the end of the introduction procedure, indicating an impact of increasing robot-specific expertise on the role of general experience.
(3) Increasing robot-specific expertise will be associated with changes in older adults' anxiety and attitude ratings. Thus, anxiety and attitude measures before and after the interaction procedure will differ significantly.
(4) Changes in older adults' anxiety and attitude ratings will differ according to the levels of general experience, indicating an impact of general experience on the acquisition of robot-specific expertise. As the relevant domain of general experience is assumed to depend on the robot's design, the following is proposed: (a) General animal experience will be associated with changes in anxiety and attitudes towards the zoomorph robot and (b) General technology experience will be associated with changes in anxiety and attitudes towards the mechanoid robot.

METHODS

The data presented here was collected as part of a comprehensive research project on the acceptance of social robots by different stakeholders involved in eldercare ("ERimAlter"; Emotional Robotics in Old Age) funded by the German Federal Ministry of Education and Research (BMBF). Other parts of the project were published elsewhere (see Baisch et al., 2017). We will only refer to those parts of the project sample and design relevant here.

Participants

A random sample of N = 31 older adults took part in the study. They were at least 65 years old and in good cognitive and physical health, as assessed by self-report. Participants were recruited from the "University of the Third Age" located at the Goethe-University of Frankfurt/Main, Germany, and received an allowance of € 100 for their participation (Acknowledgements).

The data of two participants had to be excluded from the project due to significant cognitive or medical problems. Two further participants were excluded due to missing values in key variables. The final sample consisted of N = 27 participants. Median age was M = 70.55 years (SD = 4.16; age range: 65 – 81 years). Most participants were female (n = 22; 82%) and had taken the German

Abitur (equals A-levels; n = 16; 59%). With M = 3.21 (SD = 1.00) and M = 2.50 (SD = 1.26), respectively, both experience with technology and with animals were mediocre in this sample. Animal experience (Mdn = 2.50, scale range: 1-5) ranged from completely inexperienced (sample minimum = 1) to very experienced (sample maximum = 5). Technology experience (Mdn = 3, scale range: 1-5) ranged from rather inexperienced (sample minimum = 1.71) to very experienced (sample maximum = 5). Consequentially, the sample can be considered as heterogeneous with regard to both domains of general experience.

Robots

Two commercially available social robots, Giraff and Paro, were used in this study (*Figure 1*). These robots have in common that they are aimed at supporting the fulfillment of psychosocial needs.

Giraff by Camanio Care AB (*Figure 1A*) is a mobile remote telepresence robot, which is set up like common computer-based videoconferencing systems such as Skype® or FaceTime®. As the robot allows for remote social contact and communication over longer distances (for a detailed description of Giraff's functions, see Kristofferson, Coradeschi, & Loutfi, 2013), it is utilized mostly in home-based care settings. Despite its name, Giraff has a mechanoid design without any animistic features in appearance and functions.

The companion-type therapeutic robot Paro by Intelligent System Co. Ltd. (*Figure 1B*) mimics a harp seal pup by its outer appearance and function. Thus, it resembles an unthreatening real animal with a life-like design of appearance and functions. The robot is designed to elicit positive emotional reactions in its users and to provide for communication and contact either between older adults about the robot or with the robot itself (for a detailed description of Paro's functions, see Shibata, Wada, Saito, & Tanie, 2005; for a detailed description of the social and emotional processes involved, see Kolling et al., 2016).

Instruments

Attitude towards robots

To assess attitude towards robots (ATT) a study-specific seven-point semantic differential consisting of 13 items based on the idea of the RAS (Robot Attitude Scale; Stafford, MacDonald, Jayawardena, Wegner, & Broadbent, 2014) was used. Contrary to the RAS, which was previously used with a non-social healthcare robot, the emphasis was put on items assessing the emotional effects of the robots. Cronbach's Alpha was computed as a measure of internal consistency of the scale for each assessment for both robots. Items which reduced internal consistency for at least two of each robot's assessments were excluded from further analysis. The remaining as well as the excluded items are presented in *Table 1*. The scales' final internal consistencies were very high (Cronbach's Alpha ≥ .90) for each assessment for both robots.

Since the ATT measure is a study-specific questionnaire, a principal component analysis was performed to determine its factor structure. As can be seen in *Table 1*, two factors were extracted at assessment 1, which collapsed into one factor at assessment 2 and 3. Factor loadings of items onto the respective factors were high or very high (Lambda >.70) for all but three items (Lambda >.48) across all of the assessments.

A mean score was calculated for each of the two factors at assessment 1. The overall mean of the two factor means was used for further analysis. Due to the one-factorial structure at assessments 2 and 3, the mean score of all items was computed for further analysis.

Robot-related anxiety

To assess robot-related anxiety (ANX), two items of the anxiety scale proposed by Heerink, Kröse, Evers, and Wielinga (2009) for the investigation of the acceptance of socially interactive robots were used (*"When I used the seal/giraffe, I was afraid of making mistakes", "When I used the*

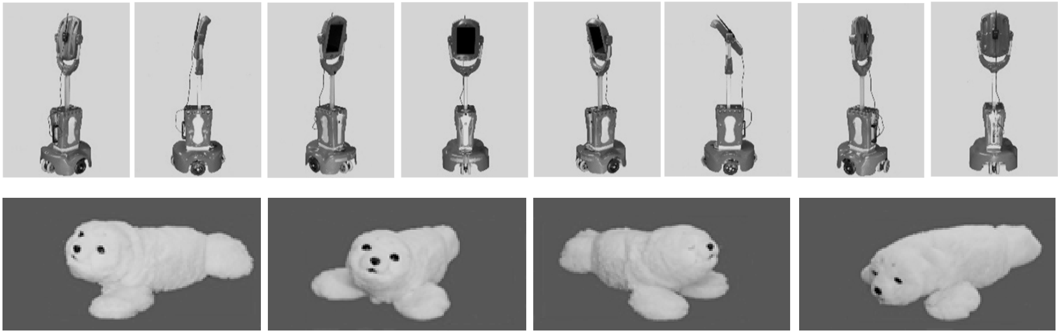

Figure 1. Pictures of the robots a shown to participant instep 1 of the introduction procedure (Top: Giraff and bottom: Paro)

Table 1. ATT items and factor loadings

ATT – items	Factor loadings							
	Paro				Giraff			
Assessment no.	*1*		*2*	*3*	*1*		*2*	*3*
Appealing – repellant	**.77**		**.83**	**.85**	**.96**		**.81**	**.83**
Guarding – threatening	**.68**	.41	**.77**	**.79**	**.64**	.61	**.78**	**.85**
Reassuring – daunting		**.85**	**.57**	**.87**	**.70**	.55		
Relieving – encumbering	**.48**		**.75**	**.90**	**.72**	.56	**.83**	**.87**
Friendly – unfriendly	**.93**		**.85**	**.81**	**.67**	.57	**.74**	**.73**
Presentable – embarrassing	**.89**		**.81**	**.90**	**.75**	.40	**.69**	**.87**
Well-made – failed	**.86**		**.80**	**.83**	.47	**.58**	**.85**	**.83**
Useful – pointless	.47	**.82**	**.88**	**.77**		**.86**	**.85**	**.77**
Interesting – uninteresting		**.83**	**.90**	**.77**		**.86**	**.81**	**.87**
R^2	*74%*		*64%*	*69%*	*77%*		*64%*	*66%*

Note: Excluded from final scale: agreeable - disagreeable, emotional – unemotional, personal – impersonal, boring – exciting. PCA: Principal Component Analysis (assessment 1: Varimax-rotation with Kaiser Criterion). Factor loadings <.40 are omitted.

seal/giraffe, I was afraid of breaking something.", I agree… 1= not at all / 5 = completely). The scale showed a sufficient to high internal consistency for both assessments (.77 < Cronbach's Alpha < .90). The mean score of the respective scale items was used for analysis.

