AI & Soc (2005)
DOI 10.1007/s00146-005-0012-7

ORIGINAL ARTICLE

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Experimental investigation into influence of negative attitudes toward robots on human–robot interaction

Received: 1 December 2004 / Accepted: 2 June 2005

Abstract Negative attitudes toward robots are considered as one of the psychological factors preventing humans from interacting with robots in the daily life. To verify their influence on humans' behaviors toward robots, we designed and executed experiments where subjects interacted with Robovie, which is being developed as a platform for research on the possibility of communication robots. This paper reports and discusses the results of these experiments on correlation between subjects' negative attitudes and their behaviors toward robots. Moreover, it discusses influences of gender and experience of real robots on their negative attitudes and behaviors toward robots.

Keywords Human–Robot interaction · Negative attitudes toward robots · Psychological experiments · Gender difference

Introduction

A great deal of study has been performed recently on robots that feature functions for communicating with humans in daily life, i.e., communication robots. This research has many applications such as entertainment, education, psychiatry, and so on (Dautenhahn et al. 2000; Druin and Hendler 2000). If communication robots are really applied to these fields, however, it should be carefully investigated on how humans are mentally affected by them.

Computer anxiety, an anxious emotion that prevents users from using computers and learning about them, has been studied in educational psychology as

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an important factor in education for computer literacy (Raub 1981; Hirata 1990). Thus, influence of communication robots on children in pedagogical applications and clients in psychiatric applications should also be considered. This influence should also be clarified from perspectives of designs for communication robots in other daily-life applications.

Our research on this subject focuses on attitudes toward communication robots as a psychological construct. We consider negative attitudes toward robots as a psychological factor preventing individuals from interaction with robots having functions of communication in daily life, and have been developing a psychological scale to measure it, the Negative Attitude toward Robots Scale (NARS).[1] By using this psychological scale, we designed and executed experiments where subjects interacted with a humanoid type communication robot "Robovie," which is being developed as a platform for research on the possibility of communication robots (Ishiguro et al. 2003) to investigate the influence of their negative attitudes toward robots into their behaviors toward them.

This paper presents procedures and results of the human–robot interaction experiments, and discusses relations between negative attitudes and human behaviors toward communication robots. Moreover, we consider influences of gender difference and experiences of real robots on them.

Negative attitude toward robots scale

The NARS has been developed for measuring humans' attitudes toward communication robots in daily life. We have already confirmed its internal consistency and construct validity (Nomura et al. 2005). In this paper, we mention only the overview of this confirmation process.

First, 32 candidates of questionnaire items were extracted from the freely described sentences in the pilot survey and the conventional psychological scales on computer anxiety and communication apprehension (Hirata 1990; Pribyl et al. 1998) and their content validity was confirmed by two psychologists including one of the authors. Second, the pretest was executed based on these 32 items, and 263 data samples were assembled. Factor analysis and item analysis consisting of good-poor analysis, correlation coefficients r, and α-coefficients were executed for the pretest data, and as a result, 14 items included in three subscales corresponding to three factors were extracted. Then, the test was executed based on these 14 items, and 240 data samples were assembled. It was confirmed by confirmatory factor analysis with Structural Equation Modeling that the test data had the factor structure consisting of three factors, the same as that in the pretest data. The indices of goodness-of-fit in this factor analysis were as follows: GFI = 0.900, AGFI = 0.856, RMSEA = 0.080. Moreover, α-coefficients of these three subscales in the test data were 0.775, 0.782, and 0.648, respectively.

Table 1 shows the sentences of the questionnaire items and subscales obtained through the above confirmation process. Note that this scale has been developed

[1] We tried to develop a psychological scale for measuring anxiety toward robots (Nomura and Kanda 2003). After some analysis, it became clear that our scale does not measure anxiety itself, but negative attitudes toward robots (Nomura et al. 2005).

in Japanese. The sentences in Table 1 show the English version of the NARS, which were translated based on back translation.

The number of grades in the answer at each item is five (i: strongly disagree, ii: disagree, iii: undecided, iv: agree, and v: strongly agree), and the score of an individual at each subscale is calculated by summing up the scores of all the items included in the scale, with reverse of scores in some items. Thus, the minimum score and maximum score are 6 and 30 in the subscale S1, 5 and 25 in the subscale S2, and 3 and 15 in the subscale S3, respectively.

