Attitudes towards service robots in domestic environments: The role of personality characteristics, individual interests, and demographic variables

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Abstract

The majority of EU citizens report a positive view about robots in general according to recent EU-level survey data. However, does this also hold true for attitudes towards service robots in particular? To investigate this research question, we conducted a survey on a representative sample from Germany. Importantly, we explored the role of demographic variables, interest in science and technology, and personality traits associated with psychological anthropomorphism in determining perceived acceptance of service robots in everyday life. Overall, attitudes towards service robots turned out to be relatively positive. Moreover, demographic variables (e.g., gender, occupation), interest in science and technology, and dispositional correlates of anthropomorphism had a significant impact on attitudes towards such assistive technology.

1. Introduction

Assistive technology, such as service robots, gains more and more importance in our daily life. For instance, such robots are deployed in the workplace, in industry, public safety, professional cleaning, in the medical realm, and at home.

The International Federation of Robotics (IFR) defines a service robot as "a robot which operates semi- or fully autonomously to perform services useful to the well-being of humans and equipment, excluding manufacturing operations", para. 2 [1]. Two groups of service robots can be differentiated: professional service robots and personal (i.e., domestic) robots. Professional service robots are mainly used in industrial and commercial domains. Personal and domestic robots are deployed in the home, in handicap assistance, and entertainment.

For the research presented in this paper, the latter are focal because service robotics for domestic and personal use is regarded as one of the most promising and important market segments of the twenty-first century [2]. In 2011, about 2.5 million service robots were sold for personal and domestic use. For the period between 2012 and 2015, market analyses predict an increase of around 15.6 million units [2]. Thus, service robots find their way into our everyday life and will become companions both in the workplace and at home. Because of such speedy technological development, it is crucial to investigate the attitudes of potential end-users towards such technology.

Recent research in social robotics takes into account psychological anthropomorphism, e.g. [3–6], the "tendency to imbue the real or imagined behavior of nonhuman agents with humanlike characteristics, motivations, intentions or emotions", p. 864 [3]. Epley, Waytz, and Cacioppo (2007) state that "anthropomorphism may be one way to cope with this increasingly technological environment, (…) and anthropomorphism can provide a sense of efficacy in interactions with technology", p.424 [3]. Following this reasoning, we investigate the impact of personality traits associated with psychological anthropomorphism on attitudes towards service robots. Specifically, we explore dispositional correlates of anthropomorphism that "are stable individual differences or personality traits that alter the extent to which certain knowledge representations or motivational states are chronically active", p.866 [3].

Epley et al. [3] have proposed the Three-Factor Model of Anthropomorphism and this suggests three psychological determinants that influence an individual's likelihood to anthropomorphize nonhuman entities, namely, *elicited agent knowledge*, *effectance motivation*, and *sociality motivation*.

First, *elicited agent knowledge* increases anthropomorphic judgments because people either use self-related knowledge or knowledge about humans in general when judging nonhuman agents. However, people differ in the extent to which anthropocentric knowledge is accessible, and in how far they are motivated to use these knowledge structures in impression formation. *Need for cognition* reflects peoples' enjoyment of being engaged in deep thinking [7] and represents the dispositional correlate of *elicited agent knowledge.*

Second, *effectance motivation* serves to explain and understand the behavior of other agents. Epley et al. [3] argue that individuals anthropomorphize nonhumans to reduce uncertainty and to increase per-

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ceived control over their social environment. The authors suggest *desire for control* as a dispositional correlate of *effectance motivation*. Finally, *sociality motivation* characterizes peoples' desire for social connection with other humans. When this need remains unfulfilled, people make anthropomorphic inferences to enable "a perceived humanlike connection with nonhuman agents", p.866 [3]. Dispositional (i.e., chronic) loneliness is correlatedwith anthropomorphic inferences about inanimate objects and agents, such as robots [3].

In order to explore which factors beyond the dispositional correlates of anthropomorphism might potentially influence attitudes towards service robots in domestic environments, we first summarize previous research on predictors of attitudes towards robots in general (e.g., gender, age, interest in science and technology) in Section 2. In Sections 3 and 4, we describe the current study and its method. Finally, in Sections 5 and 6, we report and discuss the results and present directions for future research.

2. Related Work

So far, many studies have investigated the acceptance of robots in daily life applications [8–16]. To illustrate, previous research has explored the acceptance of robots in general [16]. Moreover, the literature has focused on assistive robots in healthcare, e.g. [8–11], and existing work has studied the impact of robot acceptance on human-robot interaction (HRI), e.g. [13, 14]. Finally, various factors that influence attitudes towards robots have been examined, e.g. [8, 9, 14–16].

