

Cross-cultural Affective Evaluation of Kawaii Robots in Virtual Spaces

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Abstract. In modern society, robots have been increasingly involved in human lives in various scenarios. As a future society with human-robot interaction is approaching, it is important to consider how to develop robots that give positive impressions for a variety of users. Based on an Affective Engineering approach, affective values can strengthen the impact of the first impressions of products. Kawaii-ness is one affective value that can be a key factor in developing robots with positive impressions. In this research, we carried out a collaborative project to design and develop kawaii robot prototypes in virtual spaces by American and Japanese university students. We then performed an experiment on affective evaluation of those robots using 10 adjectives: kawaii/cute, approachable, scary, trustworthy, cool, beautiful, polite, comfortable, and soft. We previously presented our statistical analysis results for the adjective “kawaii/cute.” However, the results of other adjectives, which potentially have effects on the robot impression, have not been presented yet. Therefore, in this paper, we present our further analysis of several adjectives to clarify their relationship with kawaii/cute and robot features across genders and cultures. In addition, we statistically analyzed the effects of robot pairs, adjectives, genders, and cultures. The results suggest that robots with features such as more animal-like, rounder, and shorter tend to increase positive impressions such as kawaii, approachability, beauty, comfortable, and softness. Also, we found no difference across gender and culture for the impressions on kawaii robots, which shows the possibility of expanding the concept of kawaii robots worldwide.

Keywords: Kawaii, Robot, Virtual Space, Cross-culture.

1 Introduction

1.1 Motivation

In modern society, robots have been increasingly involved in human lives. Advancements in technology have been applied to robot development which enables them to effectively support human tasks in various scenarios, for example, service robots in public spots, companion robots for children and the elderly, and so on [1]. Because a future society with human-robot interaction is approaching, it is necessary to further develop robots so they give positive impressions to humans [2-3].

Based on the Affective Engineering approach, affective values can strengthen the impact of the first impressions of products and services [4]. Kawaiiiness is one affective value that denotes such positive connotations as cute, lovable, and charming, and plays a critical role in the worldwide success of many products such as Hello Kitty and Pokemon [5-6]. Based on this success, we believe that kawaiiiness will be a key factor for future product development.

Previous studies have examined the attributes that contribute to kawaiiiness: shape, size, color, texture, and tactile sensation, for example [7]. By employing these kawaii attributes to robot designs, we expected to improve human's impressions of robots by enabling robots to give more positive effect in human-robot interaction.

As kawaii products are increasingly popular not only in Japan but also worldwide, it will be useful to investigate people's preferences for kawaiiiness by taking into account the diversity by nationalities, genders, and even individuals [8]. Various factors might impact the shifting of understanding and impression in kawaii products. Revealing the diversity of kawaii preferences will be useful to design future kawaii robots that provide emotional fulfilment for a variety of users.

1.2 Background of Our Study on Cross-Cultural Design of Kawaii Robots in Virtual Spaces

We carried out a collaborative project between Shibaura Institute of Technology and DePauw University to design and develop kawaii robots in virtual spaces [9]. The students from both universities were divided into two teams. Each team was comprised of four students, two from each university. Each team designed and developed a virtual space and four robot pairs. Each robot pair was designed based on the requirement that one robot in the pair was more kawaii than the other one by changing one physical attribute. Unity was used as a development platform.

Team A designed and developed four robot pairs in a university (using the Toyosu campus of Shibaura Institute of Technology as a model) as shown in Fig. 1. Team B designed and developed four robot pairs in a train station as shown in Fig. 2. For all figures, more-kawaii robots are shown on the left side and less-kawaii ones are shown on the right side.

Using these robots, we further performed a formal cross-cultural study to evaluate the impressions toward the robots by Japanese and American students. We compared our experimental results across cultures and genders and found no significant difference in the perception of "kawaii" across cultures or genders [10]. In addition to "ka-

waii”, we evaluated the impressions using adjectives such as approachable, scary, cool, etc. However, the analysis of those adjectives have not been presented yet. Therefore, this paper presents our extended analysis from our previous study [10]. Our goal is to evaluate the impressions that the students have toward the kawaii robots and compare the similarities and differences of the impressions across cultures and genders.