Experimental procedure

This section explains the robot, the Negative Attitude toward Robots Scale used as a controlled variable, and concrete procedures in our experiments of human–robot interaction.

Robovie

As shown in Fig. 1, Robovie is a robot that has a human-like appearance and is designed for communication with humans (Ishiguro et al. 2003). It stands 120 cm tall, its diameter is 40 cm, and it weighs about 40 kg. The robot has two arms (4×2 DOF), a head (3 DOF), two eyes (2×2 DOF for gaze control), and a mobile platform (two driving wheels and one free wheel).

The robot has various sensors, including skin sensors covering the whole body, 10 tactile sensors located around the mobile platform, an omni-directional

Table 1 All the questionnaire items and subscales in the NARS

No.	Questionnaire items	Subscale
1	I would feel uneasy if robots really had emotions	S2
2	Something bad might happen if robots developed into living beings	S2
3	I would feel relaxed talking with robots[a]	S3
4	I would feel uneasy if I was given a job where I had to use robots	S1
5	If robots had emotions, I would be able to make friends with them[a]	S3
6	I feel comforted being with robots that have emotions[a]	S3
7	The word "robot" means nothing to me	S1
8	I would feel nervous operating a robot in front of other people	S1
9	I would hate the idea that robots or artificial intelligences were making judgments about things	S1
10	I would feel very nervous just standing in front of a robot	S1
11	I feel that if I depend on robots too much, something bad might happen	S2
12	I would feel paranoid talking with a robot	S1
13	I am concerned that robots would be a bad influence on children	S2
14	I feel that in the future society will be dominated by robots	S2
Index	Subscales	
S1	Negative attitude toward situations of interaction with robots	
id S2	Negative attitude toward social influence of robots	
S3	Negative attitude toward emotions in interaction with robots	

[a] Reversed item

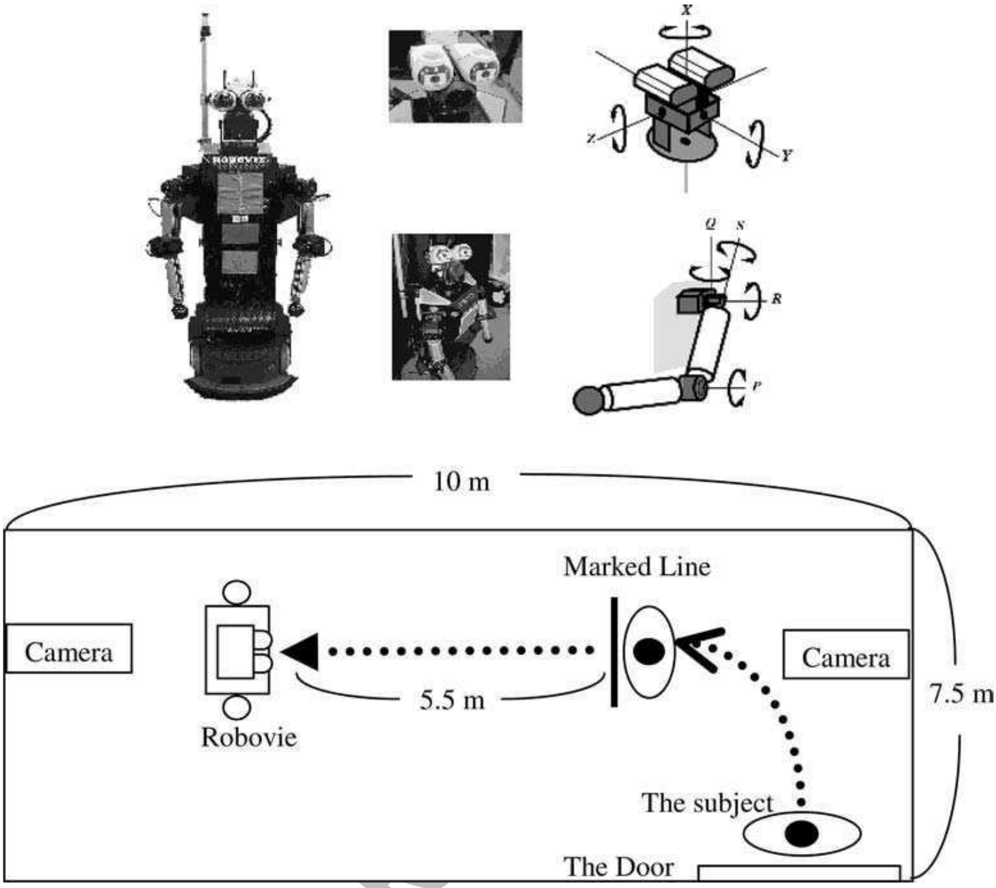

Fig. 1 Robovie and the overview of the room where the experiments were executed

vision sensor, two microphones to listen to human voices, and 24 ultra-sonic sensors for detecting obstacles. It carries a Pentium III PC on board for processing sensory data and generating gestures. The operating system is Linux.