For example, Arras and Cerqui [8] have conducted a survey on the issue of whether people would want to share their life with robots in the Swiss context. The results showed that Swiss visitors to a technology-related exhibition reported an overall positive attitude towards potential robotic co-workers, robots as companions or regarding the prospect of using robotic prostheses and artificial organs. Female respondents were "much less willing to accept robot technologies in their life", p.29 [8] than male visitors. In terms of age, results pointed in two directions: On the one hand, elderly people did not want to own a robot that would merely carry out daily tasks for them. On the other hand, they perceived a robot that would help preserve their autonomy in daily life rather positively.

Furthermore, Kuo et al. [9] investigated effects of age and gender in predicting attitudes towards, and acceptance of healthcare robots. These authors showed that men had more positive attitudes than women. Additionally, elderly participants (i.e., over 65 years) did not differ from people in the age range of 40 to 65 regarding their attitudes towards healthcare robots. A German survey by Meyer [10] investigated the acceptance of service robots by elderly people and nursing staff. Results demonstrated that 56% of the seniors and 50% of the nursing staff reported a positive attitude towards the use of service robots for the elderly. Yet, 40% of the elderly participants clearly rejected service robots in everyday life, expecting low benefits from them. The authors argued that this result could be due to the fact that the elderly might feel insecure and incompetent in handling a service robot, fearing potential malfunctions.

Moreover, Broadbent et al. [11] investigated perceptions and emotions towards the utilization of a healthcare robot. They did so by first having participants complete a questionnaire. Subsequently, either a robot or a human assistant assessed participants' blood pressure. Results showed that participants reported benefits and applications for healthcare robots, but were likewise concerned about the systems' reliability, safety and their personal care. No difference in blood pressure level was obtained for the groups treated by a medical student versus a healthcare robot. Nevertheless, participants reported feeling more comfortable when treated by a medical student [11].

Bartneck, Suzuki, Kanda, and Nomura [12] also took into account the influence of prior experiences with a social robot on participants' attitudes towards robots in general, using the robot dog Aibo. Results emphasized the positive impact of previous experience with Aibo on attitudes towards the robot dog.

In addition, Nomura et al. [13] have investigated the relationship between negative attitudes towards robots, robot anxiety, and behavior towards robots. Using the Negative Attitudes towards Robots Scale (*NARS*; 14) and the *Robot Anxiety Scale* (*RAS*; 15), Nomura et al. measured negative attitudes and robot anxiety [13]. The human-robot interaction scenario encompassed greeting, meeting, self-disclosure and physical contact between user and robot. Results revealed that negative attitudes and anxiety predicted communication avoidance behavior in HRI.

The most recent research on *public* attitudes towards robots aimed "to gauge public opinion towards robots by measuring public perceptions, acceptance levels, worries and reservations among EU citizens (. . .)", p.2 [16]. Key findings from this survey showed that the majority of EU citizens hold a positive attitude towards robots. Furthermore, male participants reported positive opinions more often (76%) than did female participants (65%). Further, the proportion of respondents with a positive attitude decreased with age. Whereas 79% of citizens aged 15 to 24 maintained a positive attitude towards robots in general, only 62% of those aged 55 and over took an equally positive stance. In terms of education, results showed that participants' level of education affected how they perceived robots – "a positive view increases with the length of time spent in full-time education and is highest among students (84%)", p.19 [16]. Moreover, the survey revealed differences between occupations. On average, managers held a more positive attitude (82%) than persons who looked after the home (57%). Finally, with respect to attitudes, a strong relationship was observed between a positive view of robots and interest in science and technology. Of those who reported being very interested in science and technology, 86% had a positive attitude towards robots, compared to only 42% in the group of participants who were disinterested in science and technology [16]. Considering possible applications of robots, the priority was given to space exploration and manufacturing whereas respondents were hesitant to utilize robots in healthcare and education. Most EU citizens assumed that domestic service robots would not become commonplace in the near future [16].

3. Current Study

Regarding attitudes towards *robots in general*, the impact of demographic variables or factors such as interest in science and technology and prior robot experience have been examined already, i.e. [8, 9, 14, 16]. However, it has not yet been investigated how these aspects shape attitudes towards *service robots in particular*. Further, existing work has not focused on the impact of dispositional personality traits on peoples' attitudes towards robots.

In the current research, we aimed to address these gaps in the literature. We predicted that respondents should differ in their attitudes towards service robots with regard to personality traits that have been associated with psychological anthropomorphism. To examine the influence of different personality traits on the acceptance of service robots, we included measures of dispositional aspects of psychological anthropomorphism [3], namely *need for cognition*, *desire for control*, and *chronic loneliness*.

