What People Assume about Robots: Cross-Cultural Analysis between Japan, Korea, and the USA

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1. Introduction

It is known that the concept of "robots" itself is very old. However, it is only recently that they have appeared as commercialized products in daily life, even in Japan that is regarded as one of the most advanced nations in the development of robotics industries. Thus, it is predicted that the old imaginary concept and embodied objects in the daily-life context mutually interact, and as a result, novel psychological reactions toward robots are caused. Moreover, there may be differences in the above psychological reactions between nations, due to the degree of presence of robotics in the society, religious beliefs, images of robots transmitted through media, and so on. Thus, it is important to investigate in different cultures what people assume when they encounter the word "robot," from not only a psychological perspective but also an engineering one that focuses on such aspects as design and marketing of robotics for daily-life applications.

On cultural studies about computers, Mawhinney et al., (1993) reported some differences about computer utilization between the USA and South Africa. Gould et al., (2000) performed comparative analysis on WEB site design between Malaysian and US companies based on the cultural dimensions proposed by Hofstede (1991). On psychological impact of technology, Weil & Rosen (1995) showed based on social research for 3,392 university students from 23 countries, that there are some cultural differences on technophobia, in particular, anxiety and attitudes toward computers. Compared with computers, which have a rather fixed set of images and assumptions, images and assumptions of robots may widely vary from humanoids to vacuum cleaner and pet-type ones. Thus, cultural differences of assumptions about robots, that is, what people assume when they hear the word "robots," should be sufficiently investigated before discussing any differences on emotions and attitudes toward robots.

On psychological reactions toward robots, Shibata et al., (2002; 2003; 2004) reported international research results on people's subjective evaluations of a seal-type robot they

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developed, called "Palo," in several countries including Japan, the U.K, Sweden, Italy, and Korea. Although their results revealed that nationality affected the evaluation factors, they were limited to a specific type of robots. Bartneck et al., (2007) reported some cultural differences on negative attitudes toward robots between several countries including the USA, Japan, the UK, and the Netherlands. However, this study did not take into account cultural differences of assumptions about robots. As mentioned above, cultural differences of assumptions about robots should be investigated before discussing those on attitudes toward robots, in the current situation where images of robots are not so fixed as those of computers. Nomura et al., (2006a; 2006b) reported some relationships between assumptions about, anxiety toward, and negative attitudes toward robots. However, these studies were limited to one culture, using Japanese data samples. Moreover, the questionnaire items used in the studies were not designed for cross-cultural studies.
This chapter reports about cross-cultural research aiming at a more detailed investigation of assumptions about robots based on comparisons between Japan, Korea, and the USA.

2. Method

2.1 Subjects

Data collection for the cross-cultural study was conducted from May to July, 2006. The participants were university students in Japan, Korea, and the USA. Table 1 shows the sample size and mean age of the participants.
In each country, sampling was performed in not only departments on natural science and engineering but also those on social sciences.

Country	#. Univ.	Male	Female	Total	Mean Age
Japan	1	200	111	313	18.68
Korea	3	159	158	317	23.54
USA	1	96	69	166	23.93

Table 1. Sample Size and Mean Age of Participants

2.2 Instrumentation

A questionnaire for measuring assumptions about robots was prepared based on discussion between researchers of engineering and psychology in Japan, Korea, and the USA, as follows. First, types of robots to be assumed were discussed. Considering the existing research result on assumptions about robots (Nomura et al., 2005), the current presence of robots in the nations, and length of the questionnaire, seven types of robots were selected. Table 2 shows these types of robots.
Then, questionnaire items measuring degrees of characteristics which each type of robot is assumed to have, and answer types were discussed. As a result, the items about autonomy, emotionality, roles to be played in the society, and images of each type of robot were prepared. On the items of autonomy and emotionality, degrees of the assumptions were measured by three levels of answers. Table 3 shows these items and their choices. On the items of roles and images, ten and seven subitems were prepared respectively, and each subitem had seven-graded scale answer to measure degrees of the assumptions. Table 4 shows these items.