Procedures of experiments on human–robot interaction

Our experiments on human–robot interaction were executed in the room shown in Fig. 1. Robovie programmed in advance was prepared for interaction with subjects in the room, and each subject communicated with it for a few minutes alone. The procedures used in one session of the experiments are shown as follows:

1. Before entering the experiment room shown in Fig. 1, the subjects responded to the following questionnaire items: i: sex, ii: age, iii: whether he/she had seen really acting robots, and iv: the NARS.
2. Just before entering the room, they were instructed to talk toward Robovie just after entering the room.

3. The subject entered the room alone. Then, he/she moved to the marked line on the floor.
4. After he/she talked to Robovie, or a constant time (30 seconds) passed, Robovie uttered a sentence to stimulate his/her self-expression ("Have you recently experienced something negative?").
5. After he/she replied to the utterance of Robovie, or a constant time (30 seconds) passed, Robovie uttered a sentence to stimulate his/her physical contact to it ("Touch me").
6. After he/she touched the body of Robovie, or a constant time (30 seconds) passed, the session finished.

Behaviors of the subjects, including their utterances, were recorded using two digital video cameras as shown in Fig. 1. Then, the following items related to their behaviors were extracted from the video data:

– The distance from the subjects to Robovie when they first stood in front of the robot after entering the room (D).
– The time elapsed until the subjects talked to Robovie after entering the room (U1).
– The time elapsed until the subjects replied to Robovie after it uttered to stimulate their self-expression (U2).
– The time elapsed until the subjects touched the robot's body after it uttered to stimulate the subjects' physical contact with it (T).

Moreover, the contents of the subjects' utterances in the above step 5, that is, their replies to stimulation from the robot for their self-expression, were classified into three categories: utterances about something related to the subjects themselves, utterances about something not related to themselves, and non-utterance. This classification was executed by two persons, and if there was a difference between classification results of the two persons, they discussed and integrated their classification results.

Experimental results

This section shows results of the experiments shown in Sect. 3. Fifty-three university students were asked to participate in the experiments as subjects (male: 22, female: 31), and the average age of these subjects was 19.9 (male: 20.6, female: 19.5). This paper focuses on the influence of the subjects' negative attitudes toward robots on their behaviors toward the robot and differences shown between genders. Moreover, influence of the subjects' experiences of real robots is considered.

Influence of negative attitudes on behaviors toward the robot

In order to clarify influence of the subjects' negative attitudes toward robots on their behaviors, we divided the subjects into two subgroups based on the median value of the scores of each subscale of the NARS, then executed a *t*-test to verify a statistically significant difference on the behavior indices shown in Sect. 3.2 between the subgroups at each subscale. Table 2 shows the mean scores and

Table 2 The mean scores and standard deviation of behavioral indices between higher-score and lower-score subgroups on each subscale and *t*-values of the scores between the subgroups

	D(mm)			U1(s)		
		Mean (SD)	*t*-Value		Mean (SD)	*t*-Value
S1	H ($n = 25$)	1264.9 (525.1)	1.01	H ($n = 21$)	6.5 (1.6)	2.65*
	L ($n = 24$)	1127.5 (392.6)		L ($n = 28$)	5.2 (1.7)	
S2	H ($n = 25$)	1161.1 (395.3)	−0.55	H ($n = 24$)	5.6 (1.5)	−0.93
	L ($n = 24$)	1235.6 (534.2)		L ($n = 25$)	6.1 (2.0)	
S3	H ($n = 21$)	1255.8 (507.3)	0.74	H ($n = 20$)	6.2 (1.8)	1.02
	L ($n = 28$)	1154.0 (434.9)		L ($n = 29$)	5.6 (1.8)	
	U2 (s)			T (s)		
		Mean (SD)	*t*-Value		Mean (SD)	*t*-Value
S1	H ($n = 25$)	2.4 (2.5)	0.28	H ($n = 22$)	4.2 (3.4)	0.13
	L ($n = 22$)	2.3 (1.4)		L ($n = 26$)	4.1 (2.0)	
S2	H ($n = 24$)	2.3 (1.3)	−0.17	H ($n = 25$)	3.7 (1.8)	−1.17
	L ($n = 23$)	2.4 (2.6)		L ($n = 23$)	4.6 (3.3)	
S3	H ($n = 19$)	2.4 (1.4)	0.22	H ($n = 20$)	4.0 (2.6)	−0.32
	L ($n = 28$)	2.3 (2.4)		L ($n = 28$)	4.2 (2.8)	

