Experimental Investigation into Influence of Negative Attitudes toward Robots on Human–Robot Interaction *

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Abstract

Negative attitudes toward robots are considered as one of psychological factors preventing humans from interacting with robots in 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 genders and experiences of real robots on their negative attitudes and behaviors toward robots.

Keywords: Human–Robot Interaction, Negative Attitudes toward Robots, Psychological Experiments, Gender Difference

1 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., 2002; Druin and Hendler, 2000). If communication robots are really applied to these fields, however, it should be carefully investigated how humans are mentally affected by them.

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

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Table 1: All the questionnaire items in the NARS

No.	Questionnaire Items
1	I feel anxiety if robots really have their own emotions.
2	I surmise that something negative for humans happen when robots become more similar to humans.
3	I will be able to be relaxed if I interact with robots.*
4	I feel anxiety when I imagine that I may be employed and assigned to a workplace where robots should be used.
5	I will be familiar with robots if they have their own emotions.*
6	I am mentally healed when I see robots behaving affectively. *
7	I am left helpless even by hearing something on robots.
8	I am likely to bring shame on myself when I use robots in public.
9	The words "artificial intelligence" or "decision by robots" make me feel unpleasant.
10	Even standing in front of robots will strain me.
11	I surmise that extreme dependence on robots may cause something negative for humans in future.
12	I will feel nervous if I interact with robots.
13	I am afraid that robots may negatively influence children's mind.
14	I surmise that future societies may be dominated by robots.
	(*inverse item)

computer literacy (Raub, 1981; Hirata, 1990). Thus, influence of communication robots on children in pedagogical applications and clients in psychiatric applications should be also considered. This influence also should 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 an 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 measuring 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.

2 Negative Attitude toward Robots Scale

The Negative Attitude toward Robots Scale (NARS) has been developed for measuring humans' attitudes toward communication robots in daily life. We have already confirmed its internal consistency and factorial validity (Nomura et al., 2004). 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

[1] We tried to develop a psychological scale for measuring anxiety toward robots (Nomura and Kanda, 2003). After some analysis, it was clarified that our scale does not measure anxiety itself, but negative attitudes toward robots (Nomura et al., 2004).

Table 2: The subordinate scales and item numbers included in them in the NARS

Index	Subordinate Scales	Item No.
S1	Negative Attitude toward Situations of Interaction with Robots	4,7,8,9,10,12
S2	Negative Attitude toward Social Influence of Robots	1,2,11,13,14
S3	Negative Attitude toward Emotions in Interaction with Robots	3, 5, 6

items, and 263 data samples were assembled. Factor analysis and item analysis consisting of good–poor analysis, correlation coefficients, and α coefficients were executed for the pretest data, and as a result, 14 items included in 3 subordinate scales corresponding to 3 factors were extracted. Then, the test was executed based on these 14 items, and 240 data samples were assembled. It was confirmed by factor analysis that the test data had the factor structure consisting of 3 factors 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 3 subordinate scales in the test data were 0.775, 0.782, and 0.648, respectively. At this time, its conceptual validity and test–retest reliability were also investigated (Nomura et al., 2004).

Table 1 shows the sentences of the questionnaire items obtained through the above confirmation process. Note that this scale has been developed in Japanese and the formal English version of it has not been completed. These sentences were roughly translated by one of the authors, not produced along formal procedures including back–translation. Moreover, table 2 shows these subordinate scales and item numbers included in them.

The number of grades in the answer at each item is five (1: I strongly disagree, 2: I disagree, 3: Undecided, 4: I agree, 5: I strongly agree), and the score of an individual at each subordinate scale is calculated by summing the scores of all the items included in the scale, with inverses of scores in some items. Thus, the minimum score and maximum score are 6 and 30 in the subordinate sale **S1**, 5 and 25 in the subordinate scale **S2**, and 3 and 15 in the subordinate scale **S3**, respectively.

3 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.

3.1 Robovie

As shown in Figure. 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 weights 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 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.

