The Relation between People’s Attitude and Anxiety towards Robots in Human-Robot Interaction

Maartje M.A. de Graaf, Member, IEEE, and Somaya Ben Allouch

Abstract—This paper examines the relation between an interaction with a robot and peoples’ attitudes and emotion towards robots. In our study, participants have had an acquaintance talk with a social robot and both their general attitude and anxiety towards social robots were measured before and after the interaction. This study has found mixed results as compared to earlier studies. However, the utility of negative attitude and anxiety to explain human behavior in interactions with robots is supported. Furthermore, a human-robot interaction (HRI) changes people’s attitudes and anxiety towards robots. Thus, from a design perspective, it seems important to further investigate which aspects of robots evoke what type of emotions and how this influences the overall evaluation of robots.

I. INTRODUCTION

Scientists agree that in the nearby future, robots will become ubiquitous in everyday life. People’s attitudes and emotions affect how people behave in a certain situation. Consequently, from a HRI perspective, it is important to study the role of attitude and emotions in human interactions with robots. While research on the implementation of emotions into robotic systems receives considerable attention, the exploration of people’s emotional reactions to robots is rather underexposed. For users to accept robots in the future, more comprehensive understanding is needed of people’s attitudes and emotions towards robots. This paper describes our findings on the relation between people’s attitude and anxiety towards robots in interactions with robots.

II. THEORETICAL BACKGROUND

Robots are expected to increasingly enter our everyday lives. To increase the acceptance of robots, they are designed to interact socially to simplify the interaction between humans and robots [4]. However, if social robots are to be introduced successfully into people’s homes, we need to understand the underlying factors which determine people’s behavior in interactions with robots. Both attitudes [9] and emotions [12] have been found to be good predictors of human behavior. In the next sections, we will address the role of attitude and emotion in human behavior in general and in interactions with robots specifically. Contrary to previous research that has mainly focused on positive aspects of HRI [3, 13, 26], the focus of this paper is on negative attitudes and emotions as this is an underexposed area of HRI research. Anticipated negative emotions or feelings that might arrive after a certain action predict people’s behavioral intentions [21]. Indeed, people with negative attitudes and emotions towards robots tend to avoid talking in a conversation with a robot [18]. Thus people’s negative attitudes and emotions towards robot affect how people behave during interactions with robots. Besides, as the ‘robots will take over the world’ scenario is predominant in Western societies [14], it seems reasonable to pay attention to the role of negative attitudes and emotions towards robots in interactions with robots.

A. Attitude and Behavior

In psychology, an attitude is defined as a relative stable and enduring predisposition to behave or react in a certain way towards persons, objects, institutions, or issues [6]. Attitudes are the end products of the socialization process and significantly influence people’s responses and behaviors. Attitudes are the likely positive or negative consequences of performing a particular behavior, and are one of the predictors of future intentions to continue the behavior in question [9]. Following this reasoning it can be articulated that negative attitudes towards robots affect people’s behavior during the interaction and their intention to interact with a robot again in the future. Thus studying people’s general attitudes of robots contribute to our knowledge on people’s behaviors towards robots. Earlier robotics research indicates that people’s attitudes towards robots influence and are influenced by interactions with robots [15, 18, 19, 24]. However, the appearance of strong emotions in behavior can activate beliefs and attitudes that were not anticipated on. Hence, it is also important to study the effects of emotions on human behavior in interactions with robots.

B. Emotion and Behavior

Although robots are supposed to enter our everyday lives, only little is known about the emotional effect robots elicit from their human users. Human behavior is not purely rational. In fact, emotions are considerably tangled in the determination of human behavioral reactions to environmental and internal events of considerable importance for the needs and goals of an individual [12]. Many researchers postulate that it is impossible for humans to act or think without involvement of, at least subconsciously, our emotions [16]. If emotions affect human behavior in general, they might be relevant for HRI research as well. Indeed, several studies indicate that people show emotional reactions when confronted with robots. People are more aroused after watching a robot being tortured as compared to watching a robot being petted [22]. Moreover, people’s negative affect towards robots decreased significantly after an interaction with a robot, which in return

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explained a large amount of variance in the overall rating of the robot [24]. While many emotions have been identified, consensus has been reached that there are six basic human emotions which are constant across culture, namely the emotions of anger, disgust, fear, happiness, sadness, and surprise [7]. As negative emotions are naturally unpleasant, people tend to perform corrective behaviors or avoid bad behaviors to mitigate the negative emotions [12]. Thus, if people feel anxious towards robots, they might avoid interactions with robots in the future or will probably behave differently when confronted with a robot.