1. Humanoid robots the size of toys or smaller
2. Humanoid robots between the sizes of human children and adults
3. Humanoid robots much taller than a person
4. Robots with appearances and sizes the same as animals familiar to humans, such as dogs, cats, rabbits, and mice
5. Machine-like robots for factories or workplaces
6. Non-humanoid robots bigger than a person, such as animal-, car-, or ship-shaped robots
7. Non-humanoid robots smaller than a person, such as animal-, car-, or ship-shaped robots

Table 2. Robot Types Dealt with in the Questionnaire (in order on the questionnaire)

Degree of autonomy to be assumed for the robot
1. Complete self decision-making and behavior
2. Self decision-making and behavior for easy tasks, and partially controlled by humans for difficult tasks
3. Completely controlled by humans, such as via remote controllers
Degree of emotional capacity that the robot is assumed to have
1. Emotional capacity equal to that of humans
2. Some capacity for emotion, but not as much as humans
3. No capacity for emotion at all

Table 3. Items Measuring Assumptions about Autonomy and Emotionality of Robots and their Choices (Common in all the Robot Types)

The questionnaire, the Robot Assumptions Questionnaire (RAQ), was originally made in Japanese, including the instructions. Then, the English version was made through formal back-translation.

Roles that the robot is assumed to play in the society (seven-graded scales from 1: Not likely at all to 7: Almost certainly)
1. Housework
2. Communication partners in the home
3. Physical tasks in the office
4. Intelligent tasks in the office, including communication
5. Tasks related to life-and-death situations in hospitals
6. Tasks related to nursing, social works, and education
7. Monotonous assembly line work in factories
8. Toys in the home or at amusement parks
9. Tasks hard for humans to do , or tasks in places hard for humans to go (such as burdensome tasks in space, the deep sea, or the battlefield)
10. Acts of hostility in the battlefield, such as causing blood shed
Images to be assumed for the robot (seven-graded scales from 1: Not likely at all to 7: Almost certainly)
1. Raise difficult ethical issues
2. Beneficial to society
3. A cause of anxiety in society, for example, as a cause of unemployment
4. Very interesting scientific and technological products
5. A technology requiring careful management
6. Friends of human beings
7. A blasphemous of nature

Table 4. Items Measuring Assumptions about Roles and Images of Robots (Common in all the Robot Types)

2.3 Procedures

Each colleague was sent the English version of the RAQ including the instructions to be read to the students. In Japan, the Japanese version of the questionnaire was administered to undergraduate classes in the departments of engineering and social sciences. In the USA, the English version was administered to both graduate and undergraduate classes in the schools of engineering and psychology. In Korea, back-translation from the English to the Korean was performed, and then the Korean version of the questionnaire was administered to classes in the departments of natural sciences, engineering, and social sciences. Participation was voluntary.

3. Results

3.1 Autonomy and Emotionality

Table 5 shows the numbers of respondents for assumed degrees and levels of autonomy and emotional capacity of each robot type. Then, to compare between the countries on the assumed degrees of autonomy and levels of emotional capacity of each robot type, correspondence analysis was performed for six cross tables shown in table 5.

Autonomy

		RT1	RT2	RT3	RT4	RT5	RT6	RT7
Japan	1. Complete	44	100	38	106	26	14	27
	2. Partial	185	178	83	154	85	108	137
	3. None	77	20	176	35	184	170	126
Korea	1. Complete	17	23	20	39	14	6	6
	2. Partial	211	227	125	177	90	105	131
	3. None	78	55	157	83	192	181	154
USA	1. Complete	17	21	16	29	22	15	13
	2. Partial	101	107	73	86	69	61	69
	3. None	41	24	60	35	57	69	61

Emotionality

		RT1	RT2	RT3	RT4	RT5	RT6	RT7
Japan	1. Equal to Human	20	55	19	12	6	7	16
	2. Some	180	188	88	218	36	54	93
	3. None	102	52	189	62	252	228	180
Korea	1. Equal to Human	14	13	9	9	6	6	6
	2. Some	189	202	123	226	68	75	110
	3. None	101	90	166	63	221	210	175
USA	1. Equal to Human	6	16	7	7	5	5	5
	2. Some	41	62	47	85	11	19	40
	3. None	112	74	98	62	138	127	103