3.2 Procedures of Experiments on Human–Robot Interaction

Our experiments on human–robot interaction were executed in the room shown in Figure 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 Figure 1, the subjects responded for the following questionnaire items:

   - sex, age,

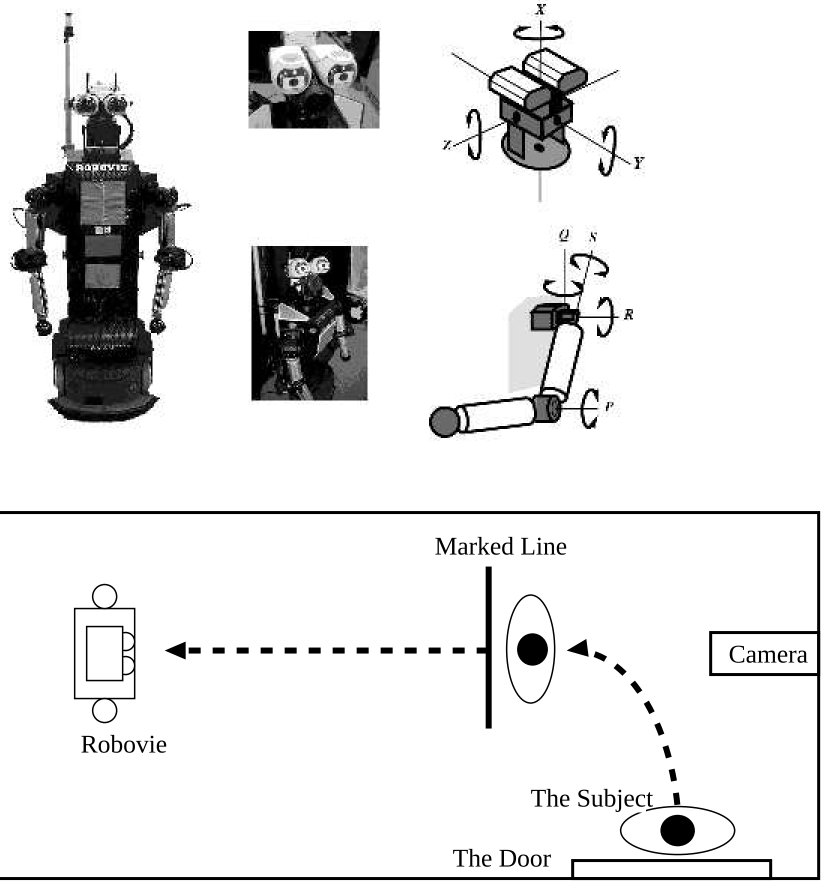

Figure 1: Robovie and the overview of the room where the experiments were executed (a view from above)

- whether he/she had seen really acting robots,
- 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 Figure 1. Then, the following items related to their behaviors were extracted from the video data:

- The distance from the subjects to Robvie when they first stood in front of the robot after entering the room (**D**)

Table 3: The average values of the behavioral indices between the higher– and lower–score subgroups on each subordinate scale and t–values of the sores between the subgroups (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).

		D (mm)			**U1** (sec)	
		Average (SD)	t–Value		Average (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 (sec)			**T** (sec)	
		Average (SD)	t–Value		Average (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)	

(* $p < .05$)

- 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.

4 Experimental Results

This section shows results of the experiments shown in section 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.

4.1 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 subordinate scale of the NARS, then executed a t–test to verify a statistically significant difference on the behavior indices shown in section 3.2 between the subgroups at each subordinate scale. Table 3

Table 4: The average values of the NARS scores in the subgroups based on the contents of the subjects' utterances and f–values of the one–way ANOVA (G_1: the subgroup of the subjects who uttered about something related to themselves, G_2: the subgroup of the subjects who uttered about something not related to themselves, G_3: 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).