III. METHOD

A user study was conducted to explore the relation between people’s negative attitude and anxiety towards robots and human behavior in an interaction with a robot. The interaction with the robot was intentionally designed to be short and simple to ensure comparable user experiences.

A. Social Robot

The social robot used in this study is NAO, an autonomous, programmable, medium-sized humanoid robot developed by Aldebaran Robotics. We employed the NAO for two reasons. First, NAO is the most widely used robot for academic purposes. Second, NAO is a humanoid robot. Earlier robotics research shows that people are interacting more naturally with humanoids because of familiarity [10]. The NAO Academic Edition body has 25 degrees of freedom. NAO also has a series of sensors: two cameras, four microphones, a sonar distance sensor, two IR emitters and receivers, one inertial board, nine tactile sensors, and eight pressure sensors. To express itself, NAO has a voice synthesizer, LED lights, and two speakers. NAO was programmed to interact with the participants according to the procedure as described under scenario. To appear to be life-like, NAO waved as the participants entered the room and its eyes led up when it was listening to the participants. Robots using gesture were more positively evaluated and were perceived as having higher anthropomorphism, even when using incongruent gestures [23]. Hence it seems that using any type of gesture in HRI is better than no gestures at all.

B. Scenario

The scenario used in this study is adopted from Nomura et al. [18]. Participants were requested to have a casual conversation in which the robot would take the lead. Letting the robot take the lead in the conversations ensured us that the interaction scenario’s for all participants were roughly the same. As social robots are designed to naturally interact with people, an informal conversation was deemed an appropriate way to evaluate user acceptance. The robot, programmed in advance, was prepared for interaction with users in the room, and each user communicated alone with the robot for a few minutes. The procedure used in each session was as follows:

1: Before entering the experiment room, participants responded to the questionnaire items of the constructs ‘negative attitude towards robots’ and ‘robot anxiety’.

2: Just before entering the room, they were instructed to take place at the table where the robot was situated and greet it when they have taken a seat.

3: Participants entered the room alone. NAO greets the participant with a hand wave and by saying: “Hello.” And after a short notice: “Take a seat, please.”

4: After the participant has taken a seat at the table, the robot asked: “I am NAO. What is your name?”

5: After talking to the robot or a constant time (30s) passed, the robot asked: “Can you tell me something about yourself?”

6: After talking to the robot or a constant time (30s) passed, the robot asked: “Tell me one thing that recently happened to you”, to encourage participants to respond.

7: After they replied to the robot or a constant time (30s) passed, the robot uttered a sentence to encourage physical contact: “Will you touch my head?”

8: After touching the robot or a constant time (30s) passed, the session was finished by the robot saying: “Nice meeting you. You may go back to the researcher now.”

C. Questionnaire

The scales for negative attitude and anxiety towards robots were adopted from Nomura et al. [18]. The negative attitude towards robots scale determines people’s attitudes towards robots with evaluations of people’s psychological states reflecting opinions that people ordinarily have towards robots. The scale consists of 14 items divided into three subscales: negative attitude towards interaction with robots (NARS S1), negative attitude towards the social influence of robots (NARS S2), and negative attitude towards emotional interactions with robots (NARS S3). The anxiety towards robot scale determines people’s state-like anxiety towards robots evoked in real and imaginary interactions scenario’s with robots. The scale consists of 11 items divided into three subscales: anxiety towards communication capacity of robots (RAS S1), anxiety towards behavioral characteristics of robots (RAS S2), and anxiety towards discourse with robots (RAS S3). The scales were presented on 7-point Likert scales from ‘strongly disagree’ to ‘strongly agree’. All items were translated to Dutch. The translation was completed by two bilingual speakers using the back-translation process. This process ensures that meaning and nuance are not lost, and that the translated versions of the constructs remain as true to the original as possible [17]. In addition to these two scales, the participants also indicated whether or not they had touched the robot and how much they had talked to the robot (from ‘much less than I had expected’ to ‘much more than I had expected’).
significant effects for the interaction on negative attitude towards robots. However, the results show that the interaction did have an effect on anxiety towards robot. The participants became more anxious towards the communication capability of robots (RAS S1; t = -5.99, p = .000) as well as more anxious towards discourse with robots (RAS S3; t = -3.06, p = .003). In contrast, anxiety towards behavioral characteristics of robots (RAS S2) decreased after the interaction (t = 3.28, p = .002).

