Social Acceptance of Humanoid Robots in Japan

A Survey for Development of the Frankenstein Syndorome Questionnaire

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Abstract—**This research explores the concept of "The Frankenstein Syndrome" in order to develop a psychological tool for measuring acceptance of humanoid robots, as well as expectations and anxieties toward these technologies. It also aims to explore factors that influences this acceptance, such as the effects of age and experiences with robots. The tool developed is tentatively named "The Frankenstein Syndrome Questionnaire", a questionnaire to measure acceptance of humanoids in humans. A preliminary survey conducted in Japan suggested that: 1) the elder population has positive expectations for the specific applications of humanoid robots in their daily lives and view the developers of these technologies more favourably, in comparison with the younger population; 2) these expectations can be made more positive through having experiences of real humanoid robots or experiences of the robots via media information; 3) such experiences of humanoid robots do not seem to affect general anxiety toward the robots in the younger population, but they do decrease the anxiety in the elder population; 4) experiences of humanoid robots increase apprehension toward risks the robots entail in the society in the younger population, although they do not affect such apprehension in the elder population. The paper discusses about implications from the results.**

Keywords-component; social acceptance; humanoid robots; age; experiences; questionnaire

I. INTRODUCTION

The acceptance of a specific technology within society is an important research subject to be tackled, by not only the social sciences, but also within the technological fields, in terms of application design. In the current situation, where research and development of humanoid robots is continually being advanced, it is necessary to investigate how the general public will accept this technology in their daily life, and what factors prevent such acceptance of humanoid robots. The development of methods for measuring people's degree of acceptance of humanoid robots, such as psychometric, validated questionnaires, can contribute to an integrated research approach to explore a variety of effects like age, gender, and cultures.

At the current stage, there have been few studies specifically addressing social acceptance of humanoid robots. Scopelliti et al. [1] found some characteristics of robot types preferred in the context of domestic use and age effect in the acceptability of these robotic devices. Oestreicher and Eklundh [2] reported on the types of task expected of domestic household robots. However, these studies did not focus on humanoids. Although Nomura et al. [3] found cultural differences on assumptions about humanoid robots between Japan, Korea, and the USA, this study was limited to university students.

Kamide et al. [4] developed a psychological scale to measure human perception of humanoid robots, consisting of six subscales including "acceptance" of humanoid robots, and found the effects of human attributes such as age and gender into the scale scores (from 10's to 70's, N = 2,624) [5]. However, this scale was aimed at determining the psychological safety of humanoid robots in front of humans, and the researchers did not deal with wider expectations and anxieties towards humanoid robotics as a technology.

The research presented in this paper is aimed at developing a psychological tool specific for measuring acceptance of humanoid robots including expectations and anxieties toward this technology in the general public. It will also explore factors influencing such acceptance. The particular factors pertinent to this research were the concept of "Frankenstein Syndrome" and the impact of age. The term "Frankenstein Syndrome" was originally used when referring to controversies in the life sciences, in particular, genetic engineering [6], and suggests that the creation of human-like artifacts is an act of potential transgression. Kaplan [7] made use of this concept to explain differences in the acceptance of humanoid robots between Japan and the West. Following this concept, we have developed a questionnaire to measure the acceptance of humanoid robots in humans. Moreover, some survey studies found effects of age [1, 8, 9, 10, 11, 12] and experiences of robots [12] into psychological reactions toward robots. Thus, it is necessary to investigate these effects into the psychological reactions measured by the questionnaire.

This paper reports the development process of "the Frankenstein Syndrome Questionnaire" (FSQ) and the results of a survey conducted in Japan. Then, it discusses about some implications from the survey results.

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II. METHOD

A. Development of Initial Version of the Questionnaire

A pilot survey was conducted to elicit opinions, attitudes and feelings towards the spread of humanoid robots in society, including what tasks and activities should be performed by such robots in the future. This survey was conducted with university students and general adults in both Japan and the UK. This survey was based on an open-ended questionnaire intended for comparative analysis between Japan and the West about the Frankenstein Syndrome [13]. From the data collected from the 204 Japanese and 130 UK respondents, we categorized sentences related to acceptance of humanoid robots. After modifying the expression of these sentences, we extracted 22 sentences, representing these categories in English.

