Psychology in Human–Robot Communication: An Attempt through Investigation of Negative Attitudes and Anxiety toward Robots

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Abstract

In order to study short–term and long–term influence of communication robots in daily–life applications, it is necessary to develop psychological scales measuring mental states of users of robots and social trends on them. This paper focuses on negative attitudes and anxiety toward robots, and shows results obtained through development of scales measuring them.

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 [1, 2]. If communication robots are really applied to these fields, however, it should be carefully investigated how humans are mentally affected by them. In the field of educational psychology, computer anxiety is defined as an anxious emotion that prevents users from using and learning about computers, and has been studied as an important factor in education for computer literacy. Thus, short–term and long–term 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 engineering designs for communication robots in other daily–life applications and analysis of markets on them.

In order to explore psychological influences of communication robots, it is necessary to develop psychological scales for measurement of attitudes toward robots and emotions evoked in human–robot communication. For this aim, we have been focusing on anxiety toward robots and trying to develop a psychological scale measuring it [6]. The previous research resulted in a psychological scale measuring negative attitudes toward robots, not anxiety itself [7, 8]. On the other hand, we also had a new type of data to develop a scale for anxiety toward robots.

In this paper, we focus on negative attitudes and anxiety toward robots, and show results obtained through development of scales measuring them.

2 Negative Attitudes toward Robots and Measurement of Them

2.1 Negative Attitude toward Robots Scale (NARS)

The concept of attitudes is one of psychological constructs and is defined as mental states prepared before behaviors. 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, factorial validity, and test–retest reliability [8]. We originally tried to develop this scale for measuring anxiety toward robots [6]. After some analyses, it was clarified that this scale does not measure anxiety itself, but negative attitudes toward robots (in fact, correlations between it and STAI, a psycholog-

Table 1: The English Version of Negative Attitude toward Robots Scale and the Subordinate Scales That Each Item Is Included

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 had influence on children.	**S2**
14	I feel that in the future society will be dominated by robots.	**S2**

(*Inverse Item)

ical scale measuring general anxiety [9, 3], were low although they were statistically not zero [8]).

This scale consists of fourteen questionnaire items in Japanese. Table 1 shows the English version of the NARS, which was translated based on back translation. These items are classified into three subordinate scales, **S1**: "Negative Attitude toward Situations of Interaction with Robots" (6 items), **S2**: "Negative Attitude toward Social Influence of Robots" (5 items), and **S3**: "Negative Attitude toward Emotions in Interaction with Robots" (3 items). 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 **S1**, 5 and 25 in **S2**, and 3 and 15 in **S3**, respectively.

2.2 Administration of NARS

From October, 2003 to December, 2003, we administrated the NARS to 240 Japanese university students (male: 146, female: 92, unknown: 2, the average age of the male: 21.8, that of the females: 22.4) in order to investigate validity of the NARS [8]. In this administration, the respondents answered another questionnaire item asking whether they had seen really acting robots. Then, we executed a two–way ANOVA for their NARS scores with the male–female factor and the factor on whether they had their experiences on robots mentioned above.

Table 2 shows the result of the two–way ANOVA. This result shows that genders and experiences on robots affect the scores of the subordinate scale **S1**, that is, negative attitude toward situations of interaction with robots. Moreover, they suggest that negative attitudes are different between not only genders but also ages, and can change in time.

2.3 An Psychological Experiment Using NARS

We executed a psychological experiment with interaction between subjects and a humanoid robot [7].

The robot used in the experiment is "Robovie" [5]. In this experiment, the subjects responded for the questionnaires including sex, age, whether he/she had seen really acting robots, and the NARS before interaction with the robot. The procedures used in one session of the experiment are shown as follows:

1. Just before entering the room, the subject were instructed to talk toward the robot just after entering the room. Then, the subject entered the room alone.

2. After he/she talked to the robot, or a constant time (30 seconds) passed, the robot uttered a sentence to stimulate his/her self–expression ("Have

Table 2: 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

(**$p < .01$)

you recently experienced something negative?")

3. After he/she replied to the utterance of the robot, or a constant time (30 seconds) passed, the robot uttered a sentence to stimulate his/her physical contact to it ("Touch me").

