Cross-cultural Design and Evaluation of Robot Prototypes based on Kawaii (Cute) Attributes

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Abstract. We report on a cross-cultural collaborative project between students and faculty at DePauw University in the United States and Shibaura Institute of Technology in Japan that used cross-cultural teams to design and evaluate robotic gadgets to gain a deeper understanding of the role that kawaii (Japanese cuteness) plays in fostering positive human response to, and acceptance of, these devices across cultures. Two cross-cultural design teams used Unity and C# to design and implement prototypes of virtual robotic gadgets as well as virtual environments for the robots to interact in. One team designed a virtual train station as well as robotic gadgets to operate in the station. The other team designed a virtual university campus as well as robotic gadgets that operated in that environment. Two versions of each robotic gadget were designed, such that the two versions differed with respect to one kawaii attribute (shape, size, etc.) Using these robots, we conducted a formal study that compared perceptions of kawaii robots between American college students and Japanese college students, as well as across genders. The findings revealed that there was not much difference in perception of kawaii across cultures and genders. Furthermore, the study shows that designing a robot to be more kawaii/cute appears to positively influence human preference for being around the robot. This study will inform our long-term goal of designing robots that are appealing across gender and culture.

Keywords: Kawaii, Human-Robot Interaction, Cross-cultural Design.

1 Introduction and Motivation

1.1 Kawaii

As robots become increasingly common in daily life, it is critical that roboticists design devices that are accepted broadly, including across cultures and genders. Toward this end, global collaboration will be pivotal today and in the future. This paper reports on a cross-cultural collaboration between students and faculty at DePauw University in the United States and Shibaura Institute of Technology in Japan. We formed two cross-cultural teams to design and evaluate robotic gadgets to gain a deeper understanding of the role that kawaii (Japanese cuteness) plays in fostering positive human response to, and acceptance of, these devices across cultures.

The word, *kawaii*, is often translated into "cute," "lovely," "adorable", "cool," and sometimes other words depending on the context. There does not seem to be an exact word that can be used as a counterpart in English [1]. That's probably because Japanese people's affection for "kawaii" has been cultivated throughout Japanese history [2]. The sentiment of kawaii seems to have been present in Japanese society since 400 B.C., and the word itself started appearing around the 11th century in literary texts [3, 4]. The meaning of the word has evolved to become a cultural concept or an emotional domain that relates to something or someone lovely, or someone or something that invokes the feeling of "wanting to protect" [4]. In the modern context, the notion of kawaii is embraced as a catalyst to evoke positive feelings [5], as can be seen in designs ranging from Hello Kitty products to road signs to robotic gadgets, to name just a few examples. Kawaii has also been gaining global audiences and customers in the last two decades as well as in Japan [6] through kawaii products. As such, kawaii design principles are incorporated into successful products that are used globally including in robotic gadgets [7, 8].

1.2 Prior Work

Previous studies have examined cross-cultural differences in the acceptance of robots based on various design characteristics. For example, researchers have documented the impact of localizing a robot's greeting style (gestures and language) on acceptance by Japanese versus Egyptian users [9].

Similarly, prior studies have examined perceptions of kawaii including differences in perceptions across cultures and genders. These studies have found gender differences in preferences for various kawaii spoon designs based on shape, color and geometric pattern [10]. A broader study examined the extent to which perceptions of kawaii in 225 photographs differ between male and female Japanese college students [11]. In this study, gender differences were established, depending on the type of object photographed. For example, male subjects found spherical geometric objects to be more kawaii than female subjects [11]. The first two authors extended the original study by presenting 217 of the original 225 images to American college students and gathering data about their perceptions of kawaii-ness in each image. For some types of objects, differences in perceptions of kawaii-ness were found, particularly between Japanese

males and American males as well as between Japanese females and all other groups [12].

Prior work that investigates the role of kawaii in user perceptions and user acceptance of robots or robotic gadgets is limited. However, one pair of papers reports on studies of kawaii-ness in the motion of robotic vacuum cleaners [13, 14]. The authors programmed a visually plain version of a Roomba vacuum cleaner to move according to 24 different patterns, including patterns that the authors describe with terms such as: bounce, spiral, attack, spin and dizzy [13, 14]. The studies demonstrated that kawaii-ness can be expressed through motion, even in the absence of more traditional visual kawaii-ness; however, the studies did not consider cultural or gender differences.

2 Cross-cultural Design of Virtual Environments and Robots

2.1 Overview

Building on the prior research described in the previous section, this paper reports on work, supported by a United States National Science Foundation (NSF) International Research Experiences for Undergraduates (IRES) grant, to gain a deeper understanding of the role that kawaii plays in fostering positive human response to, and acceptance of, robotic gadgets across cultures. More information about the goals of our grant-supported project may be found in [15].