H the higher-score subgroup, *L* the lower-score subgroup, *n* the number of subjects in the subgroup. The values in *brackets* represent the standard deviation* $p < 0.05$

standard deviation of the behavior indices between the higher-score and lower-score subgroups on each subscale, and *t*-values of the sores between the subgroups. Note that there are differences in the number of subjects in the subgroups, dependent on the median values of the subscales and indices since some behavior indices were not displayed by some subjects (the indices U1, U2, and T were treated as lost data in cases where the subjects did not respond within 30 s).

There was no statistically significant difference in the behavior indices D, U2, and T between the higher-score and lower-score subgroups divided by any of the subscales. However, there was a statistically significant difference at 0.05 level on the time elapsed until the subjects talked to Robovie after entering the room U1 between the higher-score and lower-score subgroups based on the subscale of negative attitude toward situations of interaction with robots S1. This result suggests a possibility that persons with higher negative attitude toward situations of interaction with robots tend to avoid talking to robots.

Moreover, the subjects' utterances varied from just "yes" or "no" to some concrete ones such that "I failed in an examination", "I have no money, recently", and so on. We divided the subjects into three subgroups based on the contents of their utterances mentioned in Sect. 3.2, then executed a one-way ANOVA with Tukey post hoc tests to verify a statistically significant difference on the NARS scores between the subgroups. Table 3 shows the mean scores and standard deviation of the NARS in the subgroups and the results of the ANOVA and post hoc test.

On the scores of negative attitudes toward situations of interaction with robots (S1) and social influence of robots (S2), there were statistically significant differences at 0.01 and 0.05 levels respectively. Moreover, it was found by the post-hoc tests that the scores of S1 and S2 in the subgroup of the subjects who did not utter anything were higher than those in the subgroup of the subjects

Table 3 The mean scores and standard deviation of the NARS in the subgroups based on the contents of the subjects' utterances and *F*-values of the one-way ANOVA

	Mean (SD)			*F*-Value	Post hoc test
	G1 ($n=9$)	G2 ($n=39$)	G3 ($n=3$)		
S1	13.7 (4.0)	11.6 (3.1)	18.3 (1.2)	6.523**	G2 < G3**
S2	16.6 (3.4)	15.3 (3.2)	21.0 (1.6)	4.618*	G2 < G3*
S3	9.9 (2.3)	9.0 (2.3)	11.7 (2.1)	2.166	

G1 the subgroup of the subjects who uttered about something related to themselves, *G2* the subgroup of the subjects who uttered about something not related to themselves, *G3* the subgroup of the subjects who did not utter anything, *n* the number of subjects in the subgroup. The values in *brackets* represent the standard deviation * $p < 0.05$; ** $p < 0.01$

who uttered something not related to themselves with statistical significance of 1% and 5%, respectively. This result suggests that persons with higher negative attitudes toward situations of interaction with robots and social influence of robots tend to avoid their self-expression to robots.

Influence of gender on relations between negative attitudes and behaviors toward the robot

First, we executed a *t*-test to verify statistically significant differences in the scores of NARS and behavior indices between male and female subjects. Tables 4 and 5 show the mean scores and standard deviation of the NARS and behavior indices, and *t*-values of them between males and females.

As shown in Table 4, there was a trend that the female subjects had lower negative attitudes toward robots than the male subjects. In particular, there was a statistically significant difference at 0.05 level on the scores of negative attitude toward emotions in interaction with robots (S3). Moreover, as shown in Table 5, there was a statistically significant difference at 0.001 level for the distance from the subjects to the robot when they first stood in front of the robot after entering the room (D).

Second, we investigated correlation coefficients *r* between the NARS scores and behavior indices independently for male and female subjects. Table 6 shows these correlation coefficients.

