Exploratory Investigation into Influence of Negative Attitudes toward Robots on Human-Robot Interaction

Tatsuya Nomura [1,2], Takayuki Kanda [2],
Tomohiro Suzuki [3], and Kensuke Kato [4]
[1]*Ryukoku University,*
[2]*ATR Intelligent Robotics and Communication Laboratories,*
[3]*Toyo University and Research Fellow of the Japan Society for the Promotion of Science,*
[4]*Osaka University*
Japan

1. Introduction

Robots have been beginning to move from industrial fields such as factories, to offices, houses, and schools. Furthermore, 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 & Hendler, 2000). On the other hand, some research has found that humans tend to have either extremely positive or extremely negative attitudes toward novel communication technologies (Joinson, 2002). If communication robots can be regarded as a novel communication technology, there is the possibility that humans will have negative attitudes or emotions toward these robots, regardless of whether they are pet-types or humanoid robots. Thus, it should be carefully investigated on how humans are mentally affected by them.

Regarding the measurement of human mental images and impressions toward robots, there are plenty of published studies. Shibata et al. (2002; 2003; 2004) reported international research results on people's subjective evaluations of a seal-type robot they developed, called Palo, in several countries including Japan, the U. K, Sweden, Italy, and Korea. Their results revealed that there were differences in subjective evaluations of the robot among genders and ages, and that nationality also affected the evaluation factors. Friedman et al. (2003) investigated people's relationships with robotic pets by analyzing more than 6,000 postings in online discussion forums about one of the most advanced robotic pets currently on the retail market, Sony's robotic dog AIBO. Furthermore, Kahn et al. (2004) examined preschool children's reasoning about and behavioural interactions with AIBO. Their important suggestion is that people in general, and children in particular, may fall prey to accepting robotic pets without the moral responsibilities that real, reciprocal companionship and cooperation involves. In addition, Nomura et al. (2005b) reported the results of social research on visitors to an exhibition of communication robots, called "Robovie" (Ishiguro et al., 2001),

Source: Mobile Robots Towards New Applications, ISBN 3-86611-314-5, Edited by Aleksandar Lazinica, pp. 784, ARS/plV, Germany, December 2006

suggesting that even in Japan, younger generations do not necessarily like the robots more than do elder generations. These studies are focused on specific commercialized robots.

On the other hand, some studies examined more general images independent of specific robots. Suzuki et al. (2002) developed a psychological scale for measuring humans' mental images toward robots, while Kashibuchi et al. (2002) showed by using this scale that humans' mental images toward robots are positioned in the middle of a one-dimensional scale, where one pole corresponds to humans and another pole corresponds to just physical objects. Woods & Dautenhahn (2005) investigated the difference in relations of robots' appearances to emotions toward them between children and adults, using a questionnaire–based method and photographs of several robots. In addition, Bartneck et al. (2005a; 2005b) reported the influences of cultural differences and personal experiences with robots into attitudes toward robots by using a psychological scale measuring negative attitudes toward robots (Nomura et al., 2006a).

The above studies are based on social research. Furthermore, there are experimental studies on psychological influence to human behaviours toward robots.

Reeves & Nass (1996) showed that humans tend to unconsciously react to machines in the same way as to humans, even though they recognize the fact that they are interacting with machines (Media Equation). Kanda et al. (2001) investigated the impression on humans of a humanoid robot "Robovie", mentioned above, based on a psychological experiment of interaction with the robot, measuring impressions with the semantic-differential method. Goetz et al. (2003) proposed a "matching hypothesis" to explore relationships between robots' appearances and tasks, and found that more friendly tasks match more friendly appearances. Kidd & Breazeal (2004) conducted some experiments to compare appearances between artificial agents and robots, and found that robots are more suitable than agents for tasks such as pointing at objects related to real spaces. Walters et al. (2005) experimentally investigated relations between humans' personal traits measured by some questionnaires and behaviours toward robots such as permitted distances between them. Furthermore, Nomura et al. (2006a) experimentally investigated relations between humans' negative attitudes toward robots and communication avoidance behaviours toward them.

The studies mentioned above show an increase of psychological research on human-robot interaction. In this stream, we have focused on people's negative attitudes toward robots and relations to behaviours toward robots (Nomura et al., 2006a). This chapter provides the concept of negative attitudes toward robots and a measurement method for them, "Negative Attitudes toward Robots Scale (NARS)", as a psychological index in research on human-robot interaction. Then, it shows results of psychological experiments and social research by using this psychological scale. The former explores relationships between negative attitudes and behaviours toward robots in a real situation of human robot interaction, and the latter investigates relationships between negative attitudes toward and assumptions about robots. Finally, it is discussed on how people's attitudes toward robots can be altered in near future.

2. Negative Attitudes toward Robots Scale (NARS)

An attitude is psychologically defined as a relatively stable and enduring predisposition to behave or react in a certain way toward persons, objects, institutions, or issues, and the source is cultural, familial, and personal (Chaplin 1991). This definition of attitudes implies that they can be affected by cultural backgrounds and personal experiences. Moreover, the classical psychological theory suggests that they can be changed based on mental congruity (Osgood & Tannenbaum 1955;

Newcomb 1953; Heider 1958). These facts imply that attitudes toward robots can be altered by some factors including cultural backgrounds and personal experiences.
As one of the tools to measure humans' psychological factors in interaction with robots, the Negative Attitude toward Robots Scale (NARS) was developed to determine humans' attitudes toward robots. Its internal consistency, factorial validity, and test–retest reliability have been confirmed based on Japanese respondents (Nomura et al., 2006a).

Item No.	Questionnaire Items	Sub Scale
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. *	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. *	S3
6	I feel comforted being with robots that have emotions. *	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

(*Reverse Item)

Table 1. Questionnaire Items in NARS and Subscales that the Items Included.

This scale consists of fourteen questionnaire items. Table 1 shows the English version of the NARS, which was translated using back–translation. These items are classified into three subscales, S1: "Negative Attitude toward Situations of Interaction with Robots" (six items), S2: "Negative Attitude toward Social Influence of Robots" (five items), and S3: "Negative Attitude toward Emotions in Interaction with Robots" (three items). The number of grades for each item is five (1: I strongly disagree, 2: I disagree, 3: Undecided, 4: I agree, 5: I strongly agree), and an individual's score on each subscale is calculated by summing the scores of all the items included in the subscale, with the reverse of scores in some items. Thus, the minimum and maximum scores are 6 and 30 in S1, 5 and 25 in S2, and 3 and 15 in S3, respectively.