	Average (SD)			f–Value	post–hoc test
	G_1 (n=9)	G_2 (n=39)	G_3 (n=3)		
S1	13.7 (4.0)	11.6 (3.1)	18.3 (1.2)	6.523^{**}	$G_2 < G_3{}^{**}$
S2	16.6 (3.4)	15.3 (3.2)	21.0 (1.6)	4.618^{*}	$G_2 < G_3{}^{*}$
S3	9.9 (2.3)	9.0 (2.3)	11.7 (2.1)	2.166	

($^{*}p < .05$, $^{**}p < .01$)

shows the average values of the behavior indices between the higher– and lower–score subgroups on each subordinate scale, 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 subordinate scales and indices since some behavior indices were not displayed by some subjects (the indeices **U1**, **U2**, and **T** were treated as lost data in case that the subjects did not respond within 30 seconds).

There was no statistically significant difference in the behavior indices **D**, **U2**, and **T** between the higher– and lower–score subgroups divided by any of the subordinate scales. However, there was a statistically significant difference of 5% on the time elapsed until the subjects talked to Robovie after entering the room (**U1**) between the higher– and lower–score subgroups based on the subordinate scale 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 to talk to robots.

Moreover, we divided the subjects into three subgroups based on the contents of their utterances mentioned in section 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 4 shows the average values of the NARS scores in the subgroups and f–values of the ANOVA.

On the scores of negative attitudes toward situations of interaction with robots (**S1**) and social influence of robots (**S2**), there were statistically significant differences of 1% and 5% 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 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.

4.2 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 the male and female subjects. Table 5 and 6 show the average values of the NARS scores and behavior indices, and t–values of them between the males and females.

As shown in Table 5, 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 of 5% on the scores of negative attitude toward emotions in interaction with robots (**S3**). Moreover, as shown in Table 6, there was a statistically significant difference of 0.1% 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 between the NARS scores and behavior indices independently for male and female subjects. Table 7 shows these correlation coefficients.

Table 5: The average values of the NARS scores in the male and female subjects and t–values between them (n: the number of subjects. The values in brackets represent the standard deviation).

	S1		**S2**		**S3**	
	Average (SD)	t–Value	Average (SD)	t–Value	Average (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)	

(* $p < .05$)

Table 6: The average values of the behavior indices in the male and female subjects and t–values between them (n: the number of subjects. The values in brackets represent the standard deviation).

	D			**U1**		
	n	Average (SD)	t–Value	n	Average (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	Average (SD)	t–Value	n	Average (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)	

(*** $p < .001$)

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 medium 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 the male and female subjects in Table 5, the male subjects showed a positive correlation, whereas the female subjects showed a negative correlation. On the time elapsed until the subjects talked to the robot after entering the room (**U1**) and their scores of negative attitude toward social influence of

Table 7: Correlation coefficients 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

(† $p < .1$)

Table 8: The average values of the NARS scores 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**	
	Average (SD)	t–Value	Average (SD)	t–Value	Average (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 9: The average values 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 (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).

		D			**U1**	
	n	Average (SD)	t–Value	n	Average (SD)	t–Value
EE	18	1352.1 (450.3)	$1.174^{\dagger}$	18	5.9 (1.8)	0.192
NEE	31	1107.9 (457.7)		31	5.8 (1.8)	
		U2			**T**	
	n	Average (SD)	t–Value	n	Average (SD)	t–Value
EE	17	3.2 (2.6)	$1.902^{\dagger}$	19	4.6 (2.5)	1.022
NEE	30	1.9 (1.4)		29	3.8 (2.8)	

($^{\dagger}p < .1$)

robots (**S2**), the male subjects showed a medium 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.

4.3 Influence of Experiences of Real Robots on Relations between Negative Attitudes and Behaviors toward the Robot

As mentioned in section 3.2, the subjects responded for a questionnaire item asking whether they had previously seen really acting robots. We divided the subjects into the 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. Table 8 and 9 show the average values of the NARS scores and behavior indices, and t–values of them between these subgroups.

As shown in Table 8, there was no statistically significant difference on the NARS scores between the subgroups of the subjects who had seen really acting robots and those who had not. However, as shown in Table 9, there were statistically significant tendencies of 10% 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 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 10 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

Table 10: Correlation coefficients between the NARS scores and behavior indices in the subgroups of the subjects who had seen really acting robots and those who had not (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).