In order to assemble more candidates for questionnaire items, we looked to attitudes towards research on genetically modified food products, one of the fields in which the concept of the Frankenstein Syndrome originated. 8 items were extracted from a Japanese questionnaire used in a survey about attitudes towards genetically modified food products [14]. We repladed the term "genetically modified food products" in these items with "humanoid robots," and modified them so that they were easier to read in English. The content validity of these items was discussed among engineering researchers and psychologists, and finally 30 items were selected as item candidates for the English version of the FSQ. Each questionnaire item was assigned with a seven-choice answer (1: "Strongly disagree", 2: "Disagree", 3: "Disagree a little", 4: "Not decidable", 5: "Agree a little", 6: "Agree", 7: "Strongly agree".). Then, the Japanese version of the FSQ was produced through back-translation.

B. Data Collection

The survey was conducted in November, 2011 to extract the factor structure of the FSQ and select the items. Respondents were recruited by a survey company at which about one million and thirty thousands Japanese persons have registered, via the Internet. Among people randomly selected based on gender and age, a total of 1,000 persons ranging from 20's to 60's participated in the survey. The respondents at each of the generations (20's, 30's, 40's, 50's, and 60's) consisted of 100 males and 100 females.

The questionnaire was conducted online, via a WEB page. In the instructions for the questionnaire, humanoid robots were defined as follows:

"Robots that roughly look like humans, that have two arms, legs, a head, etc. These robots may be very human-like in appearance (including details such as hair, artificial skin etc.),

TABLE I. ITEMS OF THE FRANKENSTEIN SYNDROME QUESTIONNAIRE AND RESULTS OF FACTOR AND ITEM ANALYSES

Item No.	Factor Loading I	II	III	IV	Item Sentence
9	**.842**	-.234	.131	-.025	The development of humanoid robots is a blasphemy against nature.
29	**.804**	-.128	.226	-.186	The development of humanoid robots is blasphemous.
22	**.770**	-.126	.003	.091	I feel that in the future, society will be dominated by humanoid robots.
8	**.705**	-.025	-.165	.286	I am afraid that humanoid robots will encourage less interaction between humans.
1	**.695**	-.109	.011	.083	I am afraid that humanoid robots will make us forget what it is like to be human.
26	**.659**	-.091	.225	-.056	Technologies needed for the development of humanoid robots belong to scientific fields that humans should not study.
4	**.624**	-.015	-.222	.352	Humanoid robots may make us even lazier.
21	**.616**	.209	-.050	-.145	I don't know why, but humanoid robots scare me.
24	**.613**	.224	.038	-.010	Many humanoid robots in society will make it less warm.
16	**.596**	.232	-.075	-.020	I am concerned that humanoid robots would be a bad influence on children.
27	**.569**	.325	.050	-.096	Something bad might happen if humanoid robots developed into human beings.
17	**.457**	.379	.085	-.219	I would hate the idea of robots or artificial intelligences making judgments about things.
30	**.394**	.315	-.115	.091	Widespread use of humanoid robots would take away jobs from people.
12	-.092	**.609**	.094	-.026	If humanoid robots cause accidents or trouble, persons and organizations related to development of them should give sufficient compensation to the victims.
11	.196	**.607**	.082	-.062	I would feel uneasy if humanoid robots really had emotions or independent thoughts.
23	-.163	**.539**	-.007	.253	Humanoid robots should perform dangerous tasks, for example in disaster areas, deep sea, and space.
20	.282	**.505**	-.159	.004	I feel that if we become over-dependent on humanoid robots, something bad might happen.
14	.000	**.452**	.068	.054	Widespread use of humanoid robots would mean that it would be costly for us to maintain them.
13	.091	.065	**.689**	.201	I can trust persons and organizations related to development of humanoid robots.
25	.154	-.082	**.650**	.061	I trust persons and organizations related to the development of humanoid robots to disclose sufficient information to the public, including negative information.
28	-.065	.305	**.577**	.065	Persons and organizations related to development of humanoid robots will consider the needs, thoughts and feelings of their users.
3	.080	.055	**.463**	.323	Persons and organizations related to development of humanoid robots are well-meaning.
2	.085	-.075	.156	**.571**	Humanoid robots can create new forms of interactions both between humans and between humans and machines.
19	-.198	.257	.220	**.486**	Humanoid robots can make our lives easier.
10	-.108	-.024	.205	**.483**	I don't know why, but I like the idea of humanoid robots.
5	-.231	.341	.083	**.458**	Humanoid robots can be very useful for caring the elderly and disabled.
7	*.408*	*-.031*	*-.112*	***.450***	*People interacting with humanoid robots could sometimes lead to problems in relationships between people.*
6	*.192*	*-.046*	*.040*	***.375***	*Humanoid robots should perform repetitive and boring routine tasks instead of leaving them to people.*
15	.119	-.251	.338	**.342**	Humanoid robots can be very useful for teaching young kids.
18	-.079	.114	.185	.289	Humanoid robots are a natural product of our civilization.