3. Negative Attitudes toward Robots in Human-Robot Interaction Experiments

By using the NARS, we designed and conducted 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., 2001) to investigate the influence of their negative attitudes toward robots into their behaviors toward them.

The results of the previous experiment conducted in the summer of 2003 (Nomura et al., 2006a) suggested a possibility that negative attitudes toward robots affected human behaviors toward communication robots. Moreover, it suggested 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, it also suggested a possibility that individuals' experiences of real robots influence the relations between negative attitudes and behaviors toward robots. Considering these results, we designed and conducted a new experiment at December, 2005.
This section provides with some results of the experiment, in particular, relationships between communication avoidance behaviors and negative attitudes toward robots based on regression analysis.

3.1 The Robot Used in the Experiments

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., 2001). It stands 120 cm tall, its diameter is 40 cm, and it weighs about 40 kg. The robot has two arms (4 X 2 DOF), a head (3 DOF), two eyes (2 X 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.

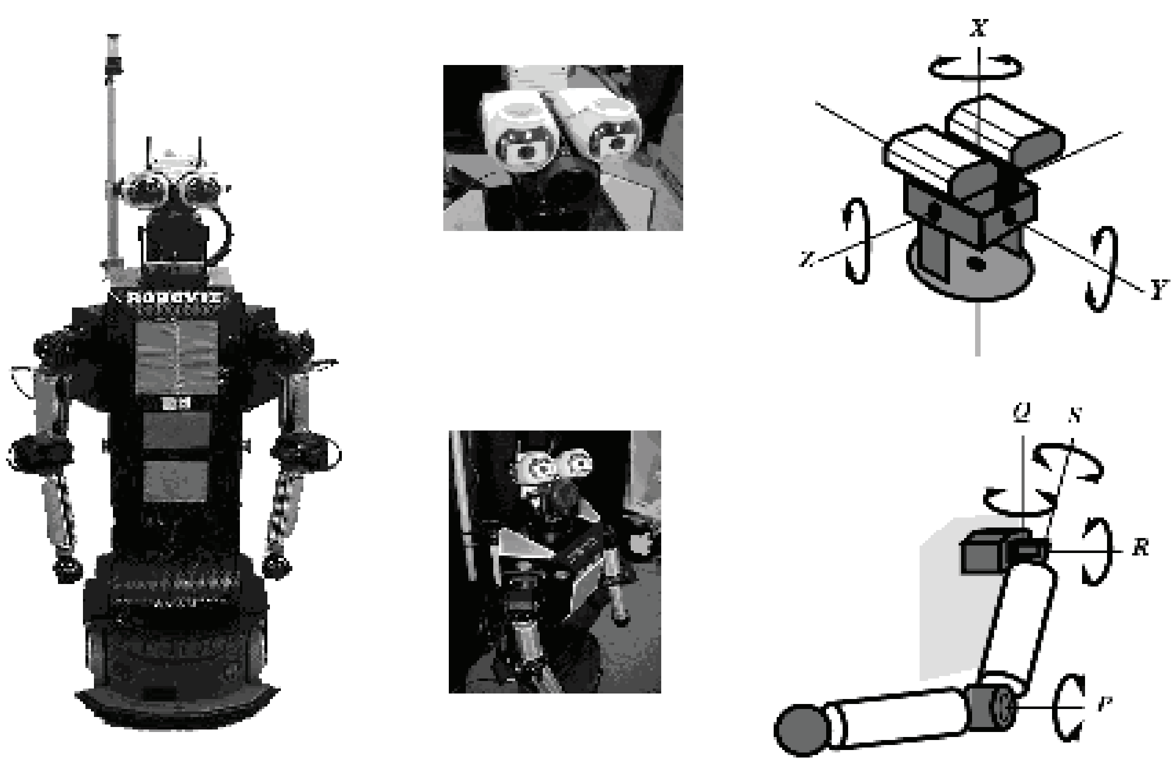

Fig 1. Robovie.

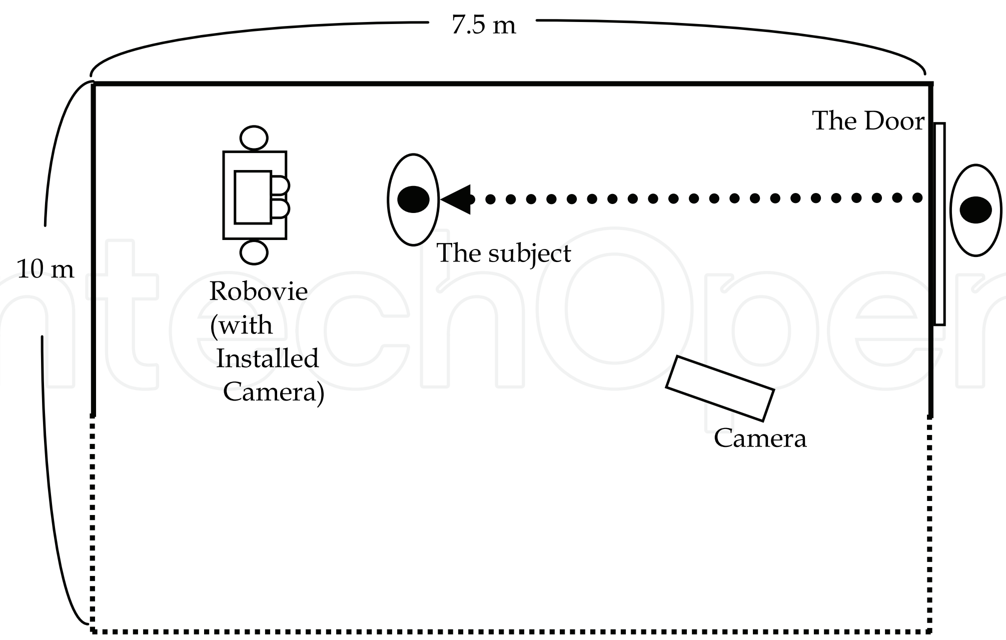

Fig. 2. Overview of the Room Where the Experiment Were Executed (A View from above).