		D	**U1**	**U2**	**T**
S1	EE	0.060	0.119	$0.478^{\dagger}$	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

($^{\dagger}p < .1$)

(**S1**), the subjects who had seen really acting robots showed a medium positive correlation with statistically significant tendency of 10% whereas the subjects who had not seen robots showed a low correlation. Although there was no statistical significance, there was a similar tendency on the time elapsed until the subjects touched the robot's body after it uttered to stimulate the subjects' physical contact with it (**T**) and their scores of negative attitude toward social influence of robots (**S2**). This result suggests a possibility that individuals' experiences of real robots influence on relations between negative attitudes and behaviors toward robots.

5 Conclusion 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 Negative Attitude for Robots Scale (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 on relations between negative attitudes and behaviors toward robots.

The results of our experiments in section 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 section 4.2 show 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 section 4.3 show that persons having seen really acting robots and those not having differ in correlation between the negative attitudes and communication behaviors such as utterances toward robots. These facts suggest that designs of communication robots' appearance and behaviors should be considered from the perspective of genders and individuals' experiences, in particular, in pedagogical and psychiatric fields.

However, our research has some problems.

We showed just a possiblity of influence of negative attitudes toward robots into behaviors toward them and gender difference in it, and the results of our experiments did sufficiently not clarify relations between the behavior indices and scores of NARS. In other words, there is a possibility that negative attitudes toward robots may directly not affect behaviors toward them. 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 are wide from arm robots in factories to pet–type robots. Thus, it is guessed that psychological attitudes toward robots are hard to be connected 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. Moreover, we should clarify which psychological mechanism causes influences by executing more detailed experiments and more complex statistical methods such as structural equation models.

Moreover, we need to solve the problem of sampling bias of subjects in this type of experiments. In other words, there is a difference on negative attitudes toward robots between subjects participating in human–robot interaction experiments and more general persons. 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 (Nomura et al., 2004). In analysis of the data, it was found by a two–ways ANOVA that genders and experiences on robots affect the scores of the subordinate scale **S1** (see Table 11 in Appendix). The statistical trend in this data did not appear in the subjects of our experiment. Moreover, we executed a two–ways ANOVA for male–female and these respondents–the subjects in section 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 12 in Appendix. Tukey post–hoc tests confirmed it with statistically significance of 1%). This type of bias influences analysis and interpretation of human–robot interaction, and it is necessary to carefully consider it, in particular, when applying the results to the design of communication robots.

Furthermore, there is a possibility that negative attitudes toward communication robots, images of robots, and relations between the negative attitudes and behaviors differ dependent on cultures. By developing the English version of NARS and combining it with other psychological scales such as STAI (Hidano et al., 2000; Spielberger et al., 1970) and the robot image scale (Suzuki et al., 2002), we should investigate international comparisons of negative attitudes toward robots and their relations with behaviors toward and images of robots.

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Appendix

The following tables show the results of analysis for 238 respondents for the NARS assembled for investigating its validity in Nomura et al. (2004). Note that these results were not described in Nomura et al. (2004).

Table 11: The result of the two–ways ANOVA for the NARS scores in 238 respondents (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).

	Average (SD)				f–Values		
	Males		Females		Factor 1	Factor 2	Mutual
	EE	NEE	EE	NEE	(Male–Female)	(EE–NEE)	Interaction
	(n=124)	(n=22)	(n=53)	(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

($^{**}p < .01$)

Table 12: The result of the two–ways ANOVA for the NARS scores in the 238 respondents and the subjects in the human–robot interaction experiments (RE: the respondents for validity confirmation, SJ: the subjects in the human–robot interaction experiments).

	Average (SD)				f–Values		
	Males		Females		Factor 1	Factor 2	Mutual
	RE	SJ	RE	SJ	(Male–Female)	(RE–SJ)	Interaction
	(n=146)	(n=22)	(n=92)	(n=31)			
S1	10.8 (3.9)	12.6 (3.9)	12.8 (4.1)	12.1 (3.3)	1.398	0.848	$3.768^{\dagger}$
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)	$3.375^{\dagger}$	8.610^{**}	4.022^{*}

($^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$)