As gender seems to affect how people react to robots [11, 18], we investigated the existence of any gender differences in the effect of interactions with robots on attitude and anxiety towards robots. Table III (next page) presents the results of a two-way mixed analysis of variance, which was performed to examine gender differences (between subject) on the pre-test and post-test measures (within subject) of both attitude and anxiety towards robots. For negative attitude towards interaction with robots (NARS S1), a gender effect was found (F 1, 58 = 11.02, p = .002) suggesting that females were more negative towards interaction with robots than males. No significant results were found for negative attitude towards social influence of robots (NARS S2). For anxiety towards communication capability of robots (RAS S1), a significant effect was found for the interaction with the robot (F 1, 58 = 34.84, p = .000) suggesting that participants felt more anxious after the interaction. For anxiety towards behavioral characteristics of robots (RAS S2), also a significant effect for the interaction with the robot (F 1, 58 = 10.69, p = .002) suggesting that participants felt less anxious after the interaction. For anxiety towards discourse with robots (RAS S3) significant effects were found for both gender and the interaction with the robot. Participants felt more anxious after the interaction (F 1, 58 = 9.05, p = .004), however, females were more anxious than males (F 1, 58 = 9.49, p = .003).

Each nation possesses its own level of exposure to robots through either media or personal experiences [5]. These nationality differences are expected to affect the experience of the interaction with the robot [2, 18]. Thus, another two-way mixed analysis of variance was performed (see table IV on the next page) to investigate if there were any differences of the effect of interactions with robots on attitude and anxiety towards robots between the Dutch and German participants. An effect for nationality was found for negative attitude towards social influence of robots (NARS S2), suggesting that Germans are more negative than Dutch. No significant results were found for nationality on the three anxiety subscales. The results for the effect of the interaction with the robot on these subscales remain similar to those earlier reported in the gender differences section above.


d. Participants

Students from a faculty of behavioral sciences in The Netherlands were recruited to participate in this study in exchange for credits. A total of 60 students, between 18 and 28 years old (M = 20.60, SD = 2.35) participated in this study. An equal distribution of gender was almost accomplished with 28 male participants and 32 female participants. Thirty participants had a Dutch nationality and thirty had a German nationality. As expected, almost all participants had no prior experience with interactions with robots.

IV. Results

Effect of human-robot interaction on attitude and anxiety towards robots. To determine the effects of the interaction with the robot on anxiety and negative attitude towards robots a Paired-Samples T-test was performed to compare the pre-test and post-test both measures. There were no significant effects for the interaction on negative attitude towards robots. However, the results show that the interaction did have an effect on anxiety towards robot. The participants became more anxious towards the communication capability of robots (RAS S1; t = -5.99, p = .000) as well as more anxious towards discourse with robots (RAS S3; t = -3.06, p = .003). In contrast, anxiety towards behavioral characteristics of robots (RAS S2) decreased after the interaction (t = 3.28, p = .002).

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Effects of attitude and anxiety on behavior during human-robot interaction. To analyze the effects of attitude and anxiety towards robots on people’s behavior during interactions with robots, first a stepwise multiple regression analysis was carried out with the pre-test measures of attitude and anxiety towards robots as explaining variables of touching the robot. Of the participants, 52 did touch the robot and 8 did not touch the robot. However, neither attitude nor anxiety explained why participants did or did not touch the robot.
Additionally, another analysis was generated on the Dutch and German sample separately to investigate any differences for nationality. However, neither attitude nor anxiety could explain how much Dutch talked to the robot. For Germans, anxiety towards discourse with robots before the interaction (RAS S3) explained 15.7 per cent how much they talked to the robot.