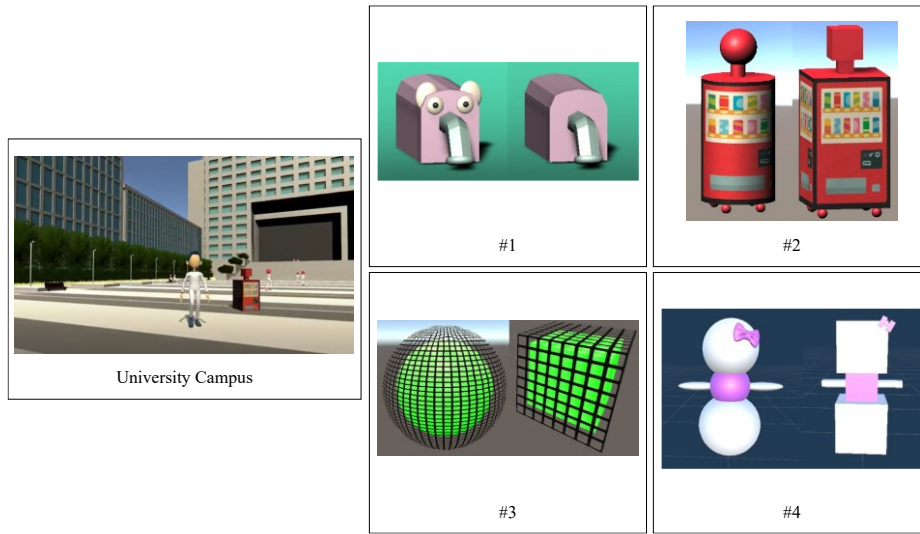


Fig. 1. Robot pairs #1 to #4 in university campus.



Fig. 2. Robot pairs #5 to #8 in train station.

2 Evaluation Method

2.1 Robot Pairs

We employed the 8 robot pairs designed and developed during the collaborative project as described in Section 1.2 [9]. For each robot pair, a short video with a length of approximately 15 seconds was created. The videos show the robot pairs side by side with some movements and audio associated with each pair.

2.2 Questionnaire

We created a questionnaire for the evaluation of robot impression. We first asked the students who collaborated in the design and development of the robots to select the adjectives that they considered related to their own robot pairs. Then, we selected the common adjectives that can be used for all robot pairs to be included in the questionnaire of the formal study. The 10 selected adjectives consist of kawaii, cute, approachable, scary, trustworthy, cool, beautiful, polite, comfortable, and soft.

For the evaluation of each robot pair, the participants were asked to compare the left and right robots in the video, and then choosing one of the following five choices with regard to each of the adjectives:

1. The left robot is much more (approachable) than the right robot.
2. The left robot is somewhat more (approachable) than the right robot.
3. The left robot and the right robot have about the same level of (approachableness).
4. The left robot is somewhat less (approachable) than the right robot.
5. The left robot is much less (approachable) than the right robot.

Note that the same question is repeated for all 10 selected adjectives and for all robot pairs by changing only the adjective inside the bracket in the choices above.

For the purpose of analysis, we reduced the choices into 3 groups to simplify the evaluation into left-neutral-right tendency as follows:

1. Choices 1 and 2: The left robot is more (approachable) than the right robot.
2. Choice 3: The left robot and the right robot have about the same level of (approachableness).
3. Choices 4 and 5: The left robot is less (approachable) than the right robot.

2.3 Evaluation Procedure

We performed an experiment to evaluate the robot pairs using the questionnaire described in the previous section. We used English and Japanese questionnaires for the participants in the United States and Japan, respectively. The questionnaire was created using Google Forms with embedded robot videos, followed by the questions for the impression evaluation with respect to the 10 adjectives. The experiment for this research was approved by the Institutional Review Board.

The experimental procedure is described as follows:

1. Participant agrees to the online informed consent and reads the instruction.
2. Participant responds to general questions including age, gender, and familiarity with “kawaii.”
3. Participant watches videos of a robot pair and evaluates their impressions by 10 questions for the 10 adjectives.
4. Step 3 is repeated for the other 7 robots.

3 Evaluation Results

3.1 Participants

We recruited a total of 81 volunteer participants who are students in the age range from 18 to 24 years old. There were 40 participants from Japan (20 males and 20 females) and 41 participants from the United States (20 males and 21 females).

3.2 Results

Robot Impression for All Participants. We previously reported our statistical analysis result for “kawaii” and “cute” impressions, which employed a chi-square test of independence to compare the impression of kawaii and cute between each robot pair [10]. Our results suggested that more animal-like, rounder, shorter, and smaller robot designs increase the impressions of kawaii and cute. According to this result, we found that two robot pairs (#7 and #8 in Fig. 2) have ambiguous tendencies of impression in terms of kawaii/cute. Therefore, we excluded them from the further analysis result presented in this paper.