General technology experience
General technology experience was assessed by a 7-item questionnaire used in prior research (e.g., "*A job that had a lot to do with technology, wouldn't have been for me.*", 1 = does not apply at all / 5 = applies perfectly; Mollenkopf, Oswald, & Wahl, 2007). Factor analysis showed that all items loaded onto one factor. The scale had a high internal consistency (Cronbach's Alpha = .90). The mean score of the scale items was used for analysis.

General experience with animals
General animal experience was assessed by two items adapted from the Person-Robot Complex Interaction Scale by Libin and Libin (2004) ("*In my life, I have had a lot to do with animals*", "*During all my life, I always had pets at home*", 1 = does not apply at all / 5 = applies perfectly). The mean score of the two items was used for analysis.

Design

Effects of increasing robot-specific expertise were assessed by repeated measures of robot-related anxiety and attitude towards the robot administered throughout the introduction procedure presented in *Table 2* (further details can be found below in the 'procedure' section).

Attitude towards robots was assessed three times for each robot. Assessment 1 was performed after the first part of the first step of the introduction procedure to record participants' initial evaluation of the robot. Assessment 2 took place after interaction with the robot. To measure participants' final attitude towards the robot, assessment 3 was conducted at the end of the introduction procedure, i.e., after participants had watched the application videos. Robot-related anxiety was assessed twice, with assessment 1 taking place just before participants interacted with the respective robot (second part of the first step). Assessment 2 was administered after participants had interacted with the respective robot.

Furthermore, between-subjects comparisons were performed in order to assess main and interaction effects of general experience in robot-related domains on robot acceptance. To this end, the sample was split post-hoc into two subsamples, resulting in one subsample with low and one with high experience with technology or animals, respectively. Participants with scores equivalent to or higher than the scale mean (value of 3 for the scales' range of 1-5) were included in the high experienced subsample, those with scores below the scale mean were part of the low experienced subsample.

Regarding general animal experience, n = 16 (59%) participants were allocated to the low, and n = 11 (41%) participants to the high experience subsample. With regard to general technology experience, n = 12 (44%) participants were allocated to the low and n = 15 (56%) participants to the high experience subsample. As participants were introduced

Table 2. Stepwise introduction procedure

Stepwise introduction procedure	Step 1(prior to interaction)		Step 2 (interaction)	Step 3 (use cases)
	Part 1	Part 2		
Presentation mode	Pictures	Video	Human-robot interaction	Video
Information gained	Basic information	Information on robot functions	Direct experience	Knowledge on use cases
Assessment	Assessment 1		Assessment 2	Assessment 3
	ATT	ANX	ATT, ANX	ATT

Note. ATT: attitude towards robots; ANX: robot-related anxiety to both robots in randomized order, the quasi-experimental procedure resulted in a 2x2x3 mixed design for attitude towards robots and a 2x2x2 mixed design for robot-related anxiety.

Procedure

A stepwise introduction procedure was conducted in individual sessions to gradually increase participants' expertise with the respective robot (*Table 2*). The procedure consisted of three steps.

The first step of the introduction procedure, before participants interacted with the robot, was divided into two parts. In the first part, participants were shown the respective robot on pictures in a laptop slideshow as presented in *Figure 1*, whilst they were verbally given details on the robots outer appearance, e.g., height, shape, and weight. In the second part, the respective robot's basic functions were explained in a video. In the Giraff video, participants were introduced to the videoconferencing system and mobile functions of the robot. They first watched a call being made via Giraff with an older adult answering the call by remote control. Afterwards, they saw how the robot is moved across the room towards the older adult and both interaction partners greet. Finally, they were shown how it is parked and docked at the recharging unit. During the scenes, an off-voice explains all of the processes.

In the Paro video, participants were shown the interactive abilities of the robot. They watched how it reacts to touch and voice both by sound as well as by motion, and watched it behave independently of stimulation. Finally, they were shown how Paro is recharged. During the scenes, an off-voice explained Paro's proactive as well as reactive features, its motion capabilities, its "sleeping cycle", as well as how it is recharged.

In the second step, participants were instructed on how to handle the robot and then interacted with it as long as they pleased. In order to experience the older adult's perspective, participants answered a call by the experimenter via remote control and watched Giraff move across the room towards them. With the robot in front of them, they were spoken to by the experimenter via Giraff. The participants were then invited to navigate the robot across the room themselves to experience the caregivers' perspective. Participants received instructions on how to operate the robot and, if necessary, they were given support with using the laptop mouse.

During the interaction with Paro, participants watched the robot being switched on. They were then shown how Paro reacts to voice and touch, i.e., to being touched in different body parts and to being caressed as opposed to being plagued. Afterwards, participants were invited to hold Paro as well as to cuddle the robot and to talk to it.

In the third step, participants watched a video of use case scenarios showing cognitively and physically impaired older adults interacting with the respective robot (Giraff: "Paula visits Pat", van Rump, 2013; Paro: sequences of "Roboter zum Kuscheln – Heilsam für Demenzkranke" ["Robots for Cuddling – beneficial for People suffering from Dementia"], Wagner, 2011). In both videos, an off-voice explains the oncoming application scenario in-between the scenes.

In the Giraff video, an older woman interacts with a formal caregiver via the robot. The use cases referred to everyday situations, i.e., reminding and controlling for medication intake, support in dealing with household equipment (i.e., getting the coffee machine to work), security issues (i.e., forgetting to turn off the stove), and social contact (i.e., face-to-face communication). In the Paro video, participants watched nursing home residents interacting with Paro in group and individual settings. Furthermore, Paro-facilitated interactions between nursing home residents and nurses are presented.

Participants' sociodemographic data and general experience in robot-related domains were assessed before participants were introduced to the robots.

Data analysis

Data analysis was performed using SPSS 24. In order to assess the association of anxiety and attitude ratings with general experience in robot-related domains, Pearson product-moment correlation coefficients were computed for both outcome measures for each assessment. Differences between correlation coefficients were computed by Steiger's z-Test. T-scores of correlation coefficient change above the critical value of 1.71 at a significance level of Alpha = .05 were reported significant.

Furthermore, one-way repeated measures ANOVAs were performed to assess changes in ATT throughout the introduction procedure for the overall sample. When sphericity could not be assumed, the Greenhouse-Geisser correction was applied. For ANX, t-tests were performed as ANX was only assessed twice. Main and interaction effects of assessment (robot-specific expertise) and general experience in robot-related domains were computed by two-way repeated measures ANOVAs for each outcome variable and each domain of general experience.

Table 3. Association between general experience in robot-related domains and anxiety and attitudes towards Paro

	General animal experience	***General technology experience***
Paro		
ATT		
Initial (ass. 1)	**.39***	.17, *ns*
After interaction (ass. 2)	.22, *ns*	.00, *ns*
Final (ass. 3)	.21, *ns*	.11, *ns*
ANX		
Prior to interaction (ass. 1)	**-.35**^{t}	-.11, *ns*
After interaction (ass. 2)	.18, *ns*	-.06, *ns*
Giraff		
ATT		
Initial (ass. 1)	.22, *ns*	**.36**^{t}
After interaction (ass. 2)	.18, *ns*	**.28**^{t}
Final (ass. 3)	.17, *ns*	.05, *ns*
ANX		
Prior to interaction (ass. 1)	-.23, *ns*	**-.39***
After interaction (ass. 2)	-.30, *ns*	-.30, *ns*

Note. Pearson Product-Moment Correlation; ^{t} Trend, .066 < α < .081; * α < .05.