3.2 Experimental Procedures

Our experiments on human-robot interaction were executed in the room shown in Fig 2.
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 2, the subjects responded to the following questionnaire items: 1: sex, 2: age, 3: the NARS, 4: State-Trait Anxiety Inventory (STAI) (Spielberger et al., 1970).
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 in front of the robot.
4. After he/she talked to Robovie, or a constant time (30 seconds) passed, Robovie uttered a sentence to stimulate his/her self-expression ("Tell me one thing that recently happened on you.")
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.

STAI (Spielberger et al., 1970) was used to measure the subjects' general anxiety before the experiment and analyze its relations to the negative attitudes toward robots. The emotion of anxiety is generally classified into two categories: state and trait anxiety. Trait anxiety is a trend of anxiety as a characteristic stable in individuals whereas state anxiety is an anxiety transiently evoked in specific situations and changed depending on the situation and time. STAI consists of twenty items for measuring state anxiety (STAI-S) and twenty items for measuring trait anxiety (STAI-T). In this experiment, only STAI-S was used.
Behaviours of the subjects, including their utterances, were recorded using two digital video cameras as shown in Fig 2. One of the cameras was installed into Robovie's eyes. Then, the following items related to their behaviours 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 two categories: utterances including the subjects' emotions and utterances not including those (all the subjects had some utterances in this step). 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.

3.3 Results

Thirty-eight Japanese university students were asked to participate in the experiment as subjects (male: 22, female: 16), and the mean age of these subjects was 21.3. Table 2 shows the means and standard deviations of their NARS scores and behaviour indices. *t*-tests for these values revealed that there was no difference on these values between the male and female subjects, except for the statistically significant trend in the S2 score of the NARS.

		N	Mean	*SD*	*t*	*p*
NARS: S1	Male	22	13.0	3.1	-.171	.865
	Female	16	13.3	4.3		
NARS: S2	Male	22	16.5	3.3	1.994	.054
	Female	16	14.3	3.6		
NARS: S3	Male	22	9.8	2.3	.711	.482
	Female	16	9.3	2.0		
D (cm)	Male	22	63.4	29.0	-.519	.607
	Female	15	68.0	21.9		
U1 (sec)	Male	22	7.2	10.5	.296	.769
	Female	15	6.4	3.0		
U2 (sec)	Male	22	3.6	1.6	-.451	.655
	Female	15	3.9	3.0		
T (sec)	Male	15	3.6	2.5	-.804	.429
	Female	11	4.4	2.8		

Table 2. Means and Standard Deviations of NARS Scores and Behaviour Indices, and Results of *t*-Tests.

First, linear regression analysis was conducted to investigate relations between the NARS scores and behaviour indices. In this analysis, the independent variables were the NARS scores and the dependent variables were the behaviour indices. The previous experiments suggested gender differences on relations between these independent and dependent variables (Nomura et al., 2006a). Thus, the analysis was conducted for the whole samples, only the male samples, and only the female samples, respectively.

Table 3 shows the statistically significant regression models in the analysis. It was revealed that the time elapsed until the subjects talked to Robovie after entering the room (U1) and the time elapsed until the subjects touched the robot's body after it uttered to stimulate the subjects' physical contact with it (T) were influenced by the negative attitude toward situations of interaction with robots (S1) and the negative attitude toward social influence of robots (S2), respectively. In the whole samples, S1 positively influenced into U1 and S2 negatively influenced into T.

The analysis for the limited samples of each gender suggested a gender difference on relations between the negative attitudes and behaviours toward robots. In the male samples, U1 and T were influenced by S1 and S2 respectively, in the same way as the case of the whole samples. Moreover, the negative attitude toward emotions in interaction with robots (S3) also positively influenced into T. On the other hand, this trend did not appear in the female samples. In addition, S3 positively influenced into the time elapsed until the subjects replied to Robovie after it uttered to stimulate their self-expression (U2) only in the female samples. Furthermore, the values of R^2 showed that the regression models for the limited samples of each gender had the higher goodness-of-fit than those for the whole samples.

Whole Samples Dependent Variable: U1	β	t	p
NARS: S1	.356	2.254	.031
R^2 (N = 37)	.102		

Whole Samples Dependent Variable: T	β	t	p
NARS: S2	-.391	-2.084	.048
R^2 (N = 26)	.118		

Male Samples Dependent Variable: U1	β	t	p
NARS: S1	.650	3.406	.003
NARS: S2	-.214	-1.034	.315
NARS: S3	.077	.385	.705
R^2 (N = 22)	.291		

Male Samples Dependent Variable: T	β	t	p
NARS: S2	-.625	-2.617	.023
NARS: S3	.541	2.263	.043
R^2 (N = 15)	.322		

Female Samples Dependent Variable: U2	β	t	p
NARS: S3	.526	2.232	.044
R^2 (N = 15)	.222		

Table 3. Statistically Significant Regression Models between NARS Scores and Behaviour Indices.

Second, two-way ANOVAs for the NARS scores were conducted to investigate their relations to the contents of the subjects' utterances toward the robot and gender. Table 4 shows the results of these ANOVAs. It was found that there were statistically significant trends of the utterance contents in S1 and gender in S2. There was no interaction effect in all the scores. Important is the trend that the subjects whose utterances toward the robots included their emotional contents had higher negative attitudes toward interaction with robots than those whose utterances did not include emotional contents.

	Male				Female			
	EU (N = 12)		NU (N = 10)		EU (N = 9)		NU (N = 7)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
NARS: S1	13.7	3.0	12.3	3.1	14.7	4.0	11.4	4.3
NARS: S2	16.6	3.5	16.4	3.2	14.2	3.4	14.3	4.2
NARS: S3	10.4	2.0	9.1	2.5	9.8	2.0	8.7	1.9

	Gender		Contents		Interaction	
	F	p	F	p	F	p
NARS: S1	.003	.956	3.884	.057	.641	.429
NARS: S2	3.670	.064	.003	.959	.011	.916
NARS: S3	.527	.473	2.845	.101	.032	.859

Table 4. Results of ANOVAs with Gender and Contents of Subjects' Utterances toward the Robot (EU: Subject Group Having Utterances Including their Emotions, NU: That Having Utterances Not Including their Emotions).