According to Cacioppo, Petty, and Kao [7], *need for cognition* reflects how much people like to engage in deep thinking and effortful and

cognitively challenging activities. For example, Olsen et al. [17] found out that people high in *need for cognition* were also more curious and strived for knowing more about their environment. Furthermore, a strong relationship between *need for cognition* and scientific interest was found [18].

Desire for control reflects peoples' motivation to control the events in their life [19]. Individuals with a strong *desire for control* are generally assertive, decisive and active, while those low in *desire for control* are usually nonassertive, indecisive and passive [19]. Furthermore, individuals high in *desire for control* display higher levels of aspiration [20] and are more engaged in attributional processes to explain others' behavior than those low *in desire for control* [21]. Epley et al. [3] concluded that this attributional activity increases the feeling of efficiency in social interaction. Consequently, they reasoned that *desire for control* would facilitate the activation and application of anthropomorphic representations to explain an agents' behavior in the present and increase the sense of predictability for an agents' future behavior.

Baumeister and Leary [22] have shown that *sociality motivation* represents a fundamental human need. Lonely people seek connection to other humans or objects [23]. To illustrate, Lee et al. [24] have found that participants high in chronic loneliness responded more positively to social agents than participants low in chronic loneliness. Generally, it appears that the more participants' sociality motivation is triggered, the more they tend to humanize nonhuman entities – like pets, religious deities, and robots, e.g. [23, 25, 26].

3.1. Hypotheses

To examine attitudes towards service robots further, we aimed to replicate and extend the reviewed literature by taking into account demographic factors, interest in science and technology, prior robot experience, and personality traits that influence peoples' perception of service robots. We set out to test the following hypotheses.

Demographic Variables (H1 to H4)
We predicted that female participants would report fewer *positive attitudes* and a greater amount of anxiety towards service robots. Additionally, female respondents should report lower *contact intentions* regarding service robots than male respondents (H1).

In line with [16], we proposed that younger participants should report more *positive attitudes* and analogously, less *service robot anxiety* as well as higher *contact intentions* to a service robot than older participants (H2).

We hypothesized that participants with higher education should report more *positive attitudes* towards service robots, less *service robot anxiety* and higher *contact intentions* than participants with lower levels of education (H3).

Moreover, we predicted that current occupation or field of study would affect attitudes towards service robots in that people who study social sciences or are employed in social professions would be more negative and anxious towards service robots than participants working in nonsocial career domains. Likewise, participants working in social domains should report lower willingness to interact with service robots (H4).

Interest in Science and Technology (H5)
We expected that participants high (vs. low) in interest in science and technology would feel more positive towards service robots. Besides, participants with little interest in science and technology should report more *service robot anxiety* and would be less willing to have contact with a service robot than participants with a strong interest in the matter (H5).

Prior Robot Experience (H6)
In line with [16], we predicted that previous experience with robots should correlate positively with interest in science and technology. Further, [16] found that individuals with a strong interest in science and

technology reported more previous experience with robots than those who reported less interest in science and technology. Taking this into account, we further hypothesized that interest in science and technology would mediate the relation between prior robot experience and *positive attitudes* towards service robots, *service robot anxiety* and *contact intentions* (H6).

Dispositional Correlates of Psychological Anthropomorphism (H7 to H9)
We predicted that participants' attitudes would differ as a function of their *need for cognition*, *desire for control*, and *chronic loneliness*. In line with findings by [7, 17, 18], we argue that participants high in *need for cognition* would report more *positive attitudes* towards service robots, less *service robot anxiety*, and more *contact intentions* than participants low in *need for cognition* (H7).

According to [3, 19–21], we predicted that participants high in *desire for control* would report more *positive attitudes* towards service robots, less *service robot anxiety*, as well as higher *contact intentions* to service robots than participants low in *desire for control* (H8). In line with results by [23–26], we predicted that dispositionally lonely participants should hold a more *positive attitude* towards service robots and report less *service robot anxiety*, and greater willingness to interact with service robots (H9).

4. Method

4.1. Participants & Procedure

A total of 366 German participants (203 females, 163 males), ranging in age from 16 to 65 years ($M = 27.20$, $SD = 9.17$) took part in the study. 242 of the participants were university students, whereas $n = 124$ were employed in the public sector, e.g., as engineers, teachers, public officials or firemen. The survey was conducted using the online tool SoSciSurvey during January and February 2013. Participants completed a survey that was used to measure their opinion towards service robots. They were recruited via the snowball procedure, electronic bulletin boards, Facebook, and by word of mouth advertising.