Effects of attitude and anxiety on future intentions to interact with robots. To analyze the effects of attitude and anxiety towards robots on people’s intention to interact with robots in the future, a regression analysis was performed with the post-test measures of attitude and anxiety towards robots as explaining variables of use intention. However, none of the attitude or anxiety measures could significantly explain if the participants would again interact with a robot in the future. Yet again, because gender and nationality effects might occur, the analysis were redone with the male and female sample, and the Dutch and German sample separately. However, again, none of the attitude or anxiety measures could significantly explain if these participants would again interact with a robot in the future.

### TABLE III. RESULTS OF TWO WAY MIXED ANALYSIS OF VARIANCE FOR GENDER VS. ROBOT INTERACTION

<table>
<thead>
<tr>
<th>Construct</th>
<th>Gender</th>
<th>Pre-test M</th>
<th>SD</th>
<th>Post-test M</th>
<th>SD</th>
<th>Male vs. Female F</th>
<th>p</th>
<th>part.ƞ²</th>
<th>Pre-test vs. Post-test F</th>
<th>p</th>
<th>part.ƞ²</th>
<th>Interaction Effect F</th>
<th>p</th>
<th>part.ƞ²</th>
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<tbody>
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<td>NARS S1</td>
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<td>3.05</td>
<td>0.95</td>
<td>3.05</td>
<td>1.00</td>
<td>0.01 .931</td>
<td>0.00</td>
<td>0.01 .931</td>
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<tr>
<td></td>
<td>Female</td>
<td>3.77</td>
<td>0.88</td>
<td>3.78</td>
<td>0.81</td>
<td>0.12 .275</td>
<td>0.02</td>
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<td>NARS S2</td>
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<td>1.17</td>
<td>4.16</td>
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<td>0.00</td>
<td>0.01 .931</td>
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<tr>
<td></td>
<td>Female</td>
<td>4.31</td>
<td>1.22</td>
<td>4.31</td>
<td>1.00</td>
<td>0.18 .931</td>
<td>0.00</td>
<td>0.01 .931</td>
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<tr>
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<td>3.03</td>
<td>1.16</td>
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<tr>
<td></td>
<td>Female</td>
<td>3.99</td>
<td>1.17</td>
<td>4.16</td>
<td>0.96</td>
<td>0.11 .931</td>
<td>0.00</td>
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<tr>
<td>RAS S2</td>
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<td>1.12</td>
<td>3.79</td>
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<tr>
<td></td>
<td>Female</td>
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<td>1.09</td>
<td>4.51</td>
<td>1.19</td>
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</table>

### TABLE IV. RESULTS OF TWO WAY MIXED ANALYSIS OF VARIANCE FOR NATIONALITY VS. ROBOT INTERACTION

<table>
<thead>
<tr>
<th>Construct</th>
<th>Natl.</th>
<th>Pre-test M</th>
<th>SD</th>
<th>Post-test M</th>
<th>SD</th>
<th>Dutch vs. German F</th>
<th>p</th>
<th>part.ƞ²</th>
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<th>p</th>
<th>part.ƞ²</th>
<th>Interaction Effect F</th>
<th>p</th>
<th>part.ƞ²</th>
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</thead>
<tbody>
<tr>
<td>NARS S1</td>
<td>Dutch</td>
<td>3.25</td>
<td>1.00</td>
<td>3.29</td>
<td>1.00</td>
<td>0.20 .153</td>
<td>0.05</td>
<td>0.01 .926</td>
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<tr>
<td></td>
<td>German</td>
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<td>3.60</td>
<td>0.92</td>
<td>0.05 .002</td>
<td>0.15</td>
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<td>1.17</td>
<td>3.99</td>
<td>1.17</td>
<td>0.06 .153</td>
<td>0.05</td>
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<tr>
<td></td>
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<td>4.41</td>
<td>1.37</td>
<td>4.41</td>
<td>1.22</td>
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<tr>
<td>RAS S1</td>
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<td>German</td>
<td>3.38</td>
<td>1.30</td>
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Because gender effects are to be expected, the analysis was generated again on the male and female sample separately. Of the male participants, 25 did touch the robot and 3 did not. However, again, neither attitude nor anxiety could explain why male participants did or did not touch the robot. Of the female participants, 27 did touch the robot and 4 did not. Anxiety towards behavioral characteristics (RAS S2; β=.32) females have before the interaction explained for 15.9 per cent the variance of touching the robot (χ² 2, 30=.025, p=.18). Additionally, as nationality differences were expected, another analysis was generated on the Dutch and German sample separately to investigate any differences for nationality. Of the Dutch participants, 27 did touch the robot and 3 did not. Of the German participants, 25 did touch the robot and 5 did not. However, for both nationalities, neither attitude nor anxiety could explain why male participants did or did not touch the robot.