4. After he/she touched the body of the robot, or a constant time (30 seconds) passed, the session finished.

Behaviors of the subjects in the experiment, including their utterances, were recorded using two digital video cameras. Then, some behavior indices (for example, the time elapsed until the subjects talked to the robot after entering the room) were extracted from the video data. Moreover, the contents of the subjects' 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.

As a result, we found the following trend:

- The subjects having higher negative attitude toward situations of interaction with robots (S1) spent more time until they first talkd to the robot than those having lower negative attitude.
- Negative attitudes of the subjects who did not utter anything were higher than those who uttered something not related to themselves.
- There was a difference between the male and female subjects, on correlations between their NARS scores and behaviors toward the robot.
- There was a difference between the subjects having seen really acting robots and those not having, on correlations between their NARS scores and behaviors toward the robot.

3 Anxiety toward Robots

3.1 Necessity of Robot Anxiety Scale

Our research mentioned in the previous section found statistically non–zero correlations between negative attitudes and communication behaviors toward robots. However, they were really low [7]. In other words, there is a possibility that negative attitudes may not have much influence to humans' concrete behaviors toward robots in real situations of interaction with them. On the other hand, it is reported that there is a middle level of correlations between computer anxiety and behaviors such as students' wellness in lectures of computer literacy [4].

It is guessed that this difference between relations of negative attitudes toward robots with behaviors and those of computer anxiety is caused by the difference between images for them. Humans' images for computers have already been fixed as those consisting of keyboards, mouses, displays, and so on. In comparison with them, humans' images for robots vary from factorial arm robots to pet type and humanoid robots.

Thus, there is a possibility that emotions really evoked in situations of interaction with robots may be different from attitudes toward robots, and as a result, correlations between attitudes and behaviors toward robots are weak. In other words, it is necessary to develop a psychological scale measuring emotions evoked in situations of interaction with robots, such as anxiety, to predict concrete behaviors toward robots.

For this aim, we define robot anxiety as emotions of anxiety or fear preventing individuals from interaction with robots having functions of communication in daily–life, in particular, dyad communication with a robot [6]. Based on this definition, we are developing a scale measuring this robot anxiety.

Figure 1: A Scene of the Experiments on Human–Robot Interaction

3.2 A Pilot Survey for Development of Robot Anxiety Scale

In order to explore candidates of questionnaire items, we administrated a pilot survey by assembling data with a form of freely described answers for two kinds of questionnaires, from April, 2004 to May, 2004.

The respondents were the Japanese subjects assembled for experiments on human–robot interaction for another aim. In these experiments, each subject interacted with some robots in random order. The interaction with one robot was done for about one minute, and the robot executed a simple task for guidance through pointing and moving in the interaction. Figure 1 shows a scene of the experiments. After these experiments, the subjects responded for the following questionnaires by freely describing sentences:

1. "Did you feel anxiety when you were faced to the robots in the experiments? If so, please answer freely and concretely on how you felt anxiety."

2. "If you are faced to robots in daily–life such as houses, offices, and schools, what situations do you feel anxiety in? Moreover, what type of anxiety do you feel concretely? Please answer freely."

A total of 48 respondents provided with their freely described answers for the above questionnaires.

The candidates of questionnaire items of Robot Anxiety Scale are going to be extracted from these freely described sentences on anxiety in situations of interaction with robots.

3.3 Some Results by the Pilot Survey

Before extracting candidates of questionnaire items from the freely described sentences in the pilot survey, we analyzed these sentences and extracted some characteristics. We report them in this paper.

First, one of the authors manually extracted sentences including words related on anxiety from these freely described sentences. For the first questionnaire, one sentence was extracted per one respondent. For the second questionnaire, one or more than two sentences were extracted per one respondent. Then, these sentences were manually classified into several categories based on similarity between the contents of the sentences. As a result, seven categories and thirteen categories were found for the first and second questionnaires, respectively.

Then, another person classified these extacted sentences based on these extacted categories, independent on the first classifier. Before this classification, the first and second classifiers discussed each other on these categories for classification. Although the second classifier had been permitted to add a new category if necessary on classifying the sentences, it was really not done.