4.2. Introduction to Service Robots

To introduce participants to the concept of service robots, we provided them with a short description of the functions and potential applications of domestic and personal service robots. This was done to rule out undesired effects which could occur in the case when only a single service robot would be used to illustrate the concept of service robots, e.g. [27, 28]. The introduction read:

Service robots can save us a great deal of tedious work in the household. For instance, they can vacuum the house, prepare meals or mow the lawn. Further, service robots can carry out more complex tasks and can provide entertainment. Moreover, they can provide important support for the care of handicapped and elderly people, as well as homework support for your children. The application domains of service robots expand more and more. Thus, we are interested in your opinion on such novel technologies!

4.3. Measures

Participants were first asked to provide demographic information (i.e., age, gender, nationality, educational qualifications, and occupation). Subsequently, *need for cognition, desire for control* and *chronic loneliness* were assessed. Then, participants reported *positive at–*

titudes towards service robots, *servicerobot anxiety*, and *contact intentions*. Finally, participants reported interest in science and technology and prior robot experience. Participants provided responses on 7-point Likert scales ranging from 1 (*not at all*) to 7 (*very much*). For subsequent data analysis, internal consistencies (Cronbach's α) were analyzed, and subsequently mean scores were computed for each scale with higher values reflecting greater endorsement of the respective construct.

Need for Cognition. To measure dispositional aspects of *elicited agent knowledge*, *need for cognition* [3] was assessed using the 10-item German version proposed by [18]. Example items read: "I only think as hard as I have to", "I would prefer complex to simple problems", and "Thinking is not my idea of fun". The items formed a reliable measure of *need for cognition* ($\alpha = .80$).

Desire for Control. Individual differences in *effectance motivation* were measured by using a 10-item German version of the *desire for control* scale [29] that included items such as: "I love having control over my own destiny", and "I prefer to give commands than to obtain them". The *desire for control* index was sufficiently reliable ($\alpha = .71$).

Dispositional Loneliness. To assess *chronic loneliness*, the 10-item German short version of the UCLA-Loneliness Scale introduced by [30] was used, including items like "I have no one I can contact" or "I feel isolated from others". The ten items of the *loneliness* scale were averaged to attain a highly reliable overall *chronic loneliness* composite ($\alpha = .90$).

Positive Attitudes towards Robots. To assess *positive attitudes* towards service robots, we administered 20 items that were adapted by replacing the term "robot" with the specification "service robot". Specifically, we adapted six items from [16] for example: "Generally speaking, I have a very positive view of service robots", "Service robots are a good thing for society, because they help people", "Service robots are a form of technology that requires careful management".
Second, we adapted 14 items from the *Negative Attitudes towards Robots Scale* [NARS; 13]. Example items read: "I would feel nervous operating a service robot in front of other people", "I feel that in the future society will be dominated by service robots" and "I would feel relaxed talking with service robots".
Where appropriate, items were reverse-scored to obtain an overall measure of *positive attitudes* towards service robots, with higher values reflecting greater endorsement of *positive attitudes* towards service robots ($\alpha = .88$).

Service Robot Anxiety. To measure anxiety associated with service robots, we adapted the 11-item *Robot Anxiety Scale* [RAS; 15] by replacing the term "robot" with the specification "service robot". The *Service Robot Anxiety Scale* (*SRAS*) was introduced by the following instruction: "Please answer freely how you feel when you imagine a scene in which you interact with a service robot having emotions". Example items read: "Service robots may talk about something irrelevant during conversation" or "I may be unable to understand the contents of service robots' utterances to me". Higher values reflect higher service robot anxiety. The *service robot anxiety* index was reliable ($\alpha = .86$).

Contact Intentions. *Contact intentions* were measured by eight self-generated items such as "I am eager to have a service robot at home", "I would like to spend time with a service robot", and "I would like to make dinner together with a service robot". For the current research we limited the willingness to interact with a service robot to the domestic environment. The eight items were averaged and formed a highly reliable index of *contact intentions* ($\alpha = .92$).

Interest in Science and Technology. Two items ($\alpha = .63$) tapped participants' interest in technological issues ("I'm very interested in scientific discoveries and technological developments", and "I'm very experienced in computers/ computer games").

Prior Robot Experience. Four items ("I've already collected experiences with robots.", "Have you ever seen a real robot?", "Have you ever performed a task with a robot?", "Have you ever used, or are you currently using a robot at home or at work?"; $\alpha = .78$) were administered to assess participants' prior experience with robots in general.