Third, Pearson's correlation coefficients r between the NARS scores and STAI-S were calculated to investigate relations between the negative attitudes toward robots and general anxiety of the subjects just before the experiment. Table 5 shows these correlation coefficients. There was a medium level of correlation between STAI-S and S1. Moreover, there was a medium level of correlation between S2 and S3. Although there was no trend of gender difference in these correlations, it was found in the correlation between S1 and S3; there was a medium level of correlation in the female samples although there was no such correlation in the male samples.

		NARS: S1	NARS: S2	NARS: S3
NARS: S2	Whole	.262		
	Male	.244		
	Female	.327		
NARS: S3	Whole	.203	.395*	
	Male	-.006	.391†	
	Female	.472†	.372	
STAI-S	Whole	.671***	.057	-.008
	Male	.668***	.024	-.196
	Female	.676**	.175	.258

($^{\dagger}p < .1$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$)

Table 5. Pearson's Correlation Coefficients r between NARS and STAI-S.

3.4 Discussion

The experiment was conducted only for the Japanese subjects. Thus, we should note that there is a limit for generalizing the results.

The above results of regression analysis imply that negative attitudes toward robots are related to concrete behaviors toward robots, such as time spent to talk with and touch to them. This implies that the NARS has predictive validity for communication avoidance behaviors toward robots. In the previous experiment, no regression models were statistically significant for the same behavior indices (Nomura et al., 2006a). This may be caused by the

differences of the room layout, the detailed experimental procedures, and widespread of communication robots from the previous experiment.
The results of regression analysis also imply the gender difference of relationships between negative attitudes and behaviors toward robots. In the samples of the experiment, there was almost no gender difference of the NARS scores and behavior indices. However, the experimental results imply that males having high negative attitude toward interaction with robots tend to avoid talking with them, and those having low negative attitude toward social influence of and high negative attitude toward emotions in interaction with robots tend to avoid touching to them. On the other hand, the results imply that females do not have this trend, and those having high negative attitude toward emotions in interaction with robots tend to avoid their self-expression toward them.
Moreover, the correlation coefficients between S1 and S3 imply the gender difference of relationships between attitudes toward interaction with robots and emotions in interaction with robots. In other words, females may have psychologically stronger connection between interaction itself and emotional subjects in interaction with robots than males.
The results of ANOVAs imply the possibility that persons having high negative attitude toward interaction with robots tend to talk with them about contents related to their emotions. Our prediction before the experiment was the converse, that is, persons having high negative attitude toward interaction with robots avoid talking with them about contents related to their emotions, since avoidance of self-expression is one of examples of communication avoidance behaviours and the results of the previous experiment partly supported it even in human-robot interaction (Nomura et. al., 2006a). Although we have not found the cause, we can consider an interpretation: persons having high negative attitude toward interaction with robots have high anxiety toward communication with robots, high anxiety toward communication lead them to their desire to get opportunities of communication, and conversely they talk with robots about things related to themselves to complement a blank in communication.
The correlation coefficients between S1 and STAI-S suggest a strong connection between general anxiety and negative attitudes toward interaction with robots in the situation just before human-robot interaction. The above interpretation may be verified by measurement of anxiety toward robots (Nomura et al., 2004; 2006b).

4. Negative Attitudes toward Robots in Social Research

This section provides with some results of social research by using the NARS.
There are some existing studies on social research using the NARS. Bartneck et al., (2005a; 2005b) suggested that cultures may influence attitudes toward robots. Moreover, Nomura et al., (2006a) also suggested the influence of personal experiences with robots on attitudes toward them, such as individuals' experiences on really acting robots. However, these studies lack perspective on what types and tasks of robots people assume.
It is considered that attitudes toward robots can more directly be influenced by assumptions about robots than by cultures and personal experiences, although these assumptions can be affected by cultures and personal experiences. Thus, we should focus on not only attitudes toward robots but also assumptions about robots. These assumptions can be influenced by cultural situations such as media, and their distribution can affect that of attitudes toward robots. Of course, cultural differences can produce differences in attitudes toward one specific type of robot such as humanoids, as Kaplan (2004) mentioned. Thus, we can consider several types of differences in attitude toward robots as follows:

1. Differences in attitudes between different assumptions about robots in one culture.
2. Differences in attitudes toward one specific type of robot between different cultures.
3. Differences in assumptions about robots and their relationship to attitudes toward robots between different cultures.

As mentioned above, Bartneck et al. (2005a; 2005b) suggested the possibility of there being cultural differences in attitudes toward robots. This section deals with the first issue in the above list. As a concrete subject, we administered a social research to investigate the differences in attitudes between assumptions about robots in one culture, Japan.

4.1 Method

The social research was administered from November 2005 to March 2006. The participants were Japanese university and special training school students. The Japanese version of the NARS was administered during lecture time. Participation by the respondents was voluntary.

The face sheet used in administering this survey included items that asked respondents to answer which type of robots they assumed and which tasks they assumed the selected robots do. The choices for the former item were: 1: human-size humanoids, 2: small-size humanoids, 3: big active robots, 4: animal-type robots, 5: stationary machines, 6: arm manipulators, and 7: others. The choices for the latter item were: 1: housework, 2: office work, 3: public service such as education, 4: medical or welfare service, 5: construction or assembling tasks, 6: guard or battle, 7: tasks in places hard for humans to go or hazardous locations such as the space and the deep sea, 8: the service trade, 9: communication partners or playmates, 10: amusement, 11: others. These choices were determined based on the pilot study by Nomura et al. (2005a).

In addition to the above face sheet and the NARS, two psychological scales were administered to investigate relationships between attitudes toward robots and personal traits. One is the STAI. In this social research, both STAI-S and STAI-T were used. The other scale is the Personal Report of Communication Apprehension (PRCA-24) (Pribyl et al., 1998). PRCA-24 measures communication apprehension in four contexts: public speaking, meetings, small-group discussion, and dyads. Each context corresponds to six items. In this administration, only six items corresponding to dyads were used to investigate their relationships with the NARS subscales directly related to interaction with robots (S1 and S3).