On the time elapsed until the subjects talked to the robot after entering the room (U1) and their scores of negative attitude toward emotions in interaction with robots (S3), the female subjects showed a statistically significant positive correlation to a moderate level, whereas the male subjects showed a low correlation. Although there was no statistical significance, on the time elapsed until the subjects replied to the robot after it uttered to stimulate their self-expression (U2) and their scores of negative attitude toward situations of interaction with robots (S1), the male subjects showed a negative correlation whereas the female subjects showed a positive correlation. Moreover, on the distance from the subjects to the robot when they first stood in front of it after entering the room (D) and their scores of negative attitude toward emotions in interaction with robots (S3), on which there was a statistically significant difference between male and female subjects in Table 4, the male subjects showed a positive correlation, whereas the female subjects showed a negative correlation. On the time elapsed

Table 4 The mean scores and standard deviation of the NARS in the male and female subjects and *t*-values between them

	S1		S2		S3	
	Mean (SD)	*t*-Value	Mean (SD)	*t*-Value	Mean (SD)	*t*-Value
Males ($n=22$)	12.6 (3.9)	0.455	16.3 (3.2)	0.751	10.1 (2.0)	2.267*
Females ($n=31$)	12.1 (3.3)		15.5 (3.6)		8.6 (2.4)	

n the number of subjects. The values in *brackets* represent the standard deviation * $p<0.05$

Table 5 The mean scores standard deviation of the behavior indices in the male and female subjects and *t*-values between them

	D			U1		
	N	Mean (SD)	*t*-Value	*N*	Mean (SD)	*t*-Value
Males	21	1479.3 (513.4)	3.860*	19	5.7 (1.9)	−0.410
Females	28	986.3 (291.1)		30	5.9 (1.7)	
	U2			T		
	N	Mean (SD)	*t*-Value	*N*	Mean (SD)	*t*-Value
Males	18	2.2 (1.3)	−0.445	20	4.9 (3.3)	1.530
Females	29	2.4 (2.4)		28	3.6 (2.0)	

n the number of subjects. The values in *brackets* represent the standard deviation *$p<0.01$

Table 6 Correlation coefficients *r* between the NARS scores and behavior indices in the male and female subjects

		D	U1	U2	T
S1	Males	0.162	0.210	−0.351	0.070
	Females	−0.022	0.141	0.260	−0.014
S2	Males	0.232	0.387	−0.244	0.245
	Females	−0.057	0.015	−0.044	−0.025
S3	Males	0.267	−0.057	−0.112	−0.115
	Females	−0.139	0.325*	0.040	−0.292

*$p<0.1$

until the subjects talked to the robot after entering the room (U1) and their scores of negative attitude toward social influence of robots (S2), the male subjects showed a moderate positive correlation, whereas the female subjects showed a low correlation. These values do suggest a possibility of gender differences in both negative attitudes toward robots and relations between them and behaviors toward robots.

Influence of experiences of real robots on relations between negative attitudes and behaviors toward the robot

As mentioned in Sect. 3.2, the subjects responded to a questionnaire item asking whether they had previously seen really acting robots. We divided the subjects into subgroups of those who denied it and those who acknowledged it, then executed a *t*-test to verify statistically significant differences in the scores of NARS and behavior indices between these subgroups. Tables 7 and 8 show the mean scores and standard deviation of the NARS and behavior indices, and *t*-values of them between these subgroups.

As shown in Table 7, there was no statistically significant difference on the NARS scores between subgroups of the subjects who had seen really acting robots and those who had not. However, as shown in Table 8, there were statistical tendencies at 0.1 level on the distance from the subjects to the robot when they first stood in front of the robot after entering the room (D) and the time elapsed until the subjects replied to the robot after it uttered to stimulate their self-expression (U2).

Second, we investigated correlation coefficients *r* between the NARS scores and behavior indices independently for the subgroups of the subjects who had seen really acting robots and those who had not. Table 9 shows these correlation coefficients.