With mentorship from faculty members at Shibaura Institute of Technology and DePauw University, two cross-cultural design teams used Unity and C# to design and implement prototypes of virtual robotic gadgets as well as virtual environments for the robots to interact in.

Each design team was comprised of four students -- two students from Shibaura Institute of Technology in Tokyo and two students from DePauw University in the United States. COVID-19 prevented travel between the United States and Japan. Therefore, all collaboration was conducted virtually, using tools such as Zoom and Slack.

One of our four-person student teams designed a virtual train station and each student on the team designed a pair of robotic gadgets to operate in the station (e.g., robots to clean the floor and to give directions to travelers). The other team designed a virtual college campus and each of its team members designed a pair of robotic gadgets that operated in that environment (e.g., robots to pick up trash and to give campus tours). As shown in the next section, each student designed their pair of robotic gadgets so the two versions differed with respect in one kawaii attribute (shape, size, etc.)

A more detailed description of the design process and tools we used to support our cross-cultural collaboration are provided in [16]. In the remainder of this paper, we present the virtual environments and robotic gadgets that were designed. In addition, we report on a formal cross-cultural study that compared the perceptions of cuteness between American college students and Japanese college students, using the robotic gadgets created by the two teams described above. This study also compared perceptions of the robotic gadgets between genders. This study will inform our long-term goal of designing robots that are appealing across gender and culture.

2.2 Environment Designs

One four-person team designed a university campus as shown in Fig. 1. The video at *tinyurl.com/hcii2021campus* provides a virtual tour of the environment. The university campus served as the context for designing robotic gadgets that served as trash collectors, vending machines, tour guides and stress-reducing human companions as illustrated in Fig. 3 through Fig. 6 in Section 2.3.

Fig. 1. University campus environment that provides context for several robotic gadgets

The other four-person team designed a train station as shown in Fig. 2. The video at *tinyurl.com/hcii2021station* provides a virtual tour of the environment.

The train station served as the context for robots that cleaned floors, shared information, assisted with shopping and made announcements. These robots are illustrated in Fig. 7 through Fig 10 in section 2.3.

Fig. 2. Train station environment that provides context for several robotic gadgets

2.3 Robot Gadget Designs for University Campus

As described previously, each team member designed a pair of robots that operated in the context of one of the virtual environments. These robot pairs are presented, along with contextual information about the robots, in the remainder of this section. The first four pairs were designed to operate on the university campus and the last four pairs were designed to operate in the train station.

Fig. 3 shows the first pair of robots that are designed to operate on the university campus. The robots move around the campus and vacuum trash from the ground. The left robot is designed to be more kawaii because it includes animal features. The video at *tinyurl.com/hcii2021vacuum* shows the robot pair in action.

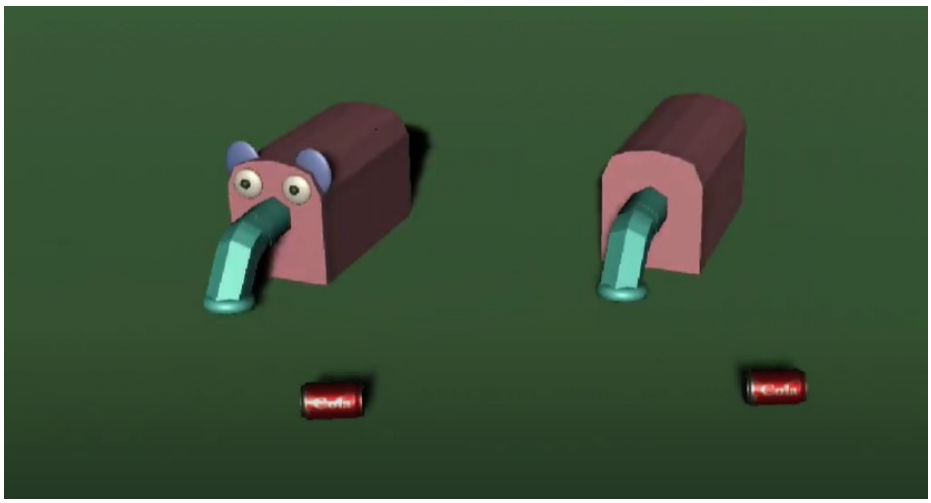

Fig. 3. Vacuum trash removal robots for the university campus

Fig. 4 shows a second pair of robots that are designed to operate on the university campus. These vending machine robots move around the campus and ask people if they would like a drink. The right robot is designed to be more kawaii because it is rounder. The video at *tinyurl.com/hcii2021drink* shows the robot pair in action.

Fig. 4. Vending machine robots for the university campus

Fig. 5 shows a third pair of robots that are designed to operate on the university campus. These tour guide robots float through the air and provide verbal information as they guide people around campus. The left robot is designed to be more kawaii because it is round. The video at *tinyurl.com/hcii2021tour* shows the robot pair in action.