4.2 Results

A total of 400 people (male: 197; female: 199; unknown: 4; mean age: 21.4) participated in the research. For the 374 samples that had no missing item in the NARS, Cronbach's α denoting reliability were 0.756 for S1, 0.647 for S2, and 0.735 for S3 respectively. The sample data were analyzed in the following three ways.

4.2.1 Relations between Assumptions about Robot Types and Tasks

First, we calculated how many respondents selected each robot type and task with respect to the assumptions about robots. Then, to find relations between specific assumptions about types and tasks, φ-coefficients were calculated to reveal the extent of relationships between the assumption choices. In addition, we performed statistical tests with Fisher's method on selection for pairs of choices to investigate the statistical significance of these φ-coefficients based on the independence among these choices (for example, to investigate the correlation between “small-size humanoids” and “amusement,”, one 2 X 2 cross table consisting of selection/no-selection of "small-size humanoids" and "amusement" was made, then the φ-coefficients was calculated and a test was done for this cross table).

Robot Type		Task Type 1	2	3	4	5	6	7	Total
1	*N*	53	12	1	0	0	0	2	68
	φ	.255***	-.012	-.179***	-.125**	-.052	-.062	-.053	
2	*N*	8	1	2	0	1	0	0	12
	φ	.059	-.047	.005	-.048	.112	-.024	-.043	
3	*N*	0	1	1	0	1	0	0	3
	φ	-.088	.033	.043	-.024	.251*	-.012	-.021	
4	*N*	5	3	0	1	0	0	1	10
	φ	.000	.047	-.070	.020	-.018	-.022	.031	
5	*N*	9	0	5	0	2	4	0	20
	φ	-.024	-.111*	.060	-.063	.180*	319***	-.057	
6	*N*	19	2	23	2	0	1	0	47
	φ	-.072	-.137**	.340***	-.039	-.042	.009	-.090	
7	*N*	26	9	13	1	1	1	1	52
	φ	.001	-.014	.101	-.077	-.022	.004	-.063	
8	*N*	11	1	0	0	0	0	0	12
	φ	.148**	-.047	-.077	-.048	-.020	-.024	-.043	
9	*N*	30	21	5	21	0	0	9	86
	φ	-.162**	.078	-.143**	.367***	-.060	-.072	.111*	
10	*N*	31	20	10	1	0	1	3	66
	φ	-.028	.135*	-.006	-.096	-.051	-.009	-.021	
11	*N*	4	3	1	1	0	0	6	15
	φ	-.094	.007	-.049	-.002	-.023	-.027	.298***	
Total		196	73	61	27	5	7	22	391

Robot Type: 1: human-size humanoids, 2: small-size humanoids, 3: big active robots, 4: animal-type robots, 5: stationary machines, 6: arm manipulators, 7: others

Task Type: 1: housework, 2: office work, 3: public service such as education, 4: medical or welfare service, 5: construction or assembling tasks, 6: guard or battle, 7: tasks in places hard for humans to go or hazardous locations such as the space and the deep sea, 8: the service trade, 9: communication partners or playmates, 10: amusement, 11: others

($^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$)

Table 6. The Number of Respondents Who Selected Each Robot Type and Task, and Correlations.

Table 6 shows the number of respondents who selected each robot type and task, and the correlations between robot types and tasks. Regarding assumptions about robot type, about 50% of the respondents selected "human-size humanoids." The humanoid type, including small-size ones, was selected by about 70% of the respondents, while the selection rate for "animal-type robots" was about 7%. The respondents who selected "others" tended to mention concrete names of some robots appearing in the media, such as "Doraemon" and "Asimo" in their written answers.

Regarding assumptions about robot tasks, there was no bias of respondents toward a specific task; the selection rates for "housework," "communication partner or playmates," and "amusement" varied from 16% and 22%. The selection rates for "guard or battle," and "tasks in places hard for humans to go or hazardous locations" were about 12"-13%. Few respondents selected "public service such as education." The respondents who selected "others" tended not to mention concrete tasks in their written answers.

Regarding relations between robot type and task, there was a moderate level of positive correlation between "big active robots" and "guard or battle," between "animal-type robots" and "communication partners or playmates, "between "arm manipulators" and "construction or assembling tasks," and between "others" and "others." Moreover, there was a low level of positive correlation between "human-size humanoids" and "housework," between "human-size humanoids" and "the service trade," between "small-size humanoids" and "amusement," between "stationary machines" and "public service such as education," between "stationary machines" and "construction or assembling tasks," and "others" and "communication partners or playmates." In addition, there was a low level of negative correlation between "human-size humanoids" and "communication partners or playmates," between "small-size humanoids" and "construction or assembling tasks," between "small-size humanoids" and "guard or battle," between "big active robots" and "housework," between "big active robots" and "communication partners or playmates," and between "animal-type robots" and "housework."

4.2.2 Relations of Gender and Assumptions about Robots with Attitudes toward Robots

Second, to investigate the relations between attitudes toward and assumptions about robots, two-way ANOVAs were executed with the independent variables of gender and robot type, and variables of gender and robot task, respectively. In this analysis, the subgroups of respondents who selected "stationary machines," "arm manipulators," and "others" were integrated into one subgroup due to their small numbers of respondents and correlations with robot tasks. Furthermore, the subgroups of respondents who selected "office work," "public service such as education," "medical or welfare service," "the service trade," and "others" were integrated into one subgroup, due to their small numbers of respondents, correlations with robot type, and the similarity of their contents.

Table 7 shows the means and standard deviations of the scores of the NARS subscales based on gender and robot type subgroups, and the results of the two-way ANOVAs for the NARS subscale scores. Table 8 shows the means and standard deviations of the scores of the NARS subscales based on gender and robot task subgroups, and the results of the two-way ANOVAs for the NARS subscale scores.

For the ANOVA of gender and robot type, there were statistically significant effects regarding both gender and robot type on the scores of S1 and S3, although there were no interaction effects. It was revealed that the female respondents had more pronounced negative attitudes toward situations of interaction with robots and lower negative attitudes toward emotions in interaction with robots, than the male respondents. Moreover, the post–hoc tests with Tukey's method revealed with a 5% significance level that the respondents in the subgroups of "small-size humanoids" and "big active robots" had stronger negative attitudes toward situations of interaction with robots than those in the integrated subgroup consisting of "stationary objects," "arm manipulators," and "others." In addition, they also revealed that the respondents in the subgroup of "small-size humanoids" had more pronounced negative attitudes toward emotions in interaction with robots than those in the subgroups of "human-size humanoids" and "animal-type robots." There were no statistically significant effects of gender, robot type, or interaction in S2, negative attitude toward the social influence of robots.