RESULTS

Preliminary analysis

As the presentation of the first robot could affect the evaluation of the second one, we tested the assumption of the presence of order effects (H1) against the assumption of an absence of order effects (H0). A MANOVA showed significant effects of presentation order neither regarding ANX and ATT ratings of Giraff (V = 0.07, F(5, 31) = 0.45, ns) nor of Paro (V = 0.26, F(5, 21) = 1.47, ns).

The role of general experience and robot-specific expertise for older adults' anxiety and attitude towards Paro

The changing role of general experience

With respect to the zoomorphic robot Paro, it was assumed that general animal rather than general technology experience would be associated with anxiety and attitude ratings prior to the interaction with the robot. It was suggested that this association would decrease with increasing expertise with Paro, indicating an impact of increasing robot-specific expertise on the role of general experience. The results are presented in *Table 3*.

No significant correlation between general technology experience and any of the two outcome measures was found for assessments 1, 2, and 3 ($.00 < r_{ATT} < .17$, ns; $-.11 < r_{ANX} < -.06$, ns). In addition, no significant changes in these correlation coefficients due to increasing expertise with Paro emerged, ATT: $t_{1\text{-}3}$(df = 24) = 0.39; $t_{1\text{-}2}$(df = 24) = 1.24; $t_{2\text{-}3}$(df = 24) = 1.46; ANX: $t_{1\text{-}2}$(df = 24) = 0.25. General animal experience showed a positive, statistically significant correlation with ATT for assessment 1 (r_1 = .39, p = .046) as well as a negative trendwise association with ANX (r_1 = -.35, p = .077). This indicates that, as expected, higher general animal but not technology experience was associated with less anxiety and a more positive attitude towards Paro at the beginning of the introduction procedure.

For assessments 2 and 3, the association between ATT and general animal experience was no longer significant (r2 = .22, ns; r3 = .21, ns), indicating that its relevance for older adults' attitudes towards robots decreased throughout the introduction procedure, as expected. The decrease in correlation coefficients was not significant, $t_{1\text{-}3}$(df = 24) = 1.27; $t_{1\text{-}2}$(df = 24) = 1.31; $t_{2\text{-}3}$(df = 24) = 0.13.

Similar results were found for ANX. For assessment 2, the association between ANX and general animal experience was no longer significant (r_2 = .18, ns). Hence, the role of general experience in this domain decreased after as compared to before the interaction, as expected. The change in correlation coefficients was significant, $t_{1\text{-}2}$(df = 24) = 3.04.

Effects of increasing robot-specific expertise on older adults' anxiety and attitude

It was assumed that anxiety and attitude towards Paro would change throughout the introduction procedure due to increasing robot-specific expertise (*Figure 2*).

With regard to ATT, a one-way repeated measures ANOVA with Greenhouse-Geisser correction showed a significant main effect of assessment, as expected, F(1.39, 36.21) = 6.09, p = .011, Eta-square = .19. As can be seen in *Figure 2A*, initial ATT for Paro was already rather positive, but still became more positive throughout the introduction procedure. Bonferroni-corrected post-hoc tests revealed a significant overall change for the positive, $diff_{1\text{-}3}$ = .44, p = .023, CI: 0.05 - 0.82.

With respect to ANX, no significant differences after, as compared to before, the interaction with the robot were found contrary to the initial assumptions, t(df = 26) = 1.12, ns (*Figure 2B*).

Impact of general experience on changes in older adults' anxiety and attitude

It was assumed that changes in anxiety and attitude ratings for Paro would differ according to

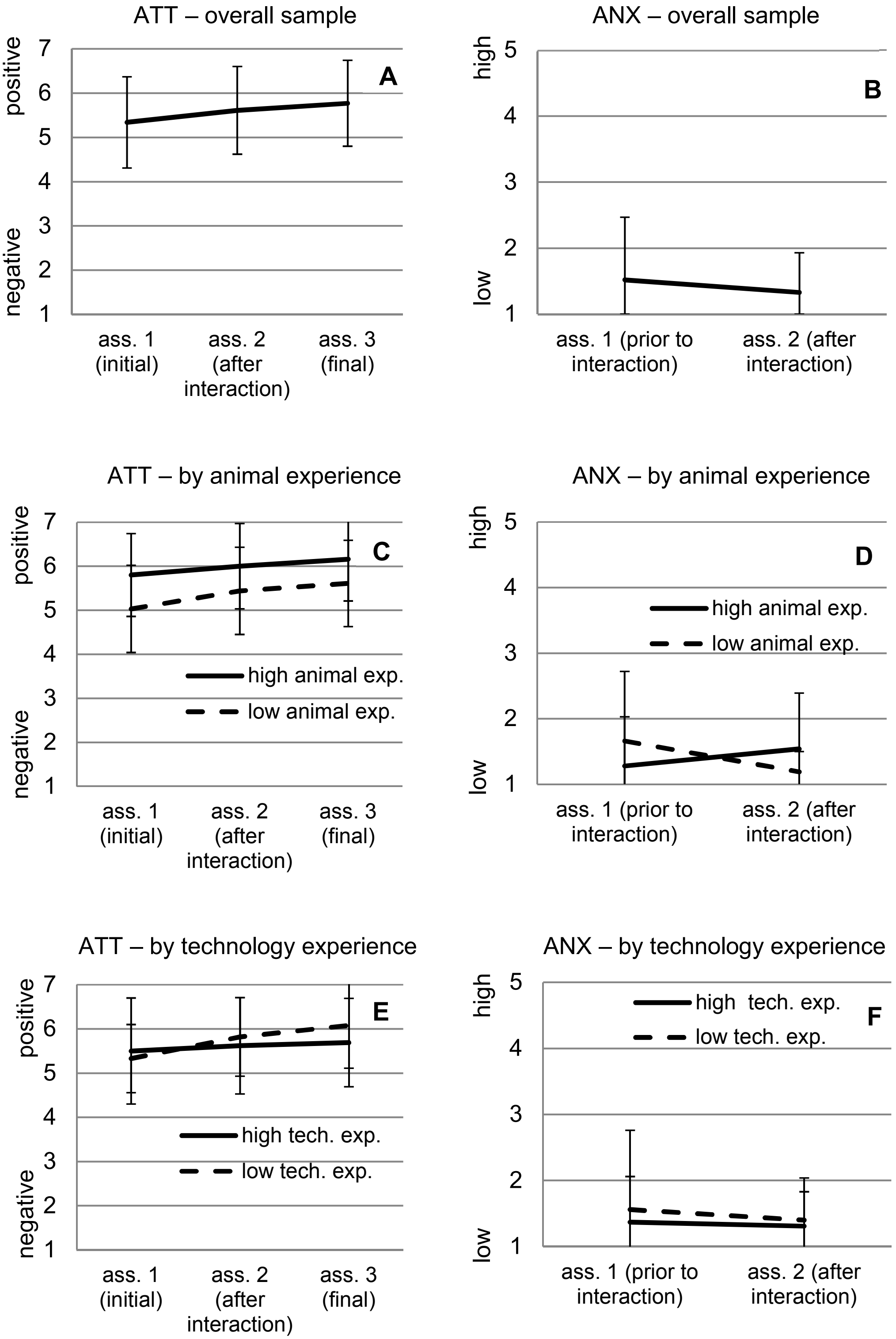

Figure 2. Paro: Mean and standard deviation for ATT and ANX throughout the introduction procedure for the overall sample and the high and low experience subsamples of both domains of general experience

levels of general animal but not technology experience (*Figure 2*).