On the time elapsed until the subjects replied to the robot after it uttered to stimulate their self-expression (U2) and their scores of negative attitude toward situations of interaction with robots (S1), the subjects who had seen really acting robots showed a moderate positive correlation with statistical tendency at 0.1

Table 7 The mean scores and standard deviation of the NARS in the subgroups of the subjects who had seen really acting robots and those who had not, and *t*-values between them (*n*: the number of subjects, EE: the subgroups of the subjects who had seen really acting robots, NEE: the subgroups of the subjects who had not seen really acting robots. The values in brackets represent the standard deviation)

	S1		S2		S3	
	Mean (SD)	*t*-Value	Mean (SD)	*t*-Value	Mean (SD)	*t*-Value
EE ($n = 20$)	11.6 (3.5)	−1.216	16.1 (3.3)	0.410	9.1 (2.5)	−0.343
NEE ($n = 33$)	12.8 (3.5)		15.7 (3.5)		9.3 (2.2)	

Table 8 The mean scores and standard deviation of the behavior indices in the subgroups of the subjects who had seen really acting robots and those who had not, and *t*-values between them

	D			U1		
	n	Mean (SD)	*t*-Value	*n*	Mean (SD)	*t*-Value
EE	18	1352.1 (450.3)	1.174*	18	5.9 (1.8)	0.192
NEE	31	1107.9 (457.7)		31	5.8 (1.8)	
	U2			T		
	n	Mean (SD)	*t*-Value	*n*	Mean (SD)	*t*-Value
EE	17	3.2 (2.6)	1.902*	19	4.6 (2.5)	1.022
NEE	30	1.9 (1.4)		29	3.8 (2.8)	

n the number of subjects, *EE* the subgroups of the subjects who had seen really acting robots, *NEE* the subgroups of the subjects who had not seen really acting robots. The values in *brackets* represent the standard deviation* $p < 0.1$

Table 9 Correlation coefficients *r* between the NARS scores and behavior indices in the subgroups of the subjects who had seen really acting robots and those who had not

		D	U1	U2	T
S1	EE	0.060	0.119	0.478*	0.140
	NEE	0.198	0.213	0.048	0.061
S2	EE	−0.075	0.256	−0.059	0.355
	NEE	−0.069	0.131	−0.103	0.109
S3	EE	0.144	0.058	−0.112	0.035
	NEE	0.258	0.216	0.195	−0.192

EE the subgroups of the subjects who had seen really acting robots, *NEE* the subgroups of the subjects who had not seen really acting robots* $p < 0.1$

level whereas the subjects who had not seen robots showed a low correlation. This result suggests a possibility that individuals' experiences of real robots influence the relations between negative attitudes and behaviors toward robots.

Conclusions and discussion

In this paper, we showed the procedures and results of our experiments on human–robot interaction by using a humanoid robot "Robovie" and the NARS. As a result, we suggested a possibility that negative attitudes for robots affected human behaviors toward communication robots. Moreover, we noticed a possibility that there were gender differences in negative attitudes toward robots, and that there were also gender differences in relations between negative attitudes and behaviors toward robots. Furthermore, we noticed a possibility that individuals' experiences of real robots influence the relations between negative attitudes and behaviors toward robots.

The results of our experiments in Sect. 4.1 show that negative attitude toward situations of interaction with robots affects interaction with communication robots, and this negative attitude and negative attitude toward social influence of robots affect self-expression toward communication robots. Mental disaffiliation is a common characteristic in behaviors associated with communication apprehension (Sakamoto et al. 1998), and the results suggest that persons with highly negative attitudes toward robots mentally tend to avoid human–robot communication.

Moreover, the results of our experiments in Sect. 4.2 imply a possibility that men and women differ in their degrees of negative attitudes toward robots, and correlation between the negative attitudes and communication behaviors such as utterances toward robots. The results in Sect. 4.3 imply a possibility that persons having seen really acting robots and those not having seen them differ in correlation between the negative attitudes and communication behaviors such as utterances toward robots. The implication may lead us to a suggestion that designs of communication robots' appearance and behaviors should be considered from the perspective of gender and individuals' experiences, in particular, in pedagogical and psychiatric fields.

However, our research has some problems. Our experiment did not have concrete hypotheses and the number of subjects in it was small. Thus, it showed just a possibility of influence of negative attitudes toward robots into behaviors toward them and gender difference in it. The results did not sufficiently clarify relations between the behavior indices and scores of NARS, or have immediate suggestions to design of communication robots. In other words, there is a possibility that negative attitudes toward robots may not directly affect behaviors toward them. In fact, we did not obtain statistically significant results on regression analysis between the NARS scores and behavior indices in our experiment mentioned in Sect. 4.