Next, we continue to analyze the impression evaluation by the adjectives other than kawaii/cute, as shown in Table 1 for approachable, beautiful, comfortable, and soft, and Table 2 for scary, trustworthy, cool, and polite.

For each robot pair, we show the robot pair number corresponding to their labels in Figs. 1 and 2, along with the different physical attribute between left and right robots. For example, the robot pair #A1 differs by the shape, in which the left robot has round shape and the right robot has square shape. Next, for each robot pair and each adjective, the 3 consecutive numbers show the rating tendency among 3 questionnaire choices, as previously described in Section 2.2, for that adjective. The left number indicates the number of participants who selected choices 1 and 2, meaning that the left robot has stronger impression than the right robot for that adjective, and vice versa for the right number. The middle number indicates the number of participants who selected choice 3, which means the left and right robots have about the same level of impression for that adjective. For example, for the “approachable” impression of robot pair #A1, the majority of participants (N=55) rated the left robot (round shape) as more approachable than the right robot (square). Under the 3 numbers, we also indicate the physical attribute with a significant stronger impression or “same” in case the left robot and the right robot have about the same level for each of the adjectives for the ease of overall comparison.

Table 1. Impression evaluation results between left vs. right robots for all participants (N=81) for approachable, beautiful, comfortable, and soft as evaluation adjectives.

Robot Pair	Approachable	Beautiful	Comfortable	Soft
#1: Vacuum trash removal robots	60-8-13**	18-41-22	44-23-14**	52-21-8**
Face vs. No face	Face	Same	Face	Face
#2: Vending machine robots	43-29-9**	44-28-9**	44-30-7**	65-14-2**
Round vs. Square	Round	Round	Round	Round
#3: Floating tour guide robots	34-34-13**	39-27-15**	35-35-11**	58-18-5**
Round vs. Square	Round	Round	Round	Round
#4: Companion robots	45-25-11**	50-19-12**	45-20-16**	67-9-5**
Round vs. Square	Round	Round	Round	Round
#5: Floor cleaning robots	55-20-6**	48-28-5**	57-19-5**	73-7-1**
Round vs. Square	Round	Round	Round	Round
#6: Information kiosk robots	52-11-18**	12-39-30**	54-17-10**	41-30-10**
Short vs. Tall	Short	Tall	Short	Short

** : Adjective with significant relationship among 3 questionnaire choices ($p < 0.001$).

Table 2. Impression evaluation results between left vs. right robots for all participants (N=81) for scary, trustworthy, cool, and polite as evaluation adjectives.

Robot Pair	Scary	Trustworthy	Cool	Polite
#1: Vacuum trash removal robots	23-27-31	31-32-18	20-25-36	19-45-17**
Face vs. No face	-	-	-	Same
#2: Vending machine robots	8-45-28**	18-46-17**	13-31-37**	22-51-8**
Round vs. Square	Square	Same	Square	Same
#3: Floating tour guide robots	9-44-28**	16-41-24**	23-21-37	18-53-10**
Round vs. Square	Square	Same	-	Same
#4: Companion robots	12-48-21**	15-52-14**	18-22-41**	18-53-10**
Round vs. Square	Square	Same	Square	Same
#5: Floor cleaning robots	8-41-32**	16-44-21**	25-28-28	17-47-17**
Round vs. Square	Square	Same	-	Same
#6: Information kiosk robots	13-28-40**	21-46-4**	7-30-44**	14-56-11**
Short vs. Tall	Tall	Same	Tall	Same

** : Adjective with significant relationship among 3 questionnaire choices ($p < 0.001$).

From the results shown in Tables 1 and 2, we obtained the following findings:

- The results are consistent for rounder robots (#2, #3, #4, #5) that they give stronger impression of approachability, beauty, comfort, and softness.
- More animal-like robot (#1) and shorter robot (#6) give stronger impression of approachability, comfort, and softness. However, having animal-like feature or not does not give any difference for the impression of beauty.
- Taller robot (#6) has strong impression of beauty, scary, and cool.

- The results are consistent for more square-shaped robots (#2, #3, #4, #5) that they give stronger impression of scariness. Some of these robots (#3, #4) also give stronger impression of coolness.
- The impressions of trustworthiness and politeness tend to be the same or inconclusive for some robot pairs.

Within- and Between-subject Effects on Impression. To analyze the effects of related factors on robot impression, we performed a mixed-design analysis of variance (mixed ANOVA) followed by post-hoc analysis using the pairwise comparison for the effect corrected with a Bonferroni adjustment.