With regard to ATT, the two-way repeated measures ANOVA with Greenhouse-Geisser correction showed a significant main effect of assessment (F(1.47, 33.87) = 7.34, p = .005, Eta-square = .24), indicating a positive overall change of ATT ratings throughout the introduction procedure.

Furthermore, there was a trend for a main effect of the general animal experience, F(1, 23) = 3.12, p = .091, Eta-square = .12. As can be seen in *Figure 2C*, the high animal experience subsample held a more positive attitude towards Paro throughout the introduction procedure as compared to the low experience subsample. Contrary to the initial assumptions, no significant interaction effect between assessment and general animal experience was found, F(1.47, 33.87) = 0.49, ns.

Regarding ANX, a two-way repeated measures ANOVA showed no main effect of assessment (F(1, 23) = 0.42, ns) or animal experience (F(1, 23) = 0.00, ns). However, as expected, an interaction effect was found, F(1, 23) = 5.05, p = .035, Eta-square = .18. As can be seen in *Figure 2D*, before the interaction with Paro, ANX was lower in the low animal experience subsample as compared to the high experience subsample. Yet, this relation was reversed after the interaction.

As expected, no significant main or interaction effects of general technology experience on ATT (F(1, 23) = 0.16, ns; F(1.47, 33.87) = 2.57, ns, respectively; see *Figure 2E*) or ANX (F(1, 23) = 0.27, ns; F(1, 23) = 0.10, ns, respectively, see *Figure 2F*) emerged.

The role of general experience and robot-specific expertise for older adults' anxiety and attitude towards Giraff

The changing role of general experience

With regard to the mechanoid robot Giraff, it was assumed that general technology but not animal experience would be associated with anxiety and attitude ratings prior to the interaction with the robot. Moreover, it was proposed that the association between general technology experience and the outcome measures would decrease with increasing expertise with Giraff, indicating an impact of increasing robot-specific expertise on the role of general experience. The results are presented in *Table 3*.

No significant associations between general animal experience and any of the outcome measures were found for assessments 1, 2, and 3 ($.17 < r_{ATT} < .22$, ns; $-.23 < r_{ANX} < -.30$, ns). In addition, there were no significant changes in these correlation coefficients due to increasing expertise with Giraff, ATT: t_{1-3}(df = 24) = 0.31, ns; t_{1-2}(df = 24) = 0.30, ns; t_{2-3}(df = 24) = .10, ns; ANX: t_{1-2}(df = 24) = .49, ns. With regard to general technology experience, a statistical trend for a positive correlation with ATT emerged at the first two assessments (r_1 = .36, p = .066; r_2 = .28, p = .081). As expected, ANX and general technology experience were significantly and negatively correlated at assessment 1 (r_1 = - .39, p = .047). This indicates that general technology but not general animal experience played a relevant role for initial anxiety and attitude ratings for Giraff, as expected.

At assessment 2, the correlation between technology experience and ATT decreased, and at assessment 3, the correlation coefficient had reached a value close to zero (r_3 = .05, ns). Hence, as expected, the relevance of general technology experience for attitude ratings decreased throughout the introduction procedure. The overall decrease in correlation coefficients was significant (t_{1-3}(df = 24) = 2.10) as a result of a significant decrease in correlation coefficients between assessments 2 and 3, t_{2-3}(df = 24) = 2.62. The change in correlation coefficients between the first two assessments was not significant, t_{1-2}(df = 24) = 0.63.

Equally, no significant association between technology experience and ANX was found at assessment 2 (r_2 = -.30, ns), indicating a decrease in the relevance of general technology experience for ANX after as compared to prior to the interaction. The change in correlation coefficients was not significant, t_{1-2} = 0.62.

Effects of increasing robot-specific expertise on older adults' anxiety and attitude

It was assumed that anxiety and attitude ratings for Giraff would change throughout the introduction procedure due to increasing robot-specific expertise (*Figure 3*). Regarding ATT, a one-way repeated measures ANOVA with Greenhouse-Geisser correction showed a significant main effect of assessment, as expected, F(1.47, 38.12) = 8.70, p = .002, Eta-square = .25. As can be seen in *Figure 3A*, ATT grew increasingly positive throughout the introduction procedure. Bonferroni-corrected post-hoc tests revealed a significant overall positivation, $diff_{1-3}$ = .67, p = .007, CI: 0.16 - 1.18. This is due to a significant change for the positive from assessment 2 to 3, $diff_{2-3}$ = .39, p = .005, CI: 0.11 - .68. Contrary to the initial assumptions, a t-test showed no significant difference in ANX before as compared to after the interaction, t(df = 26) = -1.68, ns (*Figure 3B*).

Impact of general experience on changes in older adults' anxiety and attitude

It was assumed that changes in anxiety and attitudes towards Giraff would differ according to the level of general technology experience, but not according to the level of general animal ex-