Table 5. The Numbers of Respondents for Assumed Degrees and Levels of Autonomy and Emotionality of Each Robot Type (RT1: Humanoid robots the size of toys or smaller, RT2: Humanoid robots between the sizes of human children and adults, RT3: Humanoid robots much taller than a person, RT4: Robots with appearances and sizes the same as animals familiar to humans, RT5: Machine-like robots for factories or workplaces, RT6: Non-humanoid robots bigger than a person, RT7: Non-humanoid robots smaller than a person)

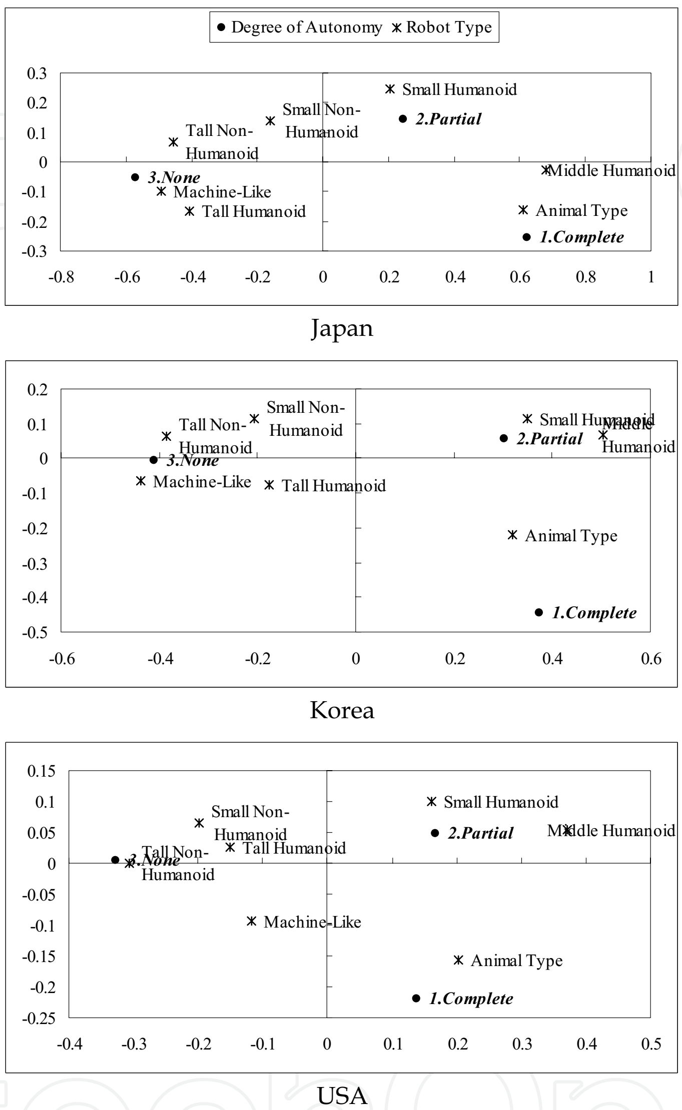


Figure 1. Results of Correspondence Analysis for Autonomy Item

Correspondence analysis allows us to visualize relationships between categories appearing in a cross table, on a 2-dimensional space. In this visualization, the categories familiar with each other are put at physically near positions. Our analysis with this method aims at clarifying what degree and level of autonomy and emotional capacity each robot is assumed to have in a specific country. On the other hand, we should note that the dimensional axes extracted from the data in a cross table are specific for the table data and are used to visualize the relative distances between categories, that is, they do not represent any absolute amount. Moreover, we should note that the axes are extracted to show the relative distances between categories arithmetically, and in general realistic meanings are hard to be assigned to these axes.