			NARS: S1		NARS: S2		NARS: S3	
		N	Mean	*SD*	Mean	*SD*	Mean	*SD*
Male	1	92	12.5	3.7	16.0	3.6	9.5	2.7
	2	27	12.3	4.2	16.3	2.8	11.1	2.2
	3	34	13.6	5.3	16.2	4.6	10.3	2.9
	4	13	12.7	4.6	15.6	3.9	9.6	1.6
	5+6+7	16	9.9	5.1	14.8	5.4	11.4	1.9
Female	1	89	13.7	3.8	16.2	3.6	9.2	2.6
	2	46	14.8	3.7	17.1	4.0	10.5	2.6
	3	21	15.2	4.9	16.4	3.8	9.6	2.6
	4	13	14.8	2.5	14.8	3.4	8.1	2.3
	5+6+7	17	12.5	3.9	16.1	4.9	9.1	2.9

	Gender		Robot Type		Interaction		Post-hoc
	F	*p*	*F*	*p*	*F*	*p*	
NARS: S1	13.910	.000	3.386	.010	.498	.738	2,3 > 5+6+7
NARS: S2	.420	.517	1.063	.375	.361	.836	
NARS: S3	10.237	.001	5.406	.000	1.285	.276	2 > 1,4

Table 7. Means and Standard Deviations of the Scores of the NARS Subscales based on Gender and Robot Type Subgroups, and Results of the two-way ANOVAs.

			NARS: S1		NARS: S2		NARS: S3	
		N	Mean	*SD*	Mean	*SD*	Mean	*SD*
Male	1	30	12.4	3.7	15.7	3.5	9.9	2.4
	5	12	11.5	4.0	16.3	2.9	10.7	2.1
	6	27	11.4	4.5	15.6	4.2	10.3	2.9
	7	28	13.9	4.5	16.8	3.9	9.8	2.9
	9	22	11.6	4.1	14.3	3.9	9.2	2.1
	10	28	13.1	4.0	16.5	3.9	10.4	2.5
	Others	31	12.9	5.0	16.1	4.1	10.0	2.9
Female	1	33	14.7	4.7	16.3	3.3	9.3	2.6
	5	5	13.6	7.5	18.8	4.1	10.4	0.9
	6	16	12.8	4.2	16.6	3.2	10.3	2.9
	7	19	15.7	3.0	18.4	4.2	10.3	2.2
	9	59	14.3	3.2	15.4	3.8	8.9	3.0
	10	34	13.6	3.4	16.4	3.9	9.6	2.7
	Others	18	12.6	4.1	15.7	3.7	9.3	1.8

	Gender		Robot Task		Interaction		Post-hoc
	F	*p*	*F*	*p*	*F*	*p*	
NARS: S1	8.460	0.004	1.899	0.080	0.875	0.513	
NARS: S2	3.576	0.059	2.774	0.012	0.543	0.775	7>9
NARS: S3	0.914	0.340	1.421	0.206	0.360	0.904	

Table 8. Means and Standard Deviations of the Scores of the NARS Subscales based on Gender and Robot Task Subgroups, and Results of the two-way ANOVAs.

For the ANOVA of gender and robot task, there was a statistically significant effect of robot task on the scores of S2. The post–hoc tests with Tukey's method revealed with a 5% significance level that the respondents in the subgroup of “tasks in places hard for humans to go or hazardous locations” had stronger negative attitudes toward the social influence of robots than those in the subgroup of “communication partner or playmates.” Moreover, there were statistically significant trends regarding robot task in S1 and gender in S2.

4.2.3 Correlations between NARS, STAI, PRCA-24

Third, to investigate the relations between attitudes toward robots, general anxiety, and communication apprehension, we calculated Pearson’s correlation coefficients *r* between the NARS subscales, STAI, and PRCA-24. Since there is a possibility of gender difference with respect to anxiety and communication apprehension, this calculation was done for each gender subgroup. Table 9 displays these coefficients. The table reveals that there was a moderate level of correlations among S1, STAI-S, and STAI-T for the female respondents, although that for the male respondents was low. Moreover, it also reveals that there was a low level of correlation among S1, S2, and PRCA-24, although there was no such correlation for the male respondents. There was no correlation among S3, STAI-S, and PRCA-24.

			NARS: S1	NARS: S2	STAI-S	STAI-T	PRCA-24
NARS: S1	Whole	*r*			0.257*	0.263*	0.080
		N			355	356	338
	Male	*r*			0.181*	0.185*	0.008
		N			171	171	160
	Female	*r*			0.333*	0.282*	0.160*
		N			182	183	176
NARS: S2	Whole	*r*	0.401**		0.082	0.121*	0.110*
		N	371		355	356	338
	Male	*r*	0.378**		0.043	0.092	0.041
		N	182		171	171	160
	Female	*r*	0.452**		0.106	0.136	0.166*
		N	187		182	183	176
NARS: S3	Whole	*r*	0.125*	0.360**	-0.004	-0.145**	0.044
		N	371	371	355	356	338
	Male	*r*	0.130	0.274**	-0.076	-0.135	-0.020
		N	182	182	171	171	160
	Female	*r*	0.180*	0.469**	0.102	-0.092	0.138
		N	187	187	182	183	176

Table 9. Pearson’s Correlation Coefficients *r* between NARS Subscales, STAI, and PRCA-24.

4.3 Discussion

In the same way as the experiment presented in the previous section, the results of the social research are based on Japanese respondents, that is, on one specific culture. We carefully discuss the results’ implications, separating those limited to Japanese culture from results that may be generalized to other cultures. The latter issue are related to alternation of attitudes toward robots. Here, we discuss the former issue since the latter are discussed in the next section.