For the independent variables, we used 4 factors divided into within-subject and between-subject factors as follows:

- Within-subject factors (independent variables)
 - Robot pairs: 6 selected robot pairs
 - Adjectives: 10 adjectives
- Between-subject factors (independent variables)
 - Genders: males vs. females (2 levels)
 - Cultures: Japanese vs. American (2 levels)

For the dependent variable, we used the rating score of each adjective and each robot pair. The rating scores were calculated from the questionnaire results with 5 choices. First, we unified the left-right order of each robot pair so that the less-kawaii robot was always set on the left side and vice versa. Therefore, the questionnaire result can be interpreted as follows:

- A rating score of 1 indicates that the less-kawaii (left) robot is highly rated for that adjective.
- A rating score of 5 indicates that the more-kawaii (right) robot is highly rated for that adjective.

Within-subject Effects. We obtained the mixed ANOVA result for within-subject effects of robot pairs, adjectives, and their interactions as shown in Tables 3, 4, and 5, respectively. The detailed results are described in the following paragraphs.

From Table 3, the result shows that there is a significant main effect of robot pair ($p < 0.01$) but no effect for its interaction with gender or culture. This effect indicates that some robot pairs were rated significantly differently from others. From Fig. 3, the post-hoc analysis of the main effect shows that the effect of robot pair reflects on a significantly higher rating score of robot pair #5 than that of #6 ($p < 0.05$).

From Table 4, the result shows that there is a significant main effect of adjective ($p < 0.001$) and its interaction with culture ($p < 0.001$). These effects indicate that some adjectives were rated significantly differently from others. From Fig. 4, the post-hoc analysis of the main effect shows that most pairs of adjectives have significantly different rating scores. There are only 4 pairs with no significant difference in rating scores: kawaii/cute vs. approachable, approachable vs. comfortable, scary vs. cool, and trustworthy vs. polite, as shown in the pairwise comparison table next to the bar

chart in Fig. 4. Also, the interaction effect between adjective and culture indicates that the participants with different cultures respond differently to some adjectives. As shown in Fig. 5, average rating scores are different for some adjectives such as cool and beautiful, in which the American students rated higher than the Japanese ones did.

From Table 5, the result shows that there is a significant interaction effect between the two within-subject factors (i.e., robot pair vs. adjective) ($p < 0.001$). This interaction effect indicates that some combinations of robot pair and adjective were rated significantly differently from others, as illustrated by the radar charts for representing the impressions by adjectives that they have certain differences in shapes (Fig. 6). On the other hand, we did not observe any interaction effects with gender and culture.

Between-subject Effects. From the mixed ANOVA result for between-subject effects, we did not obtain any effects from gender or culture, and their interaction (Table 6).

Table 3. Tests of within-subject effects of robot pairs.

Variable	Type III SS	df	MS	F	Sig.
Robot pair	43.729	5.000	8.746	3.245	0.007
Robot pair x Gender	15.237	5.000	3.047	1.131	0.343
Robot pair x Culture	20.849	5.000	4.170	1.547	0.174
Robot pair x Gender x Culture	13.287	5.000	2.657	0.986	0.426

Table 4. Tests of within-subject effects of adjectives.

Variable	Type III SS	df	MS	F	Sig.
Adjective	856.370	4.906	174.567	96.531	0.000
Adjective x Gender	17.886	4.906	3.646	2.016	0.077
Adjective x Culture	65.321	4.906	13.315	7.363	0.000
Adjective x Gender x Culture	7.128	4.906	1.453	0.804	0.546

Table 5. Tests of within-subject effects of interaction between robot pairs and adjectives.

Variable	Type III SS	df	MS	F	Sig.
Robot pair x Adjective	140.425	18.689	7.514	4.402	0.000
Robot pair x Adjective x Gender	24.013	18.689	1.285	0.753	0.763
Robot pair x Adjective x Culture	41.570	18.689	2.224	1.303	0.172
Robot pair x Adjective x Gender x Culture	43.734	18.689	2.340	1.371	0.133

Table 6. Tests of between-subject effects of gender, culture, and their interaction.