5. Results

5.1. Attitudes towards Service Robots in general

On the one hand, participants reported relatively *positive attitudes* towards service robots ($M = 3.88$, $SD = 0.93$), on the other hand they also reported moderate scores for *service robot anxiety* ($M = 3.82$, $SD = 1.21$). In terms of *contact intentions*, participants were rather unwilling to interact with a service robot ($M = 2.97$, $SD = 1.61$; see Figure 1).
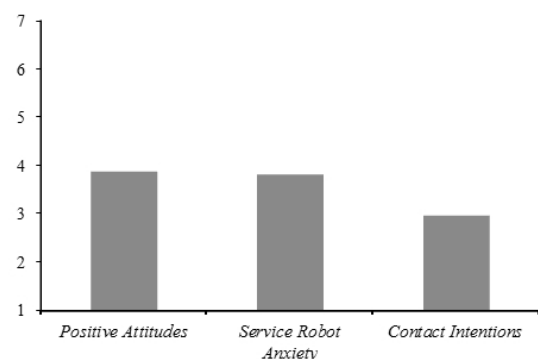

Figure 1. Mean values for *Positive Attitudes*, *ServiceRobot Anxiety*, and *Contact Intentions*.

5.2. Predictors of Attitudes towards Service Robots

We conducted a series of hierarchical multiple regression analyses to explore the impact of demographic variables, interest in science and technology, prior robot experience and dispositional correlates of psychological anthropomorphism on *positive attitudes*, *service robot anxiety* and *contact intentions* as specified in hypotheses H1 to H9.
Demographic Variables (H1 to H4)
Positive Attitudes. When entered into the regression simultaneously, the four variables gender (dummy-coded; women = 1, men = 2), age, education, and occupation (dummy-coded; social careers = 1, non-social careers = 2) predicted the extent to which participants reported *positive attitudes* towards service robots, $F(4, 177) = 6.38$, $p<.001$; $R^2 = .13$. It turned out that gender ($\beta = .25$, $p = .001$) was the strongest predictor of *positive attitudes* towards service robots, followed by occupation ($\beta = .16$, $p = .04$). Female respondents were more negative towards service robots than male respondents. Also, respondents working in social domains reported less *positive attitudes* than participants working in non-social careers. Age ($\beta = .06$, $p = .41$) and education ($\beta = .12$, $p = .11$) did not predict *positive attitudes* towards service robots.
Service Robot Anxiety. When analyzed simultaneously, neither gender, age, education, nor occupation predicted *servicerobot anxiety*, $F(4, 177) = 1.60$, $p = .18$; $R^2 = .04$. Results showed a significant

negative effect for gender ($\beta = -.16$, $p = .05$). Women reported more *service robot anxiety* than men. Age ($\beta = -.04$, $p = .65$), education ($\beta = .05$, $p = .49$), and occupation ($\beta = -.04$, $p = .61$) had no significant effect on *service robot anxiety*.

Contact Intentions. Demographic variables did not have an impact on *contact intentions* towards service robots, $F(4, 177) = 1.62$, $p = .17$, $R^2 = .04$.

Interest in Science and Technology (H5)

Positive Attitudes. As hypothesized, regression analyses revealed that interest in science and technology significantly predicted *positive attitudes* towards service robots, $\beta = .57$, $t(365) = 13.21$, $p = <.001$. Respondents with strong interest in science and technology reported more *positive attitudes* towards service robots. Interest in science and technology also explained a significant proportion of variance in *positive attitudes* scores, $R^2 = .32$, $F(1,365) = 174.44$, $p<.001$.

Service Robot Anxiety. Similarly, results regarding *robot anxiety* showed that interest in science and technology significantly predicted *service robot anxiety*, $\beta = -.28$, $t(365) = -5.52$, $p<.001$. Further, interest in science and technology explained a significant proportion of variance in *service robot anxiety* scores, $F(1, 365) = 30.5$, $p = <.001$, $R^2 = .08$.

Contact Intentions. Finally, interest in science and technology had a significantly positive effect on *contact intentions* with service robots, $\beta = .43$, $t(365) = 8.96$, $p<.001$. Interest in science and technology also explained a significant amount of variance in *contact intention* scores, $F(1, 365) = 80.24$, $p<.001$, $R^2 = .18$.

Prior Robot Experience (H6)

Positive Attitudes. Multiple regression analyses were conducted to assess the components in the proposed mediation model. Accordingly, prior robot experience was positively related to *positive attitudes* towards service robots, $B = .56$, $t(365) = 5.91$, $p<.001$. It was also found that prior robot experience was positively related to interest in science and technology, $B = .58$, $t(365) = 13.54$, $p<.001$. Interest in science and technology, in turn, was positively related to *positive attitudes* towards service robots, $B = .57$, $t(365) = 13.21$, $p<.001$. Taken together, results confirmed the mediating role of interest in science and technology in the relation between prior robot experience and *positive attitudes* towards service robots, $B = .66$, $CI = .54$ to .80. Furthermore, the direct effect of prior robot experience turned nonsignificant when controlling for interest in science and technology ($B = -.10$, $t(365) = -1.0$, $p = .34$), which suggests full mediation.