The results for assumptions about robot type suggest a bias of respondents toward humanoid-type robots. On the other hand, φ-coefficients between this type and assumptions about robot tasks suggest that "humanoid robots" were not strongly related to specific tasks. Moreover, the correlations between "big active robots" and "guard or battle," between "animals" and "communication partners or playmates," and between "arm manipulators" and "construction or assembling tasks" suggest conservative images of robots that have been reconstructed via the media. This trend is similar to the results by Nomura et al. (2005a). These suggestions imply that more Japanese people are more biased toward humanoid-type robots than other types, but are unclear about what tasks this type of robot does.

The results of the ANOVAs for the NARS subscale scores suggest that the respondents assuming "small-size humanoids" and "big active robots" had more pronounced negative attitudes toward interaction with robots than those assuming "stationary machines," "arm manipulators," and "others." We assume that the robot types "stationary machines," "arm manipulators," and "others" lead people to have conservative images of robots, such as being big computer, industrial robots, and animated robots. Thus, this suggestion implies that novel types of robots or robots related to battle evoke negative attitudes toward human interaction with robots.

Moreover, the results of the ANOVAs suggest that the respondents assuming "small-size humanoids" had stronger negative attitudes toward emotions in interaction with robots than those assuming "human-size humanoids" and "animal-type robots." This implies that emotional reactions toward robots are different between robot types, depending on interaction effects between design and size.

In addition, the results of the ANOVAs suggest that the respondents assuming "tasks in places hard for humans to go or hazardous locations" were more negative toward the social influence of robots than those assuming "communication partner or playmates." We estimate that the image of danger in the former task assumption evoked negative attitudes toward the social influence of robots performing such tasks.

The ANOVA results also suggest that the female respondents had more pronounced negative attitudes toward interaction with robots and less negative attitudes toward emotions in interaction with robots than did the male respondents. Furthermore, the correlation coefficients among the NARS, STAI, and PRCA-24 suggest that there is also a gender difference regarding relations between negative attitudes toward robots and personal traits related to anxiety. This suggestion implies that there is a gender difference in attitudes toward robots, depending on which factor we focus on in interaction with robots, and gender-based difference in their relations to some personal traits.

On the other hand, the correlation coefficients between the NARS subscales and PRCA-24 suggest that there is a low level of correlation between attitudes toward robots and communication apprehension as a personal trait related to interaction. Moreover, the correlation coefficients between the NARS subscales, and those between the NARS S1 and STAI-S were much different from those in the experiment presented in the previous section. These imply that attitudes toward robots are altered depending on situations such as daily life and real interaction with robots, and these attitudes are not directly connected to personal communication traits at the present daily life situation where robots such as humanoids are not yet widespread and images of their tasks are not yet fixed.

5. Implications

Although the implications outlined in the previous sections should be limited to Japanese culture in a strict sense, we can extend our discussion to other cultures to some extent. This section discusses on how people's attitudes toward robots can be altered in near future, based on the implications in the previous section.

The results of the experiment and social research imply that attitudes toward robots are related to concrete behaviours toward them, but they are altered depending on situations. The short-term alternation is dependent on individual situations such as real experiences of human-robot interaction, and the long-term alternation is influenced by cultural trends.
While bias toward and relations between certain assumptions about robots may be specific to each culture, what is important is that attitudes toward robots may depend on specific assumptions dominant in a given culture. In other words, if the dominant assumptions about robots are changed, the whole trend of attitudes toward robots can be altered in that culture. This may be caused by commercialization of really acting robots and media information about them. People may have negative attitudes toward robots unfamiliar to their culture, but as information about robots spreads, their assumptions may change and attitudes toward them may also alter.
An important problem is that gender differences may affect the alteration of attitudes toward robots. If there are currently gender differences in attitudes toward robots and their relations to some personal traits in a culture, these differences may affect the nature of attitude change toward robots; for example, males may develop more positive attitudes toward humanoids whereas females in the same culture may come to have more negative attitudes toward them. Of course, the trend of attitude change may depend on the cultures.
Furthermore, it is not clear which personal trait affects attitude change toward robots. Although currently there may be no strong relation between attitudes toward robots and communication apprehension in a given culture, as implied in the previous section, the increasing ability of robots, in particular those related to communication, can change assumptions about robots, and as a result can change the connection between attitudes toward robots and personal traits related to communication.

6. Conclusion

This chapter provided the concept of negative attitudes toward robots and a measurement method for them, “Negative Attitudes toward Robots Scale (NARS)”, as a psychological index in research on human-robot interaction. Then, it showed the results of some experiments and social research by using this psychological scale.
The results implicated by the NARS show the efficiency of this scale in both human-robot interaction experiments and social research. They revealed that attitudes toward robots are related to behaviours toward them, these attitudes are different depending on situations and assumptions about robots, and there may be gender differences associated with them. These implications may contribute to design issues of communication robots and marketing research of robots in daily-life applications, in particular, the field in which communication capacity is critical, such as welfare.
Furthermore, it was discussed on how people's attitudes toward robots have been determined and can be altered in near future. Alternation of attitudes toward robots is an important problem in considering development of communication robots in near future. To investigate this problem further, we should explore the psychological relationships between assumptions about robots, attitudes toward robots, and concrete emotions evoked in interaction with robots in more detail (Nomura et al. 2004; 2006b). Moreover, we need to investigate cultural differences in assumptions about robots.

7. Acknowledgement

This research was supported by the Japan Society for the Promotion of Science, Grants-in-Aid for Scientific Research No. 18500207 and 18680024.

8. References

Bartneck, C.; Nomura, T.; Kanda, T.; Suzuki, T.; and Kato, K. (2005a). A cross-cultural study on attitudes towards robots. *Proceedings of 11th International Conference on Human-Computer Interaction* (CD-ROM Proceedings).

Bartneck, C.; Nomura, T.; Kanda, T.; Suzuki, T.; and Kato, K. (2005b). Cultural differences in attitudes towards robots. Proceedings of Symposium on Robot Companions (SSAISB 2005 Convention), pp. 1-4.

Chaplin, J. P., ed. (1991). Dictionary of Psychology. Dell Pub. Co., 2nd edition.

Dautenhahn, K. ; Bond, A.H. ; Canamero, L. ; and Edmonds, B. (2002). Socially Intelligent Agents: Creating Relationships with Computers and Robots. Kluwer Academic Publishers.