Variable	Type III SS	df	MS	F	Sig.
Gender	11.568	1	11.568	2.525	0.116
Culture	9.319	1	9.319	2.034	0.158
Gender x Culture	1.291	1	1.291	0.282	0.597

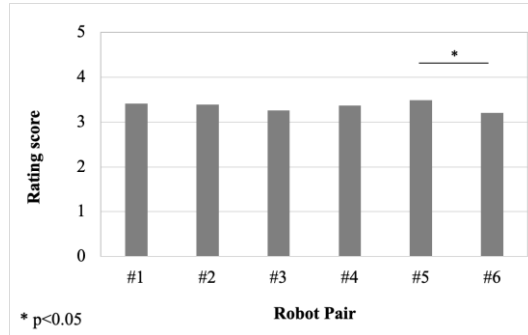


Fig. 3. Comparison of the main effect of robot pair.

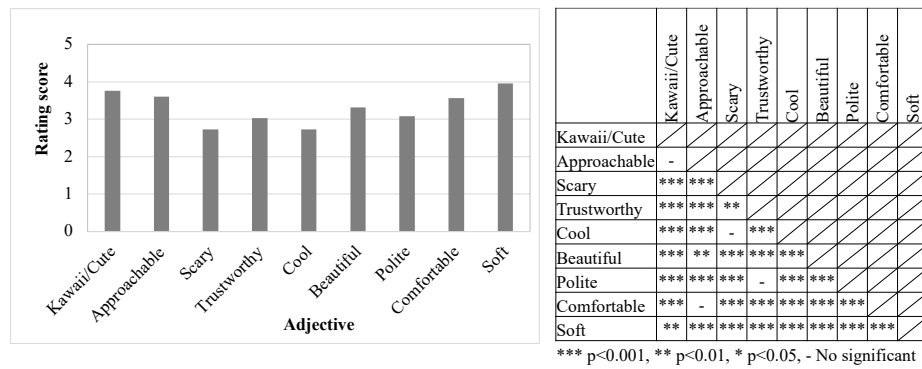


Fig. 4. Comparison of the main effect of adjective.

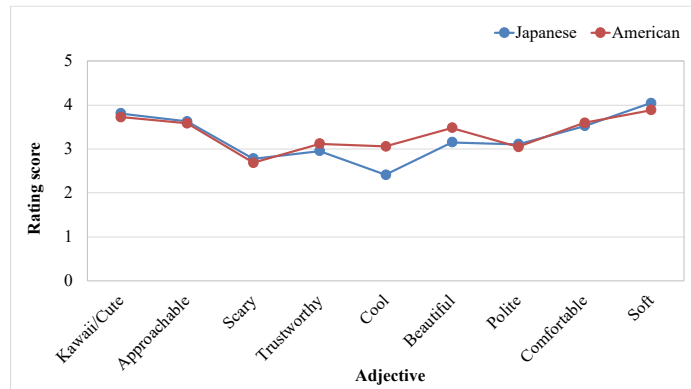


Fig. 5. Comparison of the interaction effect between adjective and culture.