Service Robot Anxiety. Regarding *service robot anxiety*, it was found that prior robot experience was negatively related to *service robot anxiety*, $B = -.33$, $t(365) = -2.60$, $p = .01$. Interest in science and technology, was also negatively related to *service robot anxiety*, $B = -.27$, $t(365) = -5.52$, $p<.001$. A significant indirect effect of interest in science and technology on *service robot anxiety* was found ($B = -.43$, $CI = -.64$ to $-.24$), and the direct effect of prior robot experience on *service robot anxiety* turned nonsignificant when the mediator was entered in the model, ($B = .10$, $t(525) = .63$, $p = .53$), indicating full mediation.

Contact Intentions. Prior robot experience was positively related to *contact intentions*, $B = .81$, $t(365) = 4.87$, $p<.001$. The potential mediator, interest in science and technology, was also positively related to *contact intentions*, $B = .55$, $t(365) = 8.96$, $p<.001$. Thus, interest in science and technology mediated the relationship between prior robot experience and *contact intentions*, $B = .81$, $CI = .58$ to 1.06. The direct effect of prior robot experience turned nonsignificant when controlling for interest in science and technology ($B = .01$, $t(365) = .03$, $p = .97$), suggesting full mediation.

Dispositional Correlates of Psychological Anthropomorphism (H7 to H9)

Positive Attitudes. A hierarchical regression analysis showed that personality traits associated with psychological anthropomorphism significantly predicted *positive attitudes* towards service robots, $F(3, 365) = 9.84$, $p<.001$; $R^2 = .08$. *Need for cognition* turned out as the strongest predictor for *positive attitudes* towards service robots ($\beta = .23$, $p<.001$), followed by *dispositional loneliness* ($\beta = .11$, $p = .04$). *Desire for control*, however, had no significant effect on *positive attitudes* towards service robots ($\beta = .08$, $p = .14$).

Service Robot Anxiety. Likewise, dispositional correlates of psychological anthropomorphism were significant predictors of *service robot anxiety*, $F(2, 365) = 2.94$, $p = .03$, $R^2 = .02$. *Need for cognition* was negatively associated with *service robot anxiety* ($\beta = -.16$, $p<.01$), while *desire for control* ($\beta = .01$, $p = .86$) and *dispositional loneliness* had no significant effect ($\beta = .02$, $p = .76$).

Contact Intentions. Personality traits associated with anthropomorphism significantly predicted *contact intentions* towards service robots, $F(2, 365) = 3.33$, $p<.02$, $R^2 = .03$. *Dispositional loneliness* was the strongest predictor of *contact intentions* ($\beta = .10$, $p<.05$), whereas *need for cognition* was only a marginally significant predictor of *contact intentions* ($\beta = .11$, $p = .06$). *Desire for control* per se, did not predict *contact intentions* ($\beta = .07$, $p = .21$).

6. Discussion

The goal of the present research was to investigate attitudes towards service robots in a representative sample of German respondents. Equally important, we examined additional factors that influence peoples' opinion about assistive technology, for instance, personality characteristics, interest in science and technology, and demographic variables.

Recently, the Eurobarometer survey showed that people perceive robots rather positively [16]. Nevertheless, people reported that robots should not be used in childcare, elderlycare or in the context of assistance for people with handicaps. They clearly opposed the use of robots in care, household or educational settings. Generally [16], and other research, e.g. [9, 10, 13] have shown that demographic characteristics, interest in science and technology, and prior robot experience were important determinants of attitudes towards robots.

Furthermore, dispositional correlates of anthropomorphism had not yet been examined in the context of attitudes towards service robots. To do so, we put three dispositional correlates of anthropomorphism that were recently proposed in the Three-Factor Model of Anthropomorphism [3] to an empirical test. In our work, we go beyond existing research on factors influencing peoples' attitudes towards robots in that we have examined not only the impact of demographic variables, but also took into account interest in science and technology and prior robot experience, and most importantly, dispositional correlates of psychological anthropomorphism.

6.1. Attitudes towards Service Robots in general

Although our survey showed that German people generally held an above-average *positive attitude* towards service robots, results were not uniformly positive. Results showed that participants were rather afraid of service robots, they were reluctant to interact with service robots and hesitant to use them in their home environment. This is in line with findings by [16]. Obviously, the contexts in which robots shall be deployed have a major influence on peoples' perception. The vision of sharing one's everyday life with domestic service robots obviously induced ambivalent attitudes. On the one hand, the prospect of assistance in the completion of household chores rendered a robot

appealing. On the other hand, respondents in our survey clearly rejected the idea of having a robot at home. Thus, the findings suggest taking into account one key aspect: that participants apparently viewed robots as a form of technology that requires careful management. However, due to the fact that assistive technology is not yet widespread in the German context, respondents were rather skeptical regarding the actual use of service robots.