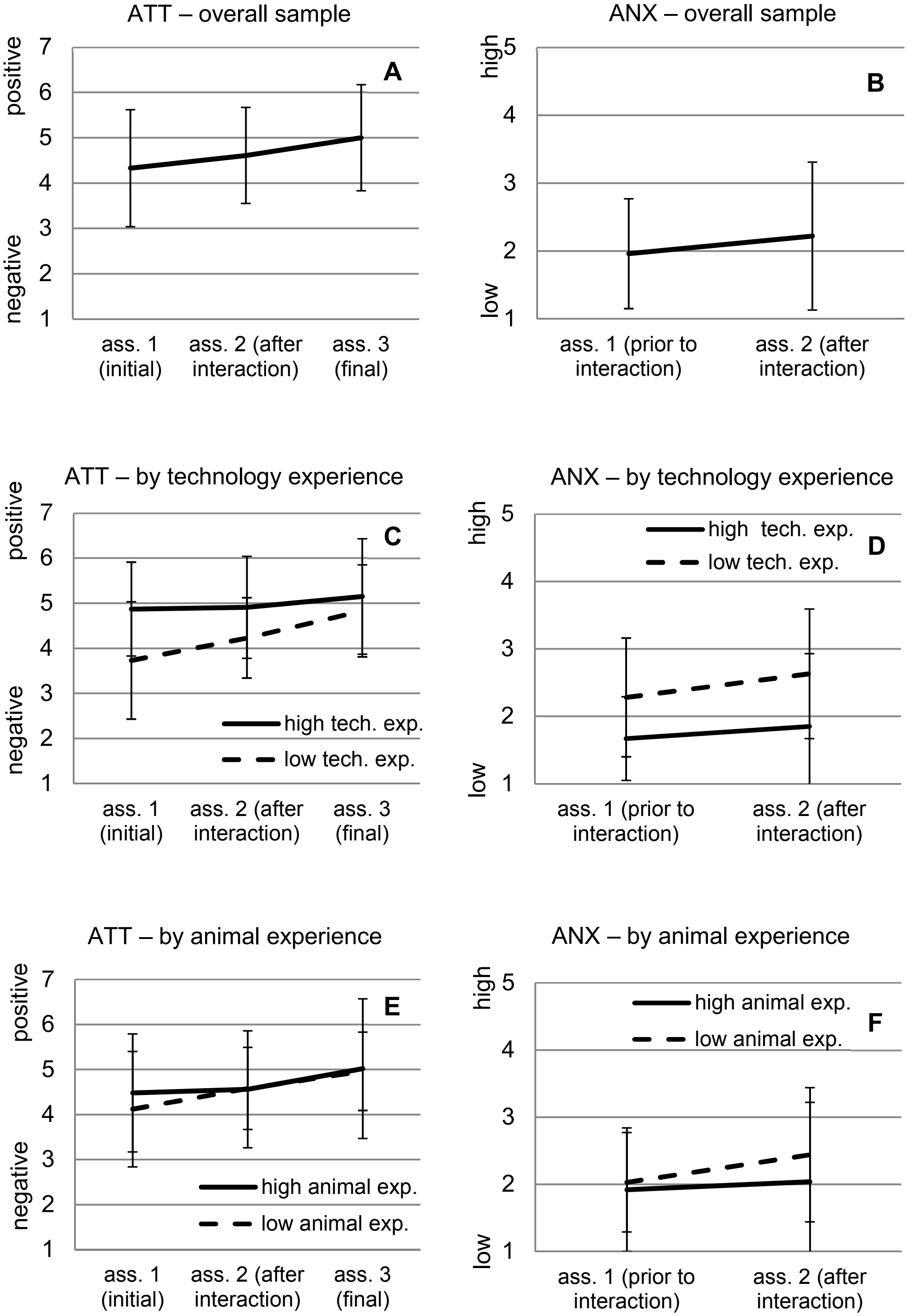

Figure 3. Giraff: Mean and standard deviation for ATT and ANX throughout the introduction procedure for the overall sample and the high and low experience subsamples of both domains of general experience

perience (*Figure 3*).

With regard to ATT, a two-way repeated measures ANOVA with Greenhouse-Geisser correction showed a significant main effect of assessment, F(1.54, 35.44) = 8.97, p = .002, Eta-square = .28. Moreover, although not present at the multivariate level (F(2, 22) = 2.14, p = .142, Eta-square = .16), there was a trend towards an interaction effect between assessment and technology experience at the univariate level, as expected, F(1.54, 35.44) = 3.08, p = .070, Eta-square = .12. Simple contrasts revealed a marginally significant difference in the overall change in ATT between both groups, F(1, 23) = 4.23, p = .051, Eta-square = .15. As can be seen in *Figure 3C*, the low technology experience subsample initially held a more negative attitude towards Giraff and showed a stronger change for the positive in ATT than the high technology experience subsample. No significant main effect of general technology experience was found, F(1, 23) = 2.82, ns.

Regarding ANX, a two-way repeated measures ANOVA showed no significant main effect of assessment, F(1, 23) = 2.60, ns. However, contrary to the initial assumption, there was a main effect of general technology experience, F(1, 23) = 4.41, p = .047, Eta-square = .16. As can be seen in *Figure 3D*, the low experience subsample indicated significantly higher anxiety scores than the high experience subsample both before and after the interaction. No significant interaction effect of assessment and general technology experience were found, F(1, 23) = 0.26, ns.

As expected, there were no significant main or interaction effects of general experience with animals on ATT (F(1, 23) = 0.96, ns; F(1.54, 35.44) = 0.74, ns; respectively; *Figure 3E*) or on ANX, (F(1, 23) = 0.60, ns; F(1, 23) = 0.80, ns, respectively; *Figure 3F*).

Discussion

The dynamics of two types of experience, i.e., general experience in robot-related domains and robot-specific expertise, at first encounter with a robot as well as their role for older adults' anxiety and attitudes towards robots were investigated. Furthermore, the effect of the robot's design was examined by using two different social robots, i.e., the mechanoid robot Giraff and the zoomorph robot Paro.

Experience as a resource for robot acceptance

The initial role of general experience and the relevance of the robot's design

Firstly, it was assumed that general experience in robot-related domains would be associated with older adults' anxiety and attitude towards each of the robots (hypothesis 1). Results of the current study confirm this assumption extending previous research s(e.g., Pino et al., 2015; Ezer et al., 2009; Heerink, 2011) by showing that more general experience is not only associated with a more positive attitude towards a robot, but also with less robot-related anxiety. Hence, general experience constitutes a relevant resource for older adults' initial robot acceptance.

As predicted, the relevant domains of general experience were found to differ according to the robots' designs throughout the introduction procedure. The finding is in line with research on the relevance of a new entity's design for selecting appropriate domains of general experience particularly in novices (e.g., Shafto & Coley, 2003). Additionally, the finding highlights the important contribution of the robots' outer appearance to the initial robot acceptance by older adults. It is of peculiar relevance for robot designers to elicit the right mental representation in users to make a robot not only most usable (O'Brian et al., 2012), but also most acceptable. Thus, in order to design robots which motivate older adults to give it a try, it is important to consider the envisaged user group's level of general experience in domains related to the robot's design.

The role of increasing robot-specific expertise for robot acceptance and general experience

Increasing robot-specific expertise was associated with several positive effects on older adults' anxiety and attitude towards robots.

Firstly, it was associated with significant positive changes in older adults' attitude towards each of the robot in the overall sample. Although the findings are in line with some previous findings (e.g., Stafford et al., 2010), they contradict other studies which show no attitudinal change (e.g., Damholdt et al., 2015; Kuo et al., 2009) or a negative change (Wu et al., 2014) as a result of increasing robot-specific expertise. Study design might play a relevant role in this context since the studies differ regarding the measurement of the theoretical construct of attitude measured and the amount of exposure to the robot. More studies are needed to disentangle the effects of different outcome measures and of the amount of exposure to the robot on robot acceptance.

In addition, subsample analysis of older adults with high and low relevant general experience showed an interaction effect for Giraff. The low experience subsample benefited particularly well from increasing robot-specific expertise, and the initial differences in attitude between the high and the low experience subsample almost equaled out at the end of the introduction procedure. Regarding Paro, older participants with less animal experience showed a decrease in robot-related anxiety, thereby approaching initial anxiety levels of more experienced participants.

Secondly, this study also shows that the relevance of general experience for both aspects of robot acceptance decreased with increasing robot-specific expertise with both robots. Together with the changes for the positive regarding participants' attitude towards the robots, this is a promising finding. It indicates that interventions intended at giving older adults information about and opportunities to interact with a robot can improve particularly the attitude and anxiety of less experienced older adults towards it. Thus, the disadvantage of having little general experience in a robot-related domain can be overcome.

Experience-related barriers to robot acceptance

It has to be noted, though, that increasing robot-specific expertise and general experience in robot-related domains did not always function as a resource for robot acceptance.

Firstly, despite significant changes in participants' attitude towards robots, no significant change in robot-related anxiety was found due to increasing robot-specific expertise. Nonetheless, participants showed a slight, but non-significant increase in anxiety after interaction with Giraff in both the high and the low experience subsample. Regarding Paro, subsample analysis revealed that the animal experienced subsample showed a significant increase in robot-related anxiety. This was masked in the overall sample by a decrease in anxiety in the low experience subsample. On the one hand, increases in anxiety after interaction with the robot have been reported before in studies involving younger samples (de Graaf & Ben Allouch, 2013). On the other hand, the current results contradict findings which show a decrease in older adults' negative affect (e.g., Stafford et al., 2010; Broadbent et al., 2010). However, anxiety is but one aspect of negative affect, and thus, decreases in other aspects may have obscured increases in anxiety in the latter studies. A possible explanation for increased anxiety after interaction with a robot may be found in participants' initial expectations regarding their mastery of the human-robot interaction in comparison to their actual experience. Initially holding high robot-related self-efficacy beliefs, participants may have realized that the interaction with the robot followed other rules than expected. This may have then resulted in an increase in robot-related anxiety. General support for this assumption comes from the Expectation-Disconfirmation Theory (Oliver, 1997), which shows that a disconfirmation of initial expectations can lead to the negative evaluation of a product. In robot acceptance research, the disadvantageous effects of expectation-disconfirmation on robot acceptance has been investigated regarding a robots' capabilities (e.g., Kwon, Jung, & Knepper, 2016; Komatsu, Kursowa, & Yamada, 2011; Mori, 1970/2012). Yet, the results of the current study suggest to extend it to also consider user-centered self-efficacy expectations.