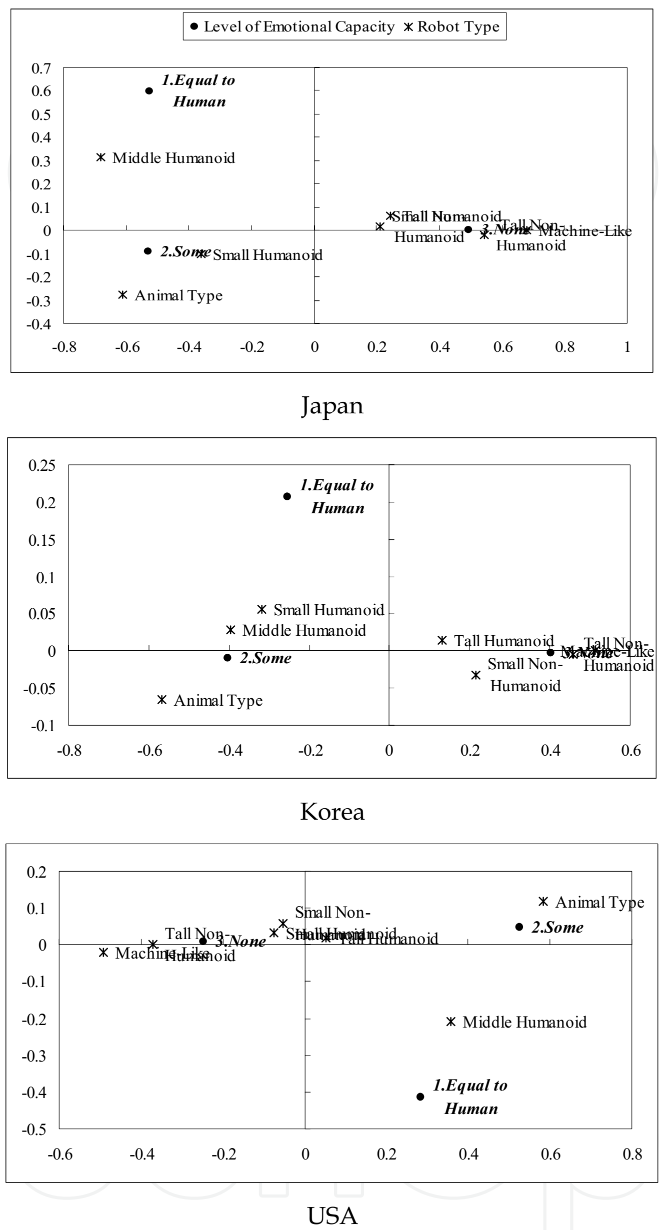


Figure 2. Results of Correspondence Analysis for Emotional Capacity Item

Fig. 1 shows the results of correspondence analysis for the cross tables on autonomy in the three countries. A common trend in all the countries was that the robot types except for "humanoid robots the size of toys or smaller," "humanoid robots between the sizes of human children and adults," and "robots with appearances and sizes the same as animals familiar to humans" were positioned near "completely controlled by humans, such as via remote controllers." Moreover, there was another common trend in all the countries that "humanoid robots the size of toys or smaller" was positioned near "self decision-making and behavior for easy tasks, and partially controlled by humans for difficult tasks," and "robots with appearances and sizes the same as animals familiar to humans" was positioned near "complete self decision-making and behavior."

On the other hand, "humanoid robots between the sizes of human children and adults" was positioned between "self decision-making and behavior for easy tasks, and partially controlled by humans for difficult tasks" and "complete self decision-making and behavior" in the Japanese samples, although it was positioned near "self decision-making and behavior for easy tasks, and partially controlled by humans for difficult tasks" in the Korean and USA samples.

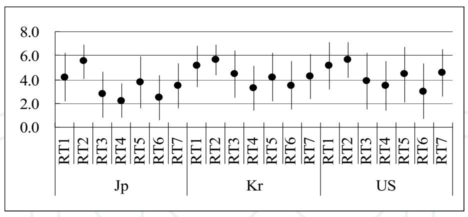
Fig. 2 shows the results of correspondence analysis for the cross tables on emotional capacity in the three countries. A common trend in Japan and Korea was that the robot types except for "humanoid robots the size of toys or smaller," "humanoid robots between the sizes of human children and adults," and "robots with appearances and sizes the same as animals familiar to humans" were positioned near "no capacity for emotion at all." Moreover, there was another common trend in these countries that "robots with appearances and sizes the same as animals familiar to humans" was positioned near "some capacity for emotion, but not as much as humans."