(Note: Items 6 and 7 were removed via item analysis.)

but can also have machine-like features (such as wheels, a metal skin etc.)"

Moreover, the photos of the following humanoid robots were shown just after the above definition to evoke respondents' images of humanoid robots:

- Geminoid (male android) [15]
- Robovie -R2 (mechanical humanoid) [16]
- Nao (small-sized mechanical humanoid) [17]
- HRP-4C (female humanoid) [18]
- HRP-2 (mechanical humanoid) [19]
- KASPAR (small-sized child-like humanoid) [20]

All of the photos were shown at the same time on the one webpage one page. The robots in the photos did not show any behavior related to specific tasks (just standing or sitting). No explanation about the robots was provided in the photos, except for the credits of the developers.

On the face sheet, respondents' experiences of humanoid robots were asked with a three-choice answer (1. I have seen real humanoid robots, 2. I have seen humanoid robots via media, 3. I have never seen humanoid robots).

III. RESULTS

A. Subscales of the FSQ and Reliability

To extract the subscales of the FSQ, a factor analysis with maximum likelihood method and Promax rotation was conducted for the 30 items. The analysis found four factors having eigen values more than 1. Then, item analysis using Cronbach's α-coefficients and I-T correlations was performed for each factor to select items in the corresponding subscale. Table 1 shows the results of these analyses.

The subscale corresponding to the first factor consisted of 13 items representing negative feelings toward the existence of humanoid robots, and their influences into the society, such as "I don't know why, but humanoid robots scare me" and "Humanoid robots may make us even lazier." Thus, the subscale was labeled "General anxiety toward humanoid robots." The subscale corresponding to the second factor consisted of 5 items representing negative feelings toward troubles and risks humanoid robots may cause in the society, such as "I feel that if we become over-dependent on humanoid robots, something bad might happen." This subscale was labeled "apprehension toward social risks of humanoid robots." The subscale corresponding to the third factor consisted of 4 items representing trustworthiness for persons and organizations related to the development of humanoid robots, such as "I can trust persons and organizations related to development of humanoid robots."It was labeled "trustworthiness for developers of humanoid robots." The subscale corresponding to the fourth factor consisted of 5 items representing positive feelings toward humanoid robots appearing in daily life, such as "Humanoid robots can make our lives easier." Thus, this subscale was labeled "expectation for humanoid robots in daily life."

TABLE II. PEARSON'S CORRELATION COEFFICIENTS BETWEEN SUBSCALE SCORES OF THE FRANKENSTEIN SYNDROME QUESTIONNAIRE

	I	II	III
II	.401**		
III	-.163**	-.026	
IV	-.290**	.069*	.510**

(*p < .05, **p < .01)

I: general anxiety toward humanoid robots
II: apprehension toward social risks of humanoid robots
III: trustworthiness for developers of humanoid robots
IV: expectation for humanoid robots in daily life

TABLE III. SAMPLE NUMBERS BASED ON EXPERIENCES OF ROBOTS, GENERATION, AND GENDER

Generation	Experience	Male	Female	Total
20's	Exp	66	62	128
	Nexp	34	38	72
30's	Exp	67	64	131
	Nexp	33	36	69
40's	Exp	67	67	134
	Nexp	33	33	66
50's	Exp	73	73	146
	Nexp	27	27	54
60's	Exp	70	67	137
	Nexp	30	33	63
Total		500	500	1000