Secondly, some of the differences in robot acceptance between experienced and unexperienced participants remained stable throughout the introduction procedure. Regarding Paro, less animal experienced older participants showed a less positive attitude towards the robot at all assessments. This might reflect an underlying person characteristic of not appreciating verbal and nonverbal interaction with non-human beings, be it animals or animal-like robots. Regarding Giraff, less technology experienced participants showed higher anxiety throughout the introduction procedure than more experienced ones. Either the single exposure to the robot was not sufficient to reassure these participants or additional information would have been necessary to put technology inexperienced participants at ease with Giraff.

These results further highlight the importance of interventions to introduce particularly inexperienced older adults to robots. They also show that a single introductory exposure to robots cannot overcome a lack of general experience in all regards. It remains open to future research to examine whether less experienced older adults benefit from longer interaction duration, repeated exposure to a robot, or from more or qualitatively different information.

Limitations

Some limitations of the study need to be considered. Firstly, with 11 to 16 participants subsamples were rather small, restricting the generalizability of the results to the current sample of older adults. Moreover, participants were predominantly female and highly educated. Both gender and education can affect robot acceptance by older adults (see, e.g., Flandorfer, 2012; de Graaf & Ben Allouch, 2013). Future studies should use larger and more diverse samples in order to replicate the current findings.

Secondly, in this study, like in many others, attitude was measured by a one-dimensional construct. Yet, some research suggests that attitude is a multifaceted construct which can be differentiated, e.g., by attitude content (e.g., Nomura, Kanda, Suzuki, & Kato, 2008; Ninomiya, Fujita, Suzuki, & Umemuro, 2015). As the construct of attitude is defined quite differently across studies, more research on this construct and the role of its facets in the context of robot acceptance is needed.

Thirdly, no explicit distinction between positive and negative general experiences in robot-related domains has been made. Differences in the quality of general experiences may result in differences in the initial reactions towards a robot. For example, older individuals with negative general experiences in robot-related domains may be more prone to rejecting a robot as compared to older individuals with positive general experiences. In order to further investigate these relationships, future research should separately target the effects of positive and negative general experiences in robot-related domains.

Finally, it has to be pointed out that Paro and Giraff are fairly extreme examples of mechanoid and zoomorph robots. Many robots for older adults, however, range along a continuum in-between both extremes, showing both mechanoid and animistic features, e.g. a mechanoid assistive robot exhibiting social skills. It is well-known that giving a robot social skills strengthens the impression of the robot as a social interaction partner, i.e., a living being. Nonetheless, a mechanoid socially assistive robot is an ambiguous object. Power and Kiesler (2006) assume that a mechanoid robot exhibiting social traits will activate experience with and knowledge about both human beings and technology, since a novel object is assumed to simultaneously trigger the retrieval of knowledge and experience with all objects to which the novel object can be related (e.g. Hintzman, 1986). Hence, it can be suggested that both general experience with humans and with technology contribute to people's initial reactions towards a mechanoid socially assistive robot. However, it remains open to future research to empirically investigate this research question.

CONCLUSIONS AND FUTURE DIRECTIONS

To our knowledge, this study is the first study to report not only either the effects of general experience in robot-related domains or of robot-specific expertise on robot acceptance by older adults but also to show the reciprocal impacts of both types of experience on each other. Hence, the study has important implications for future research, robot development, and robot implementation.

It shows that older adults' general experiences need to be considered more thoroughly in robot development as they constitute an important individual resource for robot acceptance, e.g., by assessing the amount of general experience in robot-related domains available in a representative sample of a given target group prior to robot development. The beneficial role of general experience can then be supported by an appropriate design of the robot to reduce initial anxiety and optimize initial attitude towards the robot. However, a word of caution is also needed on this point. Although initially helpful in fostering robot acceptance, the robot's design together with general experience also seems to elicit specific user expectations regarding the interaction with the robot and the ability to handle it. If the interaction does not correspond to these expectations, user anxiety increases and, consequentially, robot acceptance can decrease particularly for robots initially evaluated positively. More research is needed on how to best balance robot design and interaction behavior.

With regard to robot implementation, the positive role of robot-specific expertise for robot acceptance by older adults needs to be pointed out particularly strongly, since robot-specific expertise is able to overcome the negative effect of having little general experience in robot-related domains at least in some regards. As a consequence, unexperienced older adults may benefit particularly well from interventions increasing their robot-specific expertise. Future studies should more closely investigate the role of expertise content, the order of content presentation, as well as affordances regarding the amount of support and interaction time in order to maximize the benefits of increasing robot-specific expertise.

From a theoretical point of view, the current study shows that psychological theories and empirical findings can help to explain robot acceptance by older adults. Moreover, it highlights that both robot and user characteristics contribute to robot acceptance. However, robot acceptance studies have so far centered majorly around the role of robot characteristics. More studies are needed which concentrate on the impact of characteristics of the older robot users, i.e., the vast body of general experience older people have acquired during lifetime, and their interplay with robot characteristics. Investigating robot acceptance from a user centered perspective, guided by psychological and gerontological theories can enhance robot development by providing a sound theoretical and empirical basis for robot development.

Finally, it has to be pointed out that it remains yet unclear as to how different operationalizations of the constructs of anxiety/negative affect and attitude impact on study results. The current study alludes several times to the different measures as a possible reason for discrepancies in study findings. Moreover, the question raises whether differences in the exposure times to robot and different measures of experience (quality vs. quantity) affect robot acceptance by older adults. Future research is needed comparing the different constructs, measures and study designs in order to investigate these assumptions.

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Research involving humans: The study was approved by the local Ethics Committee and was conducted in line with the ethical standards of the American Psychological Association (APA) and the German Association of Psychology (Deutsche Gesellschaft für Psychologie e.V., DGPs). Informed consent was obtained from all participants.