On the other hand, "humanoid robots between the sizes of human children and adults" was positioned between "emotional capacity equal to that of humans" and "some capacity for emotion, but not as much as humans" in the Japanese and USA samples, although it was positioned near "some capacity for emotion, but not as much as humans" in the Korean samples. Moreover, "humanoid robots the size of toys or smaller" was positioned near "some capacity for emotion, but not as much as humans" in the Japanese and Korean samples, although it was positioned near "no capacity for emotion at all" in the USA samples."

3.2 Roles and Images

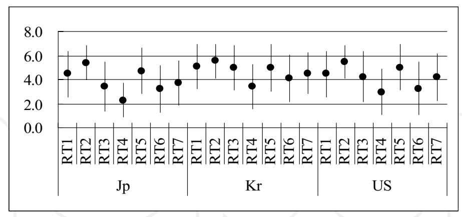
Next, to compare between the countries on the assumed degrees of roles played by and images of robots, two-way mixed ANOVAs with countries X robot type were performed for the scores of ten items of roles and seven items of images. The results revealed that there were statistically significant effects of countries in seven items of roles and five items of images, statistically significant effects of robot types in all the items of roles and images, and statistically significant interaction effects in almost all items of roles and images.

Fig. 3 shows the means and standard deviations of the role item scores related to the findings, and results of mixed ANOVAs with country and robot types, and posthoc analysis on country. As shown in the first, second, and third figures of Fig. 3, the Korean and USA students more strongly assumed housework and tasks in the office than the Japanese students. On the other hand, the posthoc analysis on each robot type revealed this difference did not appear in human-size humanoids. As shown in the fourth and fifth figures of Fig. 3, the Korean students more strongly assumed tasks related to life-and-death situations in hospitals than the Japanese and USA students. Moreover, the USA students did not assume tasks related to nursing, social works, and educations as much as the Korean and Japanese students. The posthoc analysis on each robot type revealed that this difference appeared in small-size humanoids and pet-type robots.



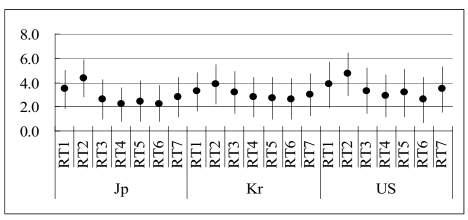
Role 1. Housework

Country:	$F(2, 585) = 41.858$***
Robot Type:	$F(6, 3510) = 186.615$***
Interaction:	$F(12, 3510) = 6.625$***
Posthoc:	USA, Kr > Jp



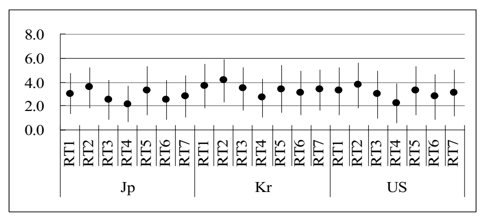
Role 3. Physical tasks in the office

Country:	$F(2, 583) = 22.553$***
Robot Type:	$F(6, 3498) = 177.456$***
Interaction:	$F(12, 3498) = 6.244$***
Posthoc:	Kr > USA > Jp



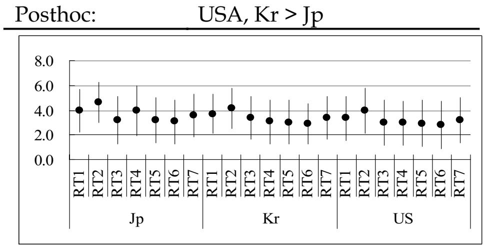
Role 4. Intelligent tasks in the office

Country:	$F(2, 580) = 11.475$***
Robot Type:	$F(6, 3480) = 116.845$***
Interaction:	$F(12, 3480) = 5.559$***
Posthoc:	USA, Kr > Jp



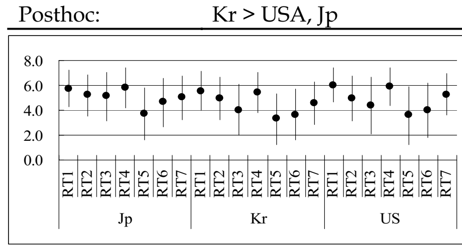
Role 5. Tasks related to life-and-death situations in hospitals