Second, a stepwise multiple regression analysis was also performed with the pre-test measures of attitude and anxiety towards robots as explaining variables of talking to the robot (see table V). Anxiety towards discourse with robots before the interaction (RAS S3) explained 8.8 per cent of the variance of how much participants talked to the robot. Once more, because of possible gender effects, the analysis was performed again on the male and female sample separately. For male participants, also anxiety towards discourse with robots before the interaction (RAS S3) explained how much males talked to the robot (F 1, 27=.50, p=.031), however explanatory power increased to 13.5 per cent of the explained variance. Analysis for the female participants resulted in a different model to predict behavior towards robots. Negative attitude towards interaction with robots (NARS S1) explained for 21.4 per cent the variance of how much females talked to the robot (F 1, 31= 9.42, p=.005). Additionally, another analysis was generated on the Dutch and German sample separately to investigate any differences for nationality. However, neither attitude nor anxiety could explain how much Dutch talked to the robot. For Germans, anxiety towards discourse with robots before the interaction (RAS S3) explained 15.7 per cent how much they talked to the robot.

Effects of attitude and anxiety on future intentions to interact with robots. To analyze the effects of attitude and anxiety towards robots on people’s intention to interact with robots in the future, a regression analysis was performed with the post-test measures of attitude and anxiety towards robots as explaining variables of use intention. However, none of the attitude or anxiety measures could significantly explain if the participants would again interact with a robot in the future. Yet again, because gender and nationality effects might occur, the analysis were redone with the male and female sample, and the Dutch and German sample separately. However, again, none of the attitude or anxiety measures could significantly explain if these participants would again interact with a robot in the future.

### I. GENERAL DISCUSSION

More understanding is needed for the underexposed influence of negative attitudes and emotions towards robots on human behavior in interactions with robots. Broadened understanding in this matter could be used to improve robotic design in the future. This study indicates an effect of attitude and anxiety on human behavior towards robots during interaction. Conversely, these interactions had an effect on people’s anxiety levels. Moreover, the results also imply gender effects as well as differences in nationality in the relation between attitude and anxiety in interactions with robots.
First, this study supports the utility of people’s attitudes and anxiety towards robots to explain and predict behavior in human robot interaction. Women’s negative attitude towards interaction with robots explained how much they talk to robots. With respect to anxiety, this study indicates that anxiety towards discourse with robots before the interaction influences how much people, and especially men, talk to robots. Anxiety towards discourse with robots before the interaction also explained how much Germans talked to the robot. These results are similar to an earlier study [18] implying that communication avoidance behavior is explained by people’s anxiety towards robots.