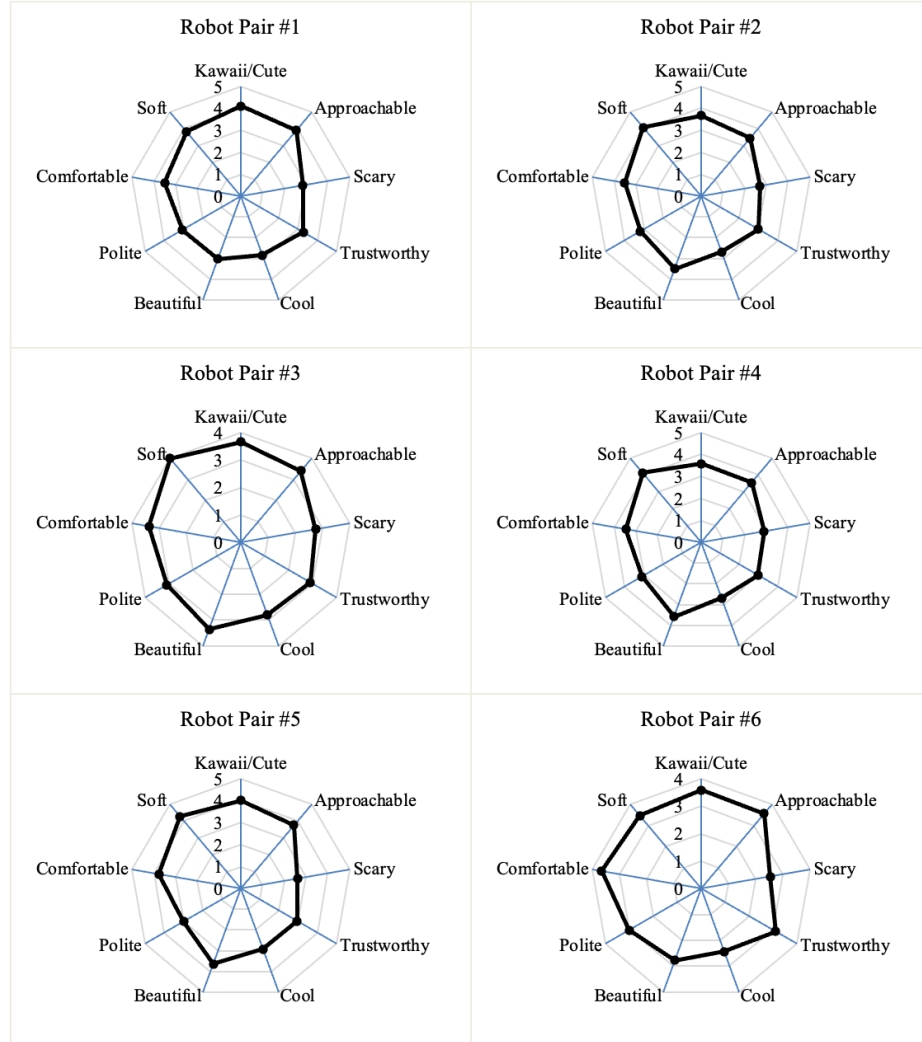


Fig. 6. Comparison of the interaction effect between robot pair and adjective.

4 Discussion

From the analysis of robot impression for all participants, we obtained a similar tendency for the impression of “approachable,” “beautiful,” “comfortable,” and “soft” from the robots with rounder, shorter, and more animal-like (Table 1). This result resembles “kawaii” that more animal-like, rounder, shorter, and smaller robots increase the impression that the robot is kawaii/cute [10]. Thus, the similarities of the results suggest that kawaii robots can potentially increase several positive impressions such as approachability, beauty, comfort, and softness.

On the other hand, we obtained similar tendency for the impression of “scary” and “cool” from more square-shaped and taller robots (Table 2). The result shows the opposite tendency to the impression of robot with kawaii features described in the previous paragraph. Furthermore, we obtained the same or inconclusive tendency for the impression of “trustworthy” and “polite,” which is reasonable because the participants only watched the robot videos in virtual space, but they did not personally interact with the robots. Therefore, the impression of trustworthiness and politeness might be unclear, making the evaluation difficult.

For the analysis of within-subject effects on impression, we found that the robot pairs (Table 3), the adjectives (Table 4), and their interactions (Table 5) have effects on the impression. This is strong evidence to show that not all kawaii robots have the same impressions.

Interestingly, for the analysis result of between-subject effects on impression, we did not obtain any effects for gender or culture (Table 6), which suggests that there is no difference between males and females or between Japanese and American participants for the impressions on kawaii robots. The result indicates that kawaii may be used as a concept to design and develop robots to will be more acceptable worldwide regardless of gender or culture.

5 Conclusion

In modern society, robots have been increasingly involved in human lives. As we are expecting a future society with more human-robot interaction, it is necessary to further develop robots that give positive impressions to humans. Our research focuses on adopting a Japanese cultural trait, kawaii, to design robots that give more positive impressions. Through our collaborative project with students in Japan and the United States, we designed the robots and evaluated several impressions in order to identify robot features that give positive impressions.

Our previous paper introduced an interesting result from the impression evaluation for “kawaii” [10]. In this paper, we continued to present the impression evaluation result using several adjectives. As a result, we found that the impression of “approachable,” “beautiful,” “comfortable,” and “soft” are similar for rounder, shorter, and more animal-like robots. These robot features also resemble our result for “kawaii,” indicating that these robots with kawaii features can increase positive impressions. Also, we found no difference across gender and culture for the impressions on kawaii robots, which shows the possibility of expanding the concept of kawaii robots worldwide.

For this research, we used the questionnaire for impression evaluation. Our future work will employ quantitative measurement such as biological signals which can evaluate the kawaiiiness of robots more clearly with quantitative results. The results will contribute to the design of kawaii robots that give positive impression to people.

Acknowledgment

This material is based upon work supported by the National Science Foundation under Grant No. OISE-1854255. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation. We thank faculty members at Shibaura Institute of Technology and the University of Tokyo for helping arrange for Japanese students to complete the study. Specifically, we thank professors Y. Ito, H. Manabe, and K. Hidaka from Shibaura Institute of Technology and professor Y. Tsuji from the University of Tokyo.

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