Druin, A. and Hendler, J. (2000). Robots for Kids: Exploring New Technologies for Learning. Morgan Kaufmann.

Friedman, B.; Kahn, P. H.; and Hagman, J. (2003). Hardware companions? - what online AIBO discussion forums reveal about the human-robotic relationship. Proceedings of CHI 2003, pp. 273-280.

Goetz, J. ; Kiesler, S. ; and Powers, A. (2003). Matching robot appearance and behavior to tasks to improve human-robot cooperation. Proceedings of 12th IEEE International Workshop on Robot and Human Interactive Communication. pp. 55-60.

Heider, F. (1958). The Psychology of Interpersonal Relations. New York: John Wiley & Sons. (Japanese Edition: Ohashi, M. (1978). Seishin).

Ishiguro, H.; Ono, T.; Imai, M.; Maeda, T.; Kanda, T.; and Nakatsu, R. (2001). Robovie: an interactive humanoid robot. International Journal of Industrial Robot, Vol. 28, No. 6, pp. 498-503.

Joinson, A. N. (2002). Understanding the Psychology of Internet Behaviors: Virtual World, Real Lives. Palgrave Macmillan. (Japanese Edition: Miura, A., et al., (2004). Kitaoji-shobo).

Kahn, P. H.; Friedman, B.; Perez-Grannados, D. R.; and Freier, N. G. (2004). Robotic pets in the lives of preschool children. Extended Abstracts of CHI 2004, pp. 1449-1452.

Kanda, T.; Ishiguro, H.; and Ishida, T. (2001). Psychological evaluation on interactions between people and robot, Journal of Robotic Society of Japan, Vol. 19, pp. 362-371. (in Japanese).

Kaplan, F. (2004). Who is afraid of the humanoid? : Investigating cultural differences in the acceptance of robots. International Journal of Humanoid Robotics, Vol. 1, No. 3, pp. 465-480.

Kashibuchi, M.; Suzuki, K.; Sakamoto, A.; and Nagata, J. (2002). Constructing an image scale for robots and investigating contents of measured images: Part 2. Proceedings of the 66th Annual Meeting of the Japanese Psychological Association, p. 115. (in Japanese).

Kidd, C. and Breazeal, C. (2004). Effect of a Robot on User Perceptions. Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems. pp. 3559- 3564.

Newcomb, T. M. (1953). An approach to the study of communicative acts. Psychological Review, Vol. 60, 393-404.

Nomura, T.; Kanda, T.; Suzuki, T.; and Kato, K. (2004). Psychology in human-robot communication: An attempt through investigation of negative attitudes and anxiety toward robots. Proceedings of the 13th IEEE International Workshop on Robot and Human Interactive Communication, pp. 35-40.

Nomura, T.; Kanda, T.; Suzuki, T.; and Kato, K. (2005a.) People's assumptions about robots: Investigation of their relationships with attitudes and emotions toward robots. Proceedings of the 14th IEEE InternationalWorkshop on Robots and Human Interactive Communication, pp. 125-130.

Nomura, T.; Tasaki, T.; Kanda, T.; Shiomi, M.; Ishiguro, H.; and Hagita, N. (2005b). Questionnaire-based research on opinions of visitors for communication robots at an exhibition in Japan. Proceedings of Tenth IFIP TC13 International Conference on Human-Computer Interaction (INTERACT'05), pp. 685-698.

Nomura, T.; Kanda, T.; and Suzuki, T. (2006a). Experimental investigation into influence of negative attitudes toward robots on human-robot interaction. AI & Society, Vol. 20, No. 2, pp. 138-150.

Nomura, T.; Suzuki, T.; Kanda, T.; and Kato, K. (2006b). Measurement of Anxiety toward Robots. Proceedings of the 15th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN) , pp.372-377.

Osgood, C. E., and Tannenbaum, P. H. (1955). The principle of congruity in the prediction of attitude change. Psychological Review, Vol. 62, pp. 42-55.

Pribyl, C. B.; Keaten, J. A.; Sakamoto, M.; and Koshikawa, F. (1998). Assessing the cross-cultural content validity of the Personal Report of Communication Apprehension scale (PRCA-24). Japanese Psychological Research, Vol. 40, pp. 47-53.

Reeves, C. B. and Nass, C. (1996). The Media Equation: How people treat computers, television, and new media like real people and places. Cambridge, UK: Cambridge Press.

Shibata, T.; Wada, K.; and Tanie, K. (2002). Tabulation and analysis of questionnaire results of subjective evaluation of seal robot at Science Museum in London. Proceedings of 11th IEEE International Workshop on Robot and Human Interactive Communication (ROMAN 2002), pp. 23-28.

Shibata, T.; Wada, K.; and Tanie, K. (2003). Subjective evaluation of a seal robot at the national museum of science and technology in Stockholm. Proceedings of International Workshop on Robot and Human Interactive Communication (RO-MAN), pp. 397-407.

Shibata, T.;Wada, K.; and Tanie, K. (2004). Subjective evaluation of a seal robot in Brunei. Proceedings of International Workshop on Robot and Human Interactive Communication (RO-MAN), pp. 135-140.

Spielberger, C. D.; Gorsuch, R. L.; and Lushene, R. E. (1970). Manual for the State-Trait Anxiety Inventory. Palo Alto, California: Counseling Psychologists Press.

Suzuki, K.; Kashibuchi, M.; Sakamoto, A.; and Nagata, J. (2002). Constructing an image scale for robots and investigating contents of measured images: Part 1. Proceedings of the 66th Annual Meeting of the Japanese Psychological Association, p. 114. (in Japanese).

Walters, M. L. ; Dautenhahn, K . ; te. Boekhorst, R. ; Koay, K. L. ; Kaouri, C. ; Woods, S. ; Nehaniv, C. ; Lee, D. ; and Werry, I. (2005). The influence of subjects’ personality traits on personal spatial zones in a human-robot interaction experiment. Proceedings of the 14th IEEE International Workshop on Robots and Human Interactive Communication. pp. 347-352.

Woods, S., and Dautenhahn, K. 2005. Child and adults' perspectives on robot appearance. Proceedings of Symposium on Robot Companions (SSAISB 2005 Convention), pp. 126-132.


Mobile Robots;
Towards New
Applications
INTECH