Country:	$F(2, 581) = 16.854$***
Robot Type:	$F(6, 3504) = 56.633$***
Interaction:	$F(12, 3504) = 2.003$*
Posthoc:	Kr > USA, Jp



Role 6. Tasks related to nursing, social works, and education

Country:	$F(2, 584) = 8.176$***
Robot Type:	$F(6, 3504) = 55,304$***
Interaction:	$F(12, 3504) = 3.472$***
Posthoc:	Jp, Kr > USA



Role 8. Toys in the home or amusement parks

Country:	$F(2, 582) = 12.552$***
Robot Type:	$F(6, 3492) = 152.0353$***
Interaction:	$F(12, 3492) = 5.061$***
Posthoc:	Jp, USA > Kr

(*$p < .05$, ** $p < .01$, *** $p < .001$)

Figure 3. Means and Standard Deviations of the 1st, 3rd, 4th, 5th, 6th, and 8th Role Item Scores, and Results of Mixed ANOVAs, and Posthoc Analysis on Country (RT1: Humanoid robots the size of toys or smaller, RT2: Humanoid robots between the sizes of human children and adults, RT3: Humanoid robots much taller than a person, RT4: Robots with appearances and sizes the same as animals familiar to humans, RT5: Machine-like robots for factories or workplaces, RT6: Non-humanoid robots bigger than a person, RT7: Non-humanoid robots smaller than a person)

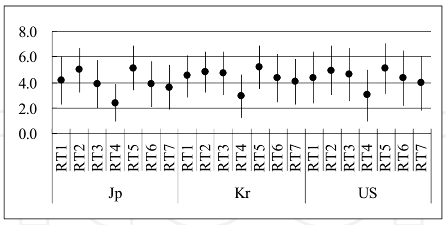


Image 3. A cause of anxiety in society

Country:	$F(2, 588) = 4.798^{**}$
Robot Type:	$F(6, 3528) = 158.986^{***}$
Interaction:	$F(12, 3528) = 5.697^{***}$
Posthoc:	Kr, USA > Jp

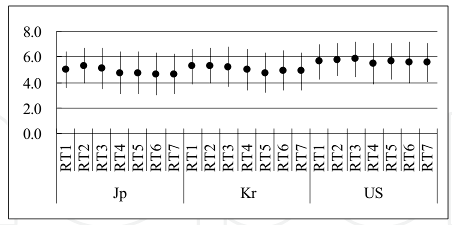


Image 4. Very interesting scientific and technological products

Country:	$F(2, 582) = 22.056^{***}$
Robot Type:	$F(6, 3492) = 12.919^{***}$
Interaction:	$F(12, 3492) = 2.623^{**}$
Posthoc:	USA > Kr, Jp

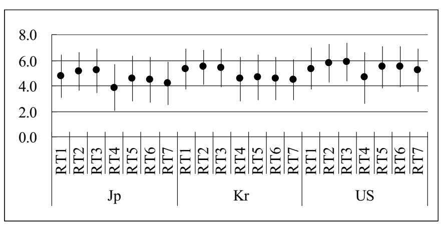


Image 5. A technology requiring careful management

Country:	$F(2, 581) = 21.804^{***}$
Robot Type:	$F(6, 3486) = 60.640^{***}$
Interaction:	$F(12, 3486) = 3.633^{**}$
Posthoc:	USA > Kr > Jp

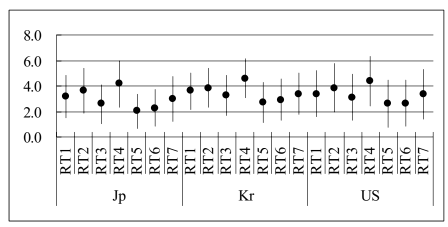


Image 6. Friends of human beings

Country:	$F(2, 587) = 7.999^{***}$
Robot Type:	$F(6, 3522) = 159.658^{***}$
Interaction:	$F(12; 3522) = 1.589$
Posthoc:	Kr, USA > Jp