References

Andonova, E. (2006). On changing mental models of a wheelchair robot. Proceedings of the Workshop on How People talk to Computers, Robots, and Other Artificial Communication Partners, Germany, 131-139. Retrieved from: https://nats-www.informatik.uni-hamburg.de/pub/User/KerstinFischer/hriproc.pdf#page=133

Baisch, S., Kolling, T., Schall, A., Selic, S., Rühl, S., Kim, Z., Rossberg, H.H., Klein, B., Pantel, J., Oswald, F., & Knopf, M. (2017). Acceptance of social robots by elder people: Does psychosocial functioning matter? International Journal of Social Robotics, 9(2), 293-307. doi: 10.1007/s12369-016-0392-5

Beer, J., Smarr, C.-A., Chen, T.L., Prakash, A., Mitzner, T., Kemp, C.C, & Rogers, W. (March, 2012). The domesticated robot: Design guidelines for assisting older adults to age in place. 7th ACM/IEEE International Conference on Human-Robot Interaction 2012, USA, 335-342. doi: 10.1145/2157689.2157806

Broadbent, E., Kuo, H., Lee, Y.I., Rabindran, J., Kerse, N., Stafford, R., & MacDonald, B.A. (2010). Attitudes and reactions to a healthcare robot. Telemedicine and e-Health, 16(5), 608-613. doi: 10.1089/tmj.2009.0171

Broadbent, E., Lee, Y.I., Stafford, R.Q., Kuo, I.H., & MacDonald, B.A. (2011). Mental schemas of robots as more humanlike are associated with higher blood pressure and negative emotions in a human-robot interaction. International Journal of Social Robotics, 3(3), 291-297. doi: 10.1007/s12369-011-0096-9

Broadbent, E., MacDonald, B., Jago, L., Juergens, M., & Mazharullah, O. (2007). Human reactions to good and bad robots. Proceedings of the 2007 IEEE7RSJ International Conference on Intelligent Robots and Systems, USA, 3703-3708. doi: 10.1109/IROS.2007.4398982

Damholdt, M.F., Nørskov, M., Yamazaki, R., Hakli, R., Hansen, C.V., Vestergaard, C., & Seib, J. (2015). Attitudinal change in elderly citizens towards social robots: The role of personality traits and beliefs about robot functionality. Frontiers in Psychology, 6. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4653284/

De Graaf, M., & Ben Allouch, S. (2013). The relation between people's attitude and anxiety towards robots in human-robot interaction. Proceedings of the International Symposium on Robot and Human Interactive Communication (RO-MAN 2013), Korea, 632-637. doi: 10.1109/ROMAN.2013.6628419

Dewar, R.D., & Dutton, J.E. (1986). The adoption of radical and incremental innovations: An empirical analysis. Management Science, 32(11), 1422-1433. doi: 10.1287/ mnsc.32.11.1422

Elliott, S.W., & Anderson, J.R. (1995). Effect of memory decay on predictions from changing categories. Journal of Experimental Psychology: Learning, Memory and Cognition, 21(4), 815-836.

Ezer, N., Fisk, A.D., & Rogers, W.A. (2009). Attitudinal and intentional acceptance of domestic robots by younger and older adults. Universal Access in Human-Computer Interaction, 5615, 39-48. doi: 10.1007/978-3-642-02710-9_5

Fischer, K. & Lohnse, M. (2007). Shaping naïve users' models of robot situational awareness. 16th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN'07), Korea, 534-539. doi: 10.1109/roman.2007.4415144

Flandorfer, P. (2012). Population ageing and socially assistive robots for elderly persons: The importance of sociodemographic factors for user acceptance. International Journal of Population Research, 2012, Article ID: 829835. doi: 10.1155/2012/829835

Frennert, S., Östlund, B., & Eftring, H. (2012). Would granny let an assistive robot into her home? In A. Kheddar, E. Yoshida, S.S. Ge, K. Suzuki, J.-J. Cabibihan, F. Eyssel, & H. He (Eds.), Lecture Notes in Artificial Intelligence: Volume 7621. Proceedings of the 9th International Conference on Social Robotics (pp. 128-137). doi: 10.1007/978-3-642-34103-8_13

Gentner, D. & Markman, A.B. (1997). Structure mapping in analogy and similarity. American Psychologist, 52 (1), 45-56. doi: 10.1037/0003-066X.52.1.45

Gentner, D., & Smith, L. (2012). Analogical reasoning. In: V.S. Ramachandran (Ed.), Encyclopedia of Human Behaviour, 2nd Edition (pp. 130-136). Oxford: Elsevier.

Giuliani, M.V., Scopelliti, M., Fornara, F., Muffolini, E., & Saggrese (2003). Human-robot interaction: How people view domestic robots. Proceedings of the First RoboCare Workshop, Italy, 57-62. Retrieved from: https://s3.amazonaws.com/academia.edu.documents/45558678/RC-Ws-1-proceedings.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1526907711&Signature=QZZbuP%2FKAsCxHwW6mw45JqC%2FpYo%3D&response-content-disposition=inline%3B%20filename%3DMulti-scale_Meshing_in_Real-time.pdf#page=65

Gonzáles, A., Ramírez, M.P., & Viadel, V. (2015). ICT learning by older adults and their attitudes towards computer use. Current Gerontology and Geriatrics Research, 2015, Article ID 849308. doi: 10.1155/2015/849308

Gregan-Paxton, J., Hoeffler, S., Zhao, M. (2005). When categorization is ambiguous: Factors that facilitate the use of multiple category inference strategy. Journal of Consumer Psychology, 15(2), 127-140. doi: 10.1207/s15327663jcp1502_5

Greca, I.M., & Moreira, M.A. (2000). Mental models, conceptual models, and modelling. International Journal on Science and Education, 22(1), 1-11. doi: 10.1080/ 095006900289976

Heerink, M. (2011). Exploring the influence of age, gender, education and computer experience on robot acceptance by older adults. 6th ACM/

IEEE International Conference on Human-Robot Interaction, Switzerland, 147-148. doi: 10.1145/1957656.1957704

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2009). Measuring acceptance of an assistive social robot: A suggested toolkit. 18th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2009), Japan. doi: 10.1109/ RO-MAN.2009.5326320

Heerink, M., Kröse, B., Evers, V., & Wielinga, B. (2010). Assessing acceptance of assistive social agent technology by older adults: The Almere Model. International Journal of Social Robotics, 2(4), 361-375. doi: 10.1007/s12369-010-0068-5

Hintzman, D.L. (1986). "Schema abstraction" in multiple-trace memory model. Psychological Review, 93 (4), 411-428. doi: 10.1037/0033-295X.93.4.411

Hwang, J., Park, T., & Hwang, W. (2013). The effects of overall robot shape on the emotions invoked in users and the perceived personality of robot. Applied Ergonomics, 44(3), 459-471. doi: 10.1016/j.apergo.2012.10.010

Jay, G.M., & Willis, S.L. (1992). Influence of direct computer experience on older adults' attitudes towards computers. Journal of Gerontology, 47(4), 250-257. doi: 10.1093/geronj/ 47.4.P250

Kiesler, S., & Götz, J. (2001). Mental models of robotic assistants. Proceedings of the CHI EA'02, Extended Abstracts on Human Factors in Computing Systems, USA, 576-577. doi: 10.1145/506443.506491

Kolling, T., Baisch, S., Schall, A., Selic, S., Rühl, S., Kim, Z., Rossberg, H.H., Klein, B., Pantel, J., Oswald, F., & Knopf, M. (2016). What is emotional in emotional robotics? In S.Y. Tettegah & Y.E. Garcia (Eds.), Emotion, Technology and Health. Communication of Feelings for, with, and through Digital Media (pp. 83-104). Elsevier: Amsterdam.

Komatsu, T., Kursowa, R., & Yamada, S. (2011). How does difference between users' expectations and perceptions about a robotic agent affect their behavior? International Journal of Social Robotics, 4(2), 109-116. doi: 10.1007/s12369-011-0122-y

Kristoffersson A., Coradeschi S., & Loutfi A. (2013) A review of mobile robotic telepresence. Advances in Human-Computer-Interaction, 2013, Article ID: 902316. doi: 10.1155/2013/902316

Kuo, I.H., Rabindran, E., Broadbent, E., Lee, Y.I., Kerse, N., Stafford, R.M. Q., & MacDonald, B.A. (2009). Age and gender factors in user acceptance of healthcare robots. The 18th IEEE International Symposium on Robot and Human Interactive Communication, Japan, 214-219. doi: 10.1109/RO-MAN.2009.5326292.