Cronbach's reliability coefficients α, showing the internal consistencies of the subscales, were .909 for "general anxiety toward humanoid robots," .693 for "apprehension toward social risks of humanoid robots," .723 for "trustworthiness for developers of humanoid robots," and .717 for "expectation for humanoid robots in daily life." The score of each subscale was calculated as a sum of the scores of the items included in the subscale ("general anxiety toward humanoid robots": max 91, min 13, "apprehension toward social risks of humanoid robots": max 35, min 5, "trustworthiness for developers of humanoid robots": max 28, min 4, and "expectation for humanoid robots in daily life": max 35, min 5).

Table 2 shows the Pearson's correlation coefficients between the subscale scores. There were moderate levels of positive correlations between "general anxiety toward humanoid robots" and "apprehension toward social risks of humanoid robots," and between "trustworthiness for developers of humanoid robots" and "expectation for humanoid robots in daily life." Moreover, there were weak levels of negative correlations between "general anxiety toward humanoid robots" and "trustworthiness for developers of humanoid robots," and "expectation for humanoid robots in daily life." There was almost no correlation between "apprehension toward social risks of humanoid robots" "trustworthiness for developers of humanoid robots," and "expectation for humanoid robots in daily life."

B. Effects of Age and Experiences

The sample was divided into the following two groups in order to to analyze the effect of experience of robots on the FSQ subscale scores:

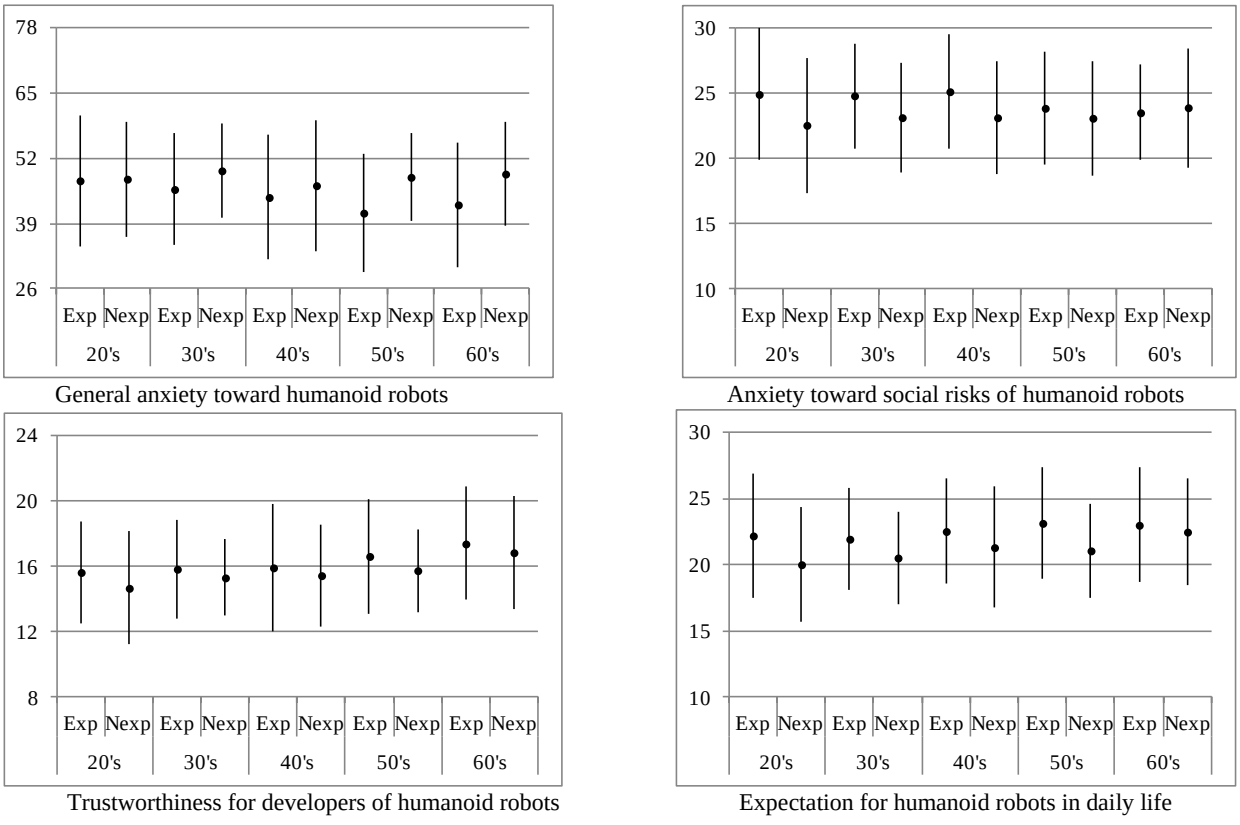

Figure 1. Means and Standard Deviations of Subscale Scores of the FSQ

TABLE IV. RESULTS OF ANOVAS FOR SUBSCALE SCORES OF THE FSQ

	Generation		Experience		Interaciton		Post-hoc test
	F	η^2	*F*	η^2	*F*	η^2	
I	2.361†	.009	24.303***	.023	2.385*	.009	Exp: 20's > 50's, 60's; 30's > 50's 30's, 50's, 60's: Exp < Nexp
II	.568	.002	18.545***	.018	2.778*	.011	Exp: 40's > 60's 20's, 30's, 40's: Exp > Nexp
III	9.088***	.035	9.102**	.009	.205	.001	20's < 50's, 60's; 30's, 40's < 60's
IV	4.534**	.017	27.376***	.026	1.143	.004	20's, 30's < 60's

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

I: general anxiety toward humanoid robots
II: anxiety toward social risks of humanoid robots
III: trustworthiness for developers of humanoid robots
IV: expectation for humanoid robots in daily life

- **Exp**: respondents who had seen real humanoid robots, or seen humanoid robots via media (1 or 2 on the item on experiences of robots in the face sheet)
- **Nexp**: respondents who had never seen humanoid robots (3 on the item on experiences of robots in the face sheet)

Table 3 shows the sample numbers based on the above experiences, generation, and gender. χ^2–tests on gender x experience for each generation group, or those on experience x generation for each gender group found no statistically significant difference.

Then, two-way ANOVAs with generation x experience were conducted for the subscale scores of the FSQ to investigate effects of age and experiences of robots into acceptance of humanoid robots. Figure 1 shows the means and standard deviations of the subscale scores of the FSQ, and table 4 shows the results of these ANOVAs.

For "general anxiety toward humanoid robots," the main effect of experience and interaction effect were at a statistically significant level. A simple main effect test with Bonferroni's method ($\alpha = .05$) found that only in the samples who had seen real humanoid robots or seen humanoid robots via media, respondents of 20's tended to feel higher anxiety than did those of 50's and 60's, and those of 30's felt higher anxiety than did those of 50's. Moreover, the test also found that only in the samples of 30's, 50's, and 60's, respondents having the

experiences of humanoid robots tended to feel lower anxiety than did those who had never seen humanoid robots.

For "apprehension toward social risks of humanoid robots", the main effect of experience and interaction effect were at a statistically significant level. A simple main effect test with Bonferroni's method ($\alpha = .05$) found that that only in the samples who had seen real humanoid robots or seen humanoid robots via media, respondents of 40's tended to feel higher apprehension than did those of 60's. Moreover, the test also found that only in the samples of 20's, 30's, and 40's, respondents having the experiences of humanoid robots tended to feel higher apprehension than did those who had never seen humanoid robots.

For "trustworthiness for developers of humanoid robots" and "expectation for humanoid robots in daily life", the main effects of generation and experience were at a statistically significant level. There were no statistically significant interaction effects for these subscales. The results revealed that the respondents having the experiences of humanoid robots tended to feel more about these positive feelings toward humanoid robots than did those who had never seen humanoid robots. Post-hoc tests with Bonferroni's method ($\alpha = .05$) found that the respondents of 20's tended to trust developers of humanoid robots more weakly than did those of 50's and 60's, and those of 30's and 40's tended to trust developers of humanoid robots more weakly than did those of 60's. Moreover, it was found that the respondents of 20's and 30's had less expectation of humanoid robots in daily life than did those of 60's.