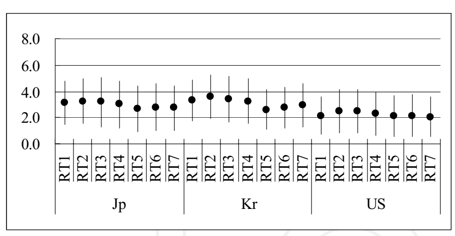


Image 7. A blasphemous of nature

Country:	$F(2, 587) = 19.054^{***}$
Robot Type:	$F(6, 3522) = 26.291^{***}$
Interaction:	$F(12, 3522) = 1.999^{*}$
Posthoc:	Jp, Kr > USA

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

Figure 4. Means and Standard Deviations of the 3rd, 4th, 5th, 6th, and 7th Image Item Scores, and Results of Mixed ANOVAs, and Posthoc Analysis on Country

As shown in the sixth figure of Fig. 3, the Japanese and USA students more strongly assumed toys in the home or at amusement parks than the Korean students. The posthoc analysis on each robot type revealed that this difference also did not appear in human-size humanoids. On the other hand, there was no difference between the countries for tasks hard for humans to do and tasks in space, the deep sea, and battle field (Role 9: country $F(2, 575) = 2.779$ (*n.s.*), robot type $F(6, 3450) = 169.792$ ($p < .001$), interaction $F(12, 3450) = 1.520$ (*n.s.*), Role 10: country $F(2, 582) = .436$ (*n.s.*), robot type $F(6, 3492) = 121.688$ ($p < .001$), interaction $F(12, 3492) = 2.199$ ($p < .01$)).

Fig. 4 shows the means and standard deviations of the image item scores related to the findings, and results of mixed ANOVAs with country and robot types, and posthoc analysis on country. As shown in the first and third figures of Fig. 4, the Korean students had more negative images of robots such as cause of anxiety in society, than the Japanese students. On the other hand, as shown in the fourth figure of Fig. 4, they also had more positive image such as friends of humans than the Japanese students.

As shown in the second, fourth, and fifth figures of Fig. 4, the USA students had more positive images such as friends of humans and interesting technology, and less negative images such as a blasphemous of nature, than the Japanese students. As shown in the first and third figures of Fig. 4, however, the USA students also more strongly assumed that robotics technology may cause anxiety in society and requires careful management, than the Japanese students.

4. Discussion

4.1 Findings

The results of the cross-cultural research imply several differences on robot assumptions between Japan, Korea, and the USA.

First, the results of section 3.1 show that the students in the three countries commonly did not assume autonomy and emotional capacity of the robots except for small humanoids, human-size humanoids, and pet-type robots. Moreover, they show that the Japanese students assumed higher autonomy of human-size humanoids than the Korean and USA students, and the Japanese and USA students assumed higher emotional capacity of human-size humanoids than the Korean students, although the USA students did not assume emotional capacity of small-size humanoids as well as the Japanese and Korean students. These facts imply that the Japanese students more strongly assume characteristics similar to humans in human-size humanoids than the Korean and USA students.

Second, the results in section 3.2 shows that the Korean and USA students more strongly assumed housework and tasks in the office than the Japanese students, although this difference did not appear in human-size humanoids. The Korean students more strongly assumed tasks related to life-and-death situations in hospitals than the Japanese and USA students. Moreover, the USA students did not assume tasks related to nursing, social works, and educations as much as the Korean and Japanese students, and this difference appeared in small-size humanoids and pet-type robots. In addition, the Japanese and USA students more strongly assumed toys in the home or at amusement parks than the Korean students, although this difference also did not appear in human-size humanoids. On the other hand, there was no difference between the countries for tasks that are hard for humans to do and tasks in space, the deep sea, and battlefield. These imply that there are more detailed cultural differences of robot assumptions related to daily-life fields.

Third, the Korean students had more negative images of robots such as cause of anxiety in society, than the Japanese students. On the other hand, they also had more positive images such as friends of humans than the Japanese students. The USA students had more positive images such as friends of humans and interesting technology, and less negative images such as a blasphemous of nature, than the Japanese students, although the USA students also more strongly assumed that robotics technology may cause anxiety in society and requires careful management, than the Japanese students. These imply that the Korean and USA students have more ambivalent images of robots than the Japanese students, and the Japanese students do not have as either positive or negative images of robots as the Korean and USA students.