Second, this study shows a significant effect of interactions with robots on people’s attitudes and anxiety towards robots. In general, it seems that people’s attitudes towards robots remain unchanged after an interaction with a robot. Contrary to these findings, earlier research into the influence of experiences with robots on negative attitudes towards robots did find some significant effects. People having experiences with robots are more positive towards interaction with robots, the social influences of robots, and, when controlled for educational background, also towards emotional interaction with robots [19]. Further gender analysis of the results of this study, however, did reveal an effect of interactions with robots on people’s attitudes towards robots. Women’s negative attitude towards interactions with robots increased after an interaction whereas men’s attitudes did not change. This is contrary to earlier research. Nomura et al. [18] did not find any gender effects on attitude change caused by an interaction with a robot. In another study [24], evaluations of people’s attitudes towards robots significantly improved after an interaction with a robot which in return explained a large amount of variance in the overall rating of the robot. Overall, it appears that interactions with robots influence people’s attitudes towards robots. However, the actual effect remains unclear after these few studies. Future research should investigate which aspects of the interaction and the robot cause either positive or negative attitude changes towards robots after an interaction and whether there are gender differences in these effects.

With respect to anxiety, it seems that interactions with robots also influence people anxiety towards robots. People become less anxious towards behavioral characteristics of robots, which, for this study, could be explained by the few bodily movements of the robot during the interaction. On the other hand, people become more anxious towards the communication capability of robots and discourse with robots. One explanation for this could be that the interaction was preprogrammed and thus unnatural, which might have caused the participants to feel uncertain about the progress of the conversation. A gender effect was also found for anxiety, whereas women seem more anxious than men towards discourse with robots.

Besides the two main findings, we would like to discuss the unsatisfactory internal consistency of the subscale of negative attitude towards emotions in interactions with robots (NARS S3) in our sample. There may be several reasons for this. For example, participants could have interpreted these items differently from how the researchers [18] invented it or participants just did not answer consistently to these items. It has also been argued that, when using a validated scale across cultures, it is insufficient to only translate the items and, in addition, cultural differences in the concept behind the scales within the different cultures should be investigated [1]. This could be another explanation for the inconsistency within this subscale in our sample. Actually, another study [25], also applying the exact same scale on a European sample, discovered that this particular subscale did not remain intact after a factor analysis in contrast to the other two subscales. This suggests that especially the subscale of negative attitude towards emotions in interactions with robots could be subject to cultural differences and might need further investigation in future research.

Furthermore, this study points to gender and nationality differences for both negative attitude and anxiety towards robots. Indeed, gender differences have previously been found to impact how users react to robots [11, 18]. Our results indicate that women hold more negative attitudes towards interactions with robots and feel more anxious towards discourse with robots than men. Germans are more negative towards social influence of robots than Dutch. Earlier research [2] investigating nationality differences in attitude towards robots also found similar results between Dutch and German. Together, these results indicate that researchers must be cautious before selecting their participants for studying aspects of HRI, especially when they are dealing with small samples.

This study also yields some interesting implications to guide future research in the design of robots. First, as interactions with robots clearly affect people’s attitudes and emotions towards robots, an area to further investigate is which aspects of robotic design evoke what specific emotions and how this could improve the attitudes people have towards robots. Second, gender differences reveal that men and women react differently to robots owing to their prior attitudes and anxiety towards robots. Increasing the attitudes and, especially, decreasing the anxious feelings people have towards robots before they interact with robots could improve their overall experiences with robots.

Limitations. As this study was conducted with one robot with a particular interaction scenario using participants from a specific group, the generalizability of these results are limited. However, this study contributes to an increasing accumulation of research on attitudes and emotions in relation to human behavior in interactions with robots. The results of this study could potentially be applied to robots with similar humanoid appearances and interactions with corresponding complexity. Although some insight was given to the consensus between these results and earlier studies, further research is necessary to establish the influences of user demographics, the type of robot and the type of conversation on the relationship between attitudes and anxiety towards robot, and behavioral aspects in HRI.
II. CONCLUSION

This study contributes to research into the role of negative attitude and emotion for human behavior in interactions with robots. First, by supporting the utility of people’s attitudes and anxiety towards robots to explain and predict behavior in human robot interaction. Second, by revealing changes in these negative attitudes and emotions after an interaction with a robot. Furthermore, this study shows both gender and nationality differences in people’s attitudes and anxious feelings towards robots. Subsequently, these effects of negative attitudes and emotions could guide future design research to further explore which design features of robots elicit what type of attitudes and emotions and how that affects people’s overall evaluations of robots.

REFERENCES