Kwon, M., Jung, M.F., & Knepper, R.A. (2016). Human expectations of social robots. 11th ACM/ IEEE International Conference on Human-Robot Interaction (HRI), New Zealand. doi: 10.1109/ HRI.2016.7451807

Libin, A., & Libin, E.V. (2004). Person-robot interaction from the robopsychologists' point of view: The robotic psychology and robotherapy approach. Proceedings of the IEEE, 92, 1789-1803. doi: 10.1109/ JPROC.2004.835366

Mitzner, T.L., Smarr, C.-A., Beer, J., Chen, T.L., Springman, J.M., Prakash, A., Kemp, C.C., & Rogers, W. (2011). Older adults' acceptance of assistive robots for their home (Technical Report HFA-TR-1105). Retrieved from the Georgia Institute of Technology, School of Psychology – Human Factors and Aging Laboratory website: https://smartech.gatech.edu/bitstream/handle/1853/39671/HFA-TR-1105-OlderAdultsAcceptanceofRobotsforHome.pdf

Mollenkopf, H., Oswald, F., & Wahl, H-W. (2007). Neue Person-Umwelt-Konstellationen im Alter: Befunde und Perspektiven zu Wohnen, außerhäuslicher Mobilität und Technik [New person-environment constellations in later life: Findings and perspectives on housing, out-of-home mobility and technology]. In: H.-W. Wahl, & H. Mollenkopf (Eds.), Alternsforschung am Beginn des 21. Jahrhunderts. Alterns- und Lebenslaufkonzeptionen im deutschsprachigen Raum [Ageing research at the beginning of the 21st century] (pp. 361-380). Berlin: Akademie-Verlag.

Ninomiya, T., Fujita, A., Suzuki, D., & Umemuro, H. (2015). Development of the multi-dimensional robot attitude scale: Constructs of people's attitudes towards domestic robots. In A. Tapus, E. André, J.C. Martin, F. Ferland, & M. Ammi, M. (Eds.), Lecture Notes in Computer Science: Volume 9388: Social Robotics (pp. 482-491). Heidelberg: Springer.

Nomura, T., Kanda, T., Suzuki, T., & Kato, K. (2008). Prediction of human behavior in human-robot interaction using psychological scales for anxiety and negative attitude towards robots. IEEE Transactions on Robotics, 24, 442-451. doi: 10.1109/ TRO.2007.914004

O'Brian, M., Rogers, W., & Fisk, A.D. (2012). Understanding age and technology experience differences in use of prior knowledge for everyday technology interactions. ACM Transactions on Accessible Computing, 4(2), 1-27. doi: 10.1145/2141943.2141947

Oliver, R. L. (1997). Satisfaction: A behavioral perspective on the consumer. New York, NY: McGraw-Hill.

Parise, S., Kiesler, S., Sproull, L., & Waters, K. (1999). Cooperating with life-like interface agents. Computers in Human Behavior, 15(2), 123-142. doi: 10.1016/S0747-5632(98)00035-1

Power & Kiesler (2006). The advisor robot: Tracing people's mental model from a robot's physical attributes. Proceedings of the 1st ACM SIGGHI/SIGART Conference on Human-Robot Interaction, USA. Retrieved from: https://www.cs.cmu.edu/~kiesler/publications/ 2006pdfs/2006_advisor-robot.pdf

Pino, M., Boulay, M., Jouen, F., & Rigaud, A.-S. (2015). "Are we ready for robots to care for us?" Attitudes and opinions of older adults towards socially assistive robots. Frontiers in Aging Neuroscience, 7. Retrieved from https://www.frontiersin.org/articles/10.3389/ fnagi.2015.00141/full

Rosenthal-von der Pütten, A.M., & Krämer, N.C. (2015). Individuals' evaluations of and attitudes towards potentially uncanny robots. International Journal of Social Robotics, 7(5), 799-824. doi: 10.1007/ s12369-015-0321-z

Shafto, P., & Coley, J.D. (2003). Development of categorization and reasoning in the natural world:

Novices to experts, naïve similarity to ecological knowledge. Journal of Experimental Psychology: Learning, Memory, and Cognition, 29(4), 641-649. doi: 10.1037/0278-7393.29.4.641

Shibata, T., Kawaguchi, Y., & Wada, K. (2012). Investigation on people living with a seal robot at home. International Journal of Social Robotics, 4(1), 53-63. doi: 10.1007/s12369-011-0111-1

Shibata, T., & Tanie, K. (2000). Influence of a-prior knowledge in subjective interpretation and evaluation by short-term interaction with mental commit robot. Proceedings of the 2000 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2000), Japan. doi: 10.1109/IROS.2000.894600

Shibata, T., Wada, K., Saito, T., & Tanie, K. (2005). Human interactive robot for psychological enrichment and therapy. Proceedings of the AISB'05: Social intelligence and interaction in animals, robots and agents, Symposium on robot companions: Hard problems and open challenges in robot-human interaction, Great Britain, 98-109. doi: 10.1109/JPROC.2004.835383

Stafford, R.Q., Broadbent, E., Jayawardena, C., Unger, U., Kuo, I.H., Igic, A., Wong, R., Kerse, N., Watson, C., & MacDonald, B.A. (2010). Improved robot attitudes and emotions at a retirement home after meeting a robot. 19th IEEE International Symposium on Robot and Human Interactive Communication, Italy, 82-87. doi: 10.1109/ROMAN.2010.5598679

Stafford, R.Q., MacDonald, B.A., Jayawardena, C., Wegner, D.M., & Broadbent, E. (2014). Does the robot have a mind? Mind perception and attitudes towards robots predict use of an eldercare robot. International Journal of Social Robotics, 6, 17-32. Doi: 10.1007/s12369-013-0186-y

Sun, H. & Zang, P. (2006). The role of moderating factors in user technology acceptance. International Journal of Human-Computer-Studies, 64(2), 53-78. doi: 10.1016/ j.ijhcs.2005.04.013

Syrdal, D.S., Dautenhahn, K., Woods, S., Walters, L. & Kaoy, K.L. (2008). Looking good? Appearance preferences and robot personality inferences at zero acquaintance. Extended abstract of the AAAI Spring Symposium: Multidisciplinary Collaboration for Socially Assistive Robotics. Retrieved from: https://pdfs.semanticscholar.org/09ac/ a9d07cf-6784b5e35a4b0c2d0a3f137a883b5.pdf

Syrdal, D.S., Koay, K., Walters, M., Dautenhahn, K., & Otero, N.R. (2010). Exploring human mental models of robots through explication interviews. Proceedings of the 18th IEEE International Symposium on Robot and Human Interactive Communication, Italy, 638-645. Retrieved from: https://uhra.herts.ac.uk/bitstream/handle/2299/6791/905013.pdf?sequence=1

Thorndyke, P.W., & Hayes-Roth, B. (1979). The use of schemata in the acquisition and transfer of knowledge. Cognitive Psychology, 11(1), 82-106. doi: 10.1016/0010-0285(79)90005-7

van Rump, S. (2013). Paula visits Pat [video]. https://vimeo.com/42391813. Accessed 21 May 2018.

Wagner, A. Roboter zum Kuscheln – Heilsam für Demenzkranke [Robots for Cuddling – beneficial for People suffering from Dementia] [documentary film]. Germany: ZDF, ARTE, Filmtank GmbH.

Wu, Y.-H., Wrobel, J., Cornuet, M., Kerhevé, H., & Rigaud, A.-S. (2014). 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. Clinical Interventions in Aging, 2014(9), 801-811. doi: 10.2147/CIA.S56435