4.2 Engineering Implications

We believe that the investigation of cultural difference will greatly contribute to design of robots.

Our implications on autonomy, emotional capacity, and roles of robots suggest that cultural differences may not be as critical a factor in applications of robots to non-daily life fields such as hazardous locations; however, we should consider degrees of autonomy and emotional capacity of robots in their applications to daily-life fields such as home and schools, dependent on nations where they are applied. For example, even if the Japanese and Korean students may commonly expect robotics application to tasks related to nursing, social works, and education, the autonomy and emotional capacity of robots should be modified in each country since there may be a difference on assumed degree and level of these characteristics.

Moreover, our implications on images of robots are inconsistent with some discourses that the Japanese like robots more than the other cultures, and that people in the USA and European countries do not like robots, due to the difference of religious backgrounds or beliefs (Yamamoto, 1983). Thus, we should not straightforwardly adopt general discourses of cultural differences on robots when considering daily-life applications of robots.

4.3 Limitations

First, sampling of respondents in each country is biased due to the limited number of universities involved in the study. Moreover, we did not deal with differences between ages such as Nomura et al., (2007) found in the Japanese visitors of a robot exhibition. Thus, the above implications may not straightforwardly be generalized as the complete comparison between these countries. The future research should extend the range of sampling.

Second, we did not define “culture” in the research. Gould et. al., (2000) used the cultural dimensions proposed by Hofstede (1991) to characterize Malaysia and the USA, and then performed comparative analysis on WEB site design. “Culture” in our research means just geographical discrimination, and it was not investigated which cultural characteristics individual respondents were constrained with based on specific determinants such as ones presented in social science literatures. The future research should include demographic variables measuring individual cultural characteristics.

Third, we did not put any presupposition since it was a preliminary research on cross-cultural research on robots. Although our results found an inconsistent implication with general discourses about the differences between Japan and the Western nations, as mentioned in the previous section, it is not clear whether the implication can be sufficient disproof for the discourses. Kaplan (2004) focused on humanoid robots and argued the cultural differences between the Western and Eastern people including Japan. His arguments lie on the epistemological differences between these nations about relationships of technological products with the nature. It should be sufficiently discussed what the difference between the Japan and the USA on reactions toward robot image item "a blasphemous of nature" in our research presents, based on theories on relationships between cultures and technologies, including Kaplan's arguments.

5. Conclusions

To investigate in different cultures what people assume when they encounter the word "robots," from not only a psychological perspective but also an engineering one including such aspects as design and marketing of robotics for daily-life applications, cross-cultural research was conducted using the Robot Assumptions Questionnaire, which was administered to university students in Japan, Korea, and the USA.
As a result, it was found that:

1. the Japanese students more strongly assume autonomy and emotional capacity of human-size humanoid robots than the Korean and USA students,
2. there are more detailed cultural differences of robot assumptions related to daily-life fields,
3. the Korean and USA students have more ambivalent images of robots than the Japanese students, and the Japanese students do not have as either positive or negative images of robots as the Korea and USA students.

Moreover, we provided some engineering implications on considering daily-life applications of robots, based on these cultural differences.
As future directions, we consider the extension of the sampling range such as different ages and other nations, and focus on a specific type of robot to clarify differences on assumptions about robots in more details.

6. Acknowledgments

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Human-robot interaction research is diverse and covers a wide range of topics. All aspects of human factors and robotics are within the purview of HRI research so far as they provide insight into how to improve our understanding in developing effective tools, protocols, and systems to enhance HRI. For example, a significant research effort is being devoted to designing human-robot interface that makes it easier for the people to interact with robots. HRI is an extremely active research field where new and important work is being published at a fast pace. It is neither possible nor is it our intention to cover every important work in this important research field in one volume. However, we believe that HRI as a research field has matured enough to merit a compilation of the outstanding work in the field in the form of a book. This book, which presents outstanding work from the leading HRI researchers covering a wide spectrum of topics, is an effort to capture and present some of the important contributions in HRI in one volume. We hope that this book will benefit both experts and novice and provide a thorough understanding of the exciting field of HRI.