6.2. Predictors of Attitudes towards Service Robots

Broadly, the results of this study replicated previous findings. Demographic variables and interest in science and technology had an impact on reported *positive attitudes* towards robots and *contact intentions*. Furthermore, the study extended previous research by showing that dispositional correlates of psychological anthropomorphism in part influenced peoples' opinion about service robots.

Demographic Variables (H1 to H4)
We predicted gender differences regarding attitudes towards service robots, namely, that female participants would report a greater amount of *service robot anxiety* and fewer *positive attitudes*. Further, female respondents would be less willing to accept service robots in their lives than male participants (H1).

We found this effect for *positive attitudes* towards service robots and *service robot anxiety* with female respondents reporting less *positive attitudes* towards service robots and more *service robot anxiety* than male respondents. The results are similar to those by Arras and Cerqui [8]. These authors interpret robotics as a male domain which explains the negative stance of women. Although we represented service robots as useful help in the domestic environment, female respondents were quite negative towards them. Evidently, they were not only more negative towards service robots; they also reported more *service robot anxiety* than male respondents. Women's critical position towards robots remained, even though they seemed to be a helpful feature in domestic settings. Interestingly, however, for *contact intentions*, no effect of respondent gender emerged. This finding suggests that male and female respondents are both quite disinterested in interacting with a service robot at home.

We had predicted that *positive attitudes* towards service robots and *contact intentions* should decrease with participants' age, while *robot anxiety* should increase, respectively (H2). Unexpectedly, we found that *positive attitudes* towards service robots, *service robot anxiety* and *contact intentions* did not change as a function of participants' age. These results are contrary to the previous findings by [16], where younger participants held more positive views about robots. However, [16] had studied four age groups (15-24, 25-39, 40-54, 55 +) using a considerably larger sample, whereas in the present research, the majority of participants were in their twenties.

Further, we had proposed that attitudes would be more positive as a function of participants' education (H3). However, participants' level of education did neither influence participants' *positive attitudes* towards service robots, their *service robot anxiety*, nor their *contact intentions*.

Furthermore, we had predicted that participants working in non-social careers would report more *positive attitudes* towards service robots, less *service robot anxiety* and more *contact intentions* than respondents working in social areas (H4).

As predicted, respondents with an occupational background in science or technology and other non-social careers indeed reported more *positive attitudes* towards service robots than respondents who work or study in social areas. Surprisingly, results do not support our hypothesis with regard to *service robot anxiety* and *contact intentions*. Professionals in social and non-social careers did not differ significantly in self-reported *service robot anxiety* and their willingness to interact with a service robot. These results point to the fact that non-social occupations, even though they correspond with an affinity for technology, do not automatically reflect greater openness towards novel technologies like service robots. Although people employed in non-social careers seemed to be more positive towards service robots in general, they still responded only moderately positive regarding *contact intentions* with a service robot.

Interest in Science and Technology (H5)
As hypothesized, interest in science and technology affected participants' attitudes towards service robots positively. Respondents who were interested in science and technology were significantly more positive towards service robots, reported less *service robot anxiety*, and were more open to accept service robots in their life than those with no or little interest in science and technology. This effect is not surprising, as service robots represent an important novel technology of the twenty-first century.

Prior Robot Experience (H6)
Mediation analyses indicated full mediation of the positive relationship of prior robot experience and *positive attitudes* towards service robots, and the negative relationship of prior robot experience and *service robot anxiety* through interest in science and technology. Interest in science and technology also mediated the relationship between prior robot experience and *contact intentions*.

Respondents with previous robot experience were not more likely to have a positive view of service robots, did not report less *service robot anxiety* and were not more willing to interact with a service robot than those who lacked such experiences. In fact, attitudes towards service robots were determined by participants' interest in science and technology.

Dispositional Correlates of Psychological Anthropomorphism (H7 to H9)
Our hypotheses regarding the role of *need for cognition*, *desire for control*, and *chronic loneliness* in predicting the outcome variables were mainly supported.

Regarding *need for cognition*, we had proposed that participants high in *need for cognition* would report a) more *positive attitudes* towards service robots, b) less *service robot anxiety*, and c) more *contact intentions* than participants low in *need for cognition* (H7).

As predicted, participants high in *need for cognition* were more positive towards service robots and reported less *service robot anxiety* than participants low in *need for cognition*. Moreover, results indicated a similar trend for *contact intentions* to service robots. This suggests that the dispositional tendency to think deeply has a positive impact on the perception of service robots. People high in *need for cognition* strive for enhanced knowledge, and seem to be more curious about technological developments.

Regarding *desire for control*, we hypothesized that participants high in *desire for control* would report more *positive attitudes* towards and *contact intentions* to service robots, and less *service robot anxiety* than participants low in *desire for control* (H8). Unexpectedly, however, participants high and low in *desire for control* did not differ in their attitudes towards service robots.