Table 3 shows the categories extracted from the freely described sentences and the numbers of sentences classified into these categories by the first and second classifiers. The κ–values, degrees of equality between classifications by the first and second classifiers, were 0.685 and 0.615 ($p < .001$) for the first and second questionnaires, respectively. These values mean a middle level of degrees of equality in the classifications by the two persons. (It should be noted that the above methods for exraction of categories and evaluation of extracted categories are standard ones in psychology.)

One characteristic commonly appeared in the categories extracted from the freely described sentences. Anxiety toward motions or approach of robots, anxiety toward unpredictability of robots' actions, and anxiety toward interaction with robots were commonly extracted from the sentences for both the first and second questionnaires. Moreover, it is considered that these types of anxiety correspond to a physiological level, a cognitive level, and a social level, respectively.

Important is that about a half of the respondents explicitly described the fact that they did not feel anxiety when they were faced to the robots in the experiments. On the other hand, almost all respondents described something anxious when they imagined robots in daily–life. It suggests that peoples' images on robots are different from their impression evoked by real robots, at least, in Japan. In fact, the categories extracted from the sentences for the second

Table 3: Categories on Contents of Anxiety Extracted from the Sentences in the Pilot Survey and the Numbers of Sentences Classified into These Categories by the First and Second Classifiers

Categories extracted from the sentences for the 1st questionnaire	the first classifier	the second classifier	Average
Unpredictability of robots' actions and communication	6	13	9.5
Approach of roots	6	6	6
Stability in interaction with robots	6	3	4.5
Turnover of robots	3	2	2.5
Others on anxiety	4	1	2.5
No anxiety except for specific situations and types of robots	5	6	5.5
No anxiety	18	17	17.5
(Total)	48	48	48
Categories extracted from the sentences for the 2nd questionnaire	**the first classifier**	**the second classifier**	**Average**
Trouble of robots	17	20	18.5
Unpredictability of robots' actions	6	13	9.5
Interaction with robots	10	7	8.5
Maintenance and management of robots	7	3	5
Reliability of robots in practical situations	6	3	4.5
Social influence of robots	5	4	4.5
Situations like scientific fictions	5	4	4.5
Usage of robots in situations related to human life	4	4	4
Motion of robots (itself)	4	3	3.5
Existence of robots (itself)	1	4	2.5
Emotions of robots	2	3	2.5
Others on anxiety	2	1	1.5
No anxiety	2	2	2
(Total)	71	71	71

questionnaire include the things related to social situations where robots act, such as usage of robots in situations related to human life, reliability of robots in practical situations, and so on. These situations have still not been realized in general.

Some sentences categorized into situations like scientific fictions show anxiety toward domination of humans by robots, like some movies. Moreover, some sentences categorized into existence and emotions of robots suggest principle anxiety caused by a possibility that robots may be equal to humans, and the fact that they do not know how to deal with these robots if they are realized, in a philosophical sense. These types of anxiety may be related on a kind of anxiety toward just “unknown objects”.

4 Conclusion

In this paper, we showed the concepts of negative attitudes and anxiety toward robots, the Negative Attitude toward Robots Scale (NARS) and some results by administration of the NARS, and some results in the pilot survey for development of Robot Anxiety Scale.

The most important subject is to develop psychological scales measuring emotions deeply related to concrete behaviors in situations of interaction with robots, and development of Robot Anxiety Scale is one of attempts to realize them. We are going to extract candidates of questionnaire items in Robot Anxiety Scale from data in the pilot survey mentioned in the previous section. And then, we are going to select items through consideration of content validity, a pre–test, and investigation of internal consistency, concurrent validity with general anxiety scales, and test–retest reliability. Important is investigation of its predictive validity based on psychological experiments by real interaction between humans and robots.

As one of future problems on negative attitudes toward robots, we have already developed the English version of NARS by cooperation of some researchers. Based on this English version, we are going to assemble data in Europe and USA and compare data in Japan with it to investigate differences on attitudes toward robots between countries. Moreover, we should investigate relations between attitudes toward robots and images for them in individuals by using the NARS and another psychological scale measuring images for robots [10].

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