IV. Discussion

A. Findings

With regards to social acceptance of humanoid robots, the factor structure of the FSQ revealed a positive relationship between general anxiety towards humanoid robots and apprehension towards the social risks of them, and a negative relationship between these factors and the perceived trustworthiness of developers of humanoid robots and expectations for robots in daily life. The result also suggests that the older age groups expressed less general anxiety and a similar effect was found for experiences of real humanoid robots or exposure to humanoid robots in the media.. This is partly consistent with earlier results on attitudes toward robots by Nomura, et al, [12].

However, different types of interaction effects were found that mediated the above findings.. On general anxiety toward humanoid robots, the age effect appeared only in the samples that had experiences of robots. Moreover, the effect of experiences of humanoid robots was found only in the elder generations. On apprehension toward social risks of humanoid robots, the effect of experiences of the robots was found only in the younger generations. In addition, the apprehension was higher in the samples that had experiences of the robots than in the samples that had no experiences of the robot. It showed an opposite trend with general anxiety toward humanoid robots.

The above results suggest the following trend of social acceptance of humanoid robots in Japan:

- The elder population has positive expectation for possible applications of humanoid robots in daily life and a more positive view of their developers, in comparison with the younger population.
- These expectations can be improved through having experiences of real humanoid robots or experiences of such robots through the media..
- Such experiences of humanoid robots do not affect general anxiety toward the robots in the younger population, although they decrease this anxiety in the elder population.
- Experiences of humanoid robots increase apprehension toward risks the robots may cause in the society in the younger population, although they do not affect the apprehension in the elder population.

B. Implications

The above findings imply the possibility that the stereotypical view that "the Japanese prefer humanoid robots in comparison with people in other countries" [7] is, if it was ever correct, in the past. The results in the survey suggest that younger people in Japan do not accept the development of humanoid robots as strongly as do older people. While the younger population may have their expectations improved through encountering humanoid robots in person or through the media, the results in the survey also suggest that such experiences may also increase their apprehension of risks arising from humanoid robots in daily life. In this sense, the younger population in Japan may have more realistic expectations for robotics applications in comparison with the older population.

When considering these results from the perspective of developing robotics technologies, we should take care that these are developed for concrete aims and applications. When engaging with the general public, developers of humanoid robots should explain for what user-groups a robot is intended for, and how specifically the robot can contribute to the needs of this user group. It is also important to disclose what benefits and risks the robots can have in comparison with conventional technologies, and how the developers can cope with the risks, in order to engender trust in robotics researchers.

C. Limitation and Future Works

First, the survey reported in the paper was at a preliminary stage as a part of the pilot survey for item selection of "the Frankenstein Syndrome Questionnaire". Thus, it has some problems in the validity since the items were originally assembled from the results of the cross-cultural survey between Japan and the UK [13]. In fact, the second subscale had lower internal consistency ($\alpha < .7$ on 5 items). Thus, the factor structure, is tentative, and should be re-considered based on both the Japanese and UK samples. The pilot survey in the UK is being conducted for this purpose at the current stage.

Second, the survey reported in the paper did not take into account relationships between the Frankenstein Syndrome and other psychological constructs. To confirm the criterion-related validity of the FSQ, the main survey should include some

constructs such as general technophobia, intention to use in humanoids applications, and religious beliefs.

Third, it is not clear from the survey what images of humanoid robots the respondents actually had and how the images affected their responses. Nomura et al., [21] suggested that images of robots affected negative attitudes toward robots. Moreover, experiences of robots may influence these images. However, the survey in the paper dealt with a simple distinction on the experience, and did not take into account the concrete contents such as types of robots experienced and contexts of the experience including robot tasks. The main survey should also measure images that respondents have and detailed experiences of robots, and explore their relationships with social acceptance of humanoid robots and other psychological constructs.

Finally, the survey adopted the photos of the real humanoid robots to evoke the respondents' images of humanoid robots. However, the effect of this stimulus is not clear. Future surveys should adopt more abstract pictures of humanoid robots or video stimuli to avoid this ambiguity.

The above problems must be solved for the final aim of the Frankenstein Syndrome Questionnaire, international comparison on social acceptance of humanoid robots and influential factors into it.

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