Concerning *chronic loneliness*, we had predicted that dispositionally lonely participants should hold more *positive attitudes* towards service robots and report less *service robot anxiety*. Further, they would report a greater willingness to interact with a service robot than participants feeling a little or not at all lonely (H9).

Participants' *dispositional loneliness* affected their *positive attitudes* towards service robots and their *contact intentions*, but not their self-reported *service robot anxiety*. The higher participants' *chronic loneliness*, the more positive they were towards service robots and the more they were willing to interact with a service robot. Apparently, dispositionally lonely participants formed a more positive

impression of service robots as compared to socially connected respondents. Interestingly, this effect was obtained despite generally low levels of *dispositional loneliness* reported by participants in our sample. Although *chronic loneliness* did not affect self-reported *service robot anxiety*, socially disconnected respondents evaluated service robots more positively, nevertheless.

7. Conclusions

The present research investigated attitudes towards service robots used in domestic and personal environments, and factors influencing these attitudes using a representative German sample. German-speaking potential end users reported an overall positive attitude. At the same time, however, they reported considerable *service robot anxiety* and only low *contact intentions* towards service robots. These results indicate that, in general, people view positively the idea of service robots as an assistance feature in domestic settings; but since these types of robots are not yet widely used in everyday life contexts within Germany, people seem to remain skeptical towards it.

The present research extends recent findings [9, 11, 14, 16] in several aspects. First, instead of exploring respondents' attitudes towards robots in general, we set focus on a specific robot type. That is, we investigated peoples' attitudes towards service robots which can be applied in domestic environments. Second, existing research has utilized mostly a single measure to assess peoples' attitudes towards robots. For instance, the *Public Attitudes Questionnaire* was the sole measure in [16] or the *NARS* alone was administered to assess robot-related attitudes in [14–16]. To broaden the repertoire of measures regarding attitudes towards service robots, we have adapted and utilized a broader range of self-reports: We not only used the *Public Attitudes Questionnaire* [16] and the *NARS* [14], but also the *Robot Anxiety Scale* [15], and *contact intentions*. Finally, we explored a wider range of key factors that presumably affect attitudes towards robots in general and service robots in particular. We demonstrated that above and beyond demographic variables and interest in science and technology, personality traits associated with psychological anthropomorphism influence *positive attitudes* towards service robots, *service robot anxiety*, and *contact intentions*. Specifically *need for cognition* and *dispositional loneliness* proved to be important factors affecting peoples' attitudes towards robots. These findings provide further evidence for the Three-Factor Theory of Anthropomorphism by Epley et al. [3]. Thus, people high in *need for cognition* and *chronic loneliness* not only anthropomorphize inanimate agents, see [3, 25, 26] more, they also perceive robots more positively and report greater *contact intentions*. These results provide an important basis for further research on the impact of other dispositional correlates of anthropomorphism on service robot acceptance.

Even though we were able to recruit representative data from several hundred participants, future survey research should collect even bigger samples in order to cover a greater range in demographics, for instance, regarding age and education. In the current German survey, most respondents were below 30 years of age. Further, respondents in our survey were relatively highly educated, with a large number of them being university students. Thus, future research should investigate respondents with a broader range of age, education and profession. Regarding previous robot experience, it would be interesting to examine various forms of prior robot experience and their impact on attitudes towards service robots in more detail. For instance, by measuring familiarity with robots using multiple dimensions, for instance in terms of experience via media, experience via workplace, having seen a real robot, possessing a robot, etc. This could offer further information on the impact of type and duration of robot contact on peoples' attitudes towards service robots. In addition, it would be interesting to study different aspects of *contact intentions* with regard to service robots. For instance, robotic help to liberate people from domestic duties, robotic assistance to support people in need of help to master daily routines (children, elderly, people with handicaps) or the use of service robots for entertainment. A broader examination of contact opportunities with service robots would also provide important understanding of the acceptance of robots in daily life. Finally, at this point, follow-up research should also examine different robot types to shed more light on their impact on robot acceptance in everyday life.

Taking into account predictions regarding marketing of service robots in the future [2], it seems that sooner or later, assistive technology will become a natural part of the domestic environment. Our research shed light on potential impact factors regarding the acceptance of such technology. We showed that above and beyond demographic aspects and interest in science and technology, personality traits associated with psychological anthropomorphism likewise influenced attitudes towards service robots. Importantly, *need for cognition* and *chronic loneliness* positively predicted *positive attitudes* towards service robots and negatively predicted *service robot anxiety*.

Taken together, these results provide important insights into the future acceptance of assistive robotic in everyday life.

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