As a cause of it, we consider the fact that communication robots have been less popular than computers, of which concrete images have been constructed in general people. Images of robots range from arm robots in factories to pet-type robots. Thus, it is expected that psychological attitudes toward robots are hard to connect with behaviors toward them in situations of real interaction with them, in comparison with computers. In order to predicate individuals' communication avoidance behaviors toward robots, we need to develop another psychological scale to measure anxiety or fear in situations of interaction with robots (Normura et al. 2004). Moreover, we should clarify which psychological mechanism causes influences by executing more detailed experiments.

Moreover, we need to consider a possibility that assumptions on communication robots influences negative attitudes, and relations between the negative attitudes and behaviors, and they differ among individuals. We assembled data consisting of 238 respondents (male: 146, female: 92, the average age of the male: 21.8, that of the females: 22.4) in order to investigate validity of the NARS (Normura 2005). In analysis of the data, it was found by a two-way ANOVA that gender and experience of robots affect the scores of the subscale S1 (see Table 10 in Appendix). The statistical trend in this data did not appear in the subjects of our experiment. Moreover, we executed a two-way ANOVA between male–female groups and the groups of these respondents and the subjects in the experiement of Sect. 4 to investigate difference on the NARS scores between them. As a result, it was found that the female subjects had lower negative attitudes toward emotions in interaction with robots than the respondents (see Table 11 in Appendix. Tukey post hoc tests confirmed it with statistically significance at 0.01 level). These facts imply a possibility that negative attitudes toward robots are affected by what type of robots the respondents assumed and in what situation they assumed robots existed, although they simply answered

Table 10 The result of the two-ways ANOVA for the NARS scores in 238 respondents

	Mean (SD)				*F*-Values		
	Males		Females		Male–Female	EE–NEE	Interaction
	EE ($n = 124$)	NEE ($n = 22$)	EE ($n = 53$)	NEE ($n = 39$)			
S1	10.7 (3.9)	12.0 (4.0)	11.7 (3.4)	14.1 (4.4)	8.997*	6.993*	0.785
S2	15.1 (4.3)	16.5 (4.1)	16.6 (4.2)	16.6 (4.9)	1.111	1.386	0.945
S3	10.5 (2.4)	10.0 (2.4)	10.5 (2.5)	10.4 (2.3)	0.507	0.224	0.248

n the number of respondents, *EE* the subgroups of the respondents who had seen really acting robots, *NEE* the subgroups of the respondents who had not seen really acting robots * $p < 0.01$

Table 11 The result of the two-ways ANOVA for the NARS scores in the 238 respondents and the subjects in the human–robot interaction experiments

	Mean (SD)				F-Values		
	Males		Females		Male-Female	RE-SJ	Interaction
	RE ($n = 146$)	SJ ($n = 22$)	RE ($n = 92$)	SJ ($n = 31$)			
S1	10.8 (3.9)	12.6 (3.9)	12.8 (4.1)	12.1 (3.3)	1.398	0.848	3.768*
S2	15.3 (4.3)	16.3 (3.2)	16.6 (4.5)	15.5 (3.6)	0.188	0.006	2.367
S3	10.4 (2.4)	10.1 (2.0)	10.5 (2.4)	8.6 (2.4)	3.375*	8.610**	4.022***

RE the respondents for validity confirmation, *SJ* the subjects in the human–robot interaction experiments $^{*}p < 0.1$; $^{**}p < 0.01$; $^{***}p < 0.05$

on whether they had seen them. Of course, there is a possibility that negative attitudes toward communication robots, assumptions on robots, and relations between the negative attitudes and behaviors differ depending on cultures. By developing the English version of NARS, we should investigate international comparisons of negative attitudes toward robots and their relations with behaviors toward and assumptions of robots.

Acknowledgements This research was supported by the National Institute of Information and Communications Technology. We thank Prof. Masahiro Sakamoto of Bunkyo Gakuin University for providing us with the Japanese version of the Personal Report of Communication Apprehension (PRCA-24), as his form of cooperation with our research on constructing the Negative Attitude toward Robots Scale. Moreover, we thank Dr. Kensuke Kato in Osaka University for his cooperation in checking the content validity of the Negative Attitude toward Robots Scale. We also thank Dr. Christoph Bartneck of the Technical University of Eindhoven and his colleagues for their cooperation on translating the Negative Attitude toward Robots Scale into English.

Appendix

Tables 10 and 11 show the results of analysis for 238 respondents for the NARS assembled for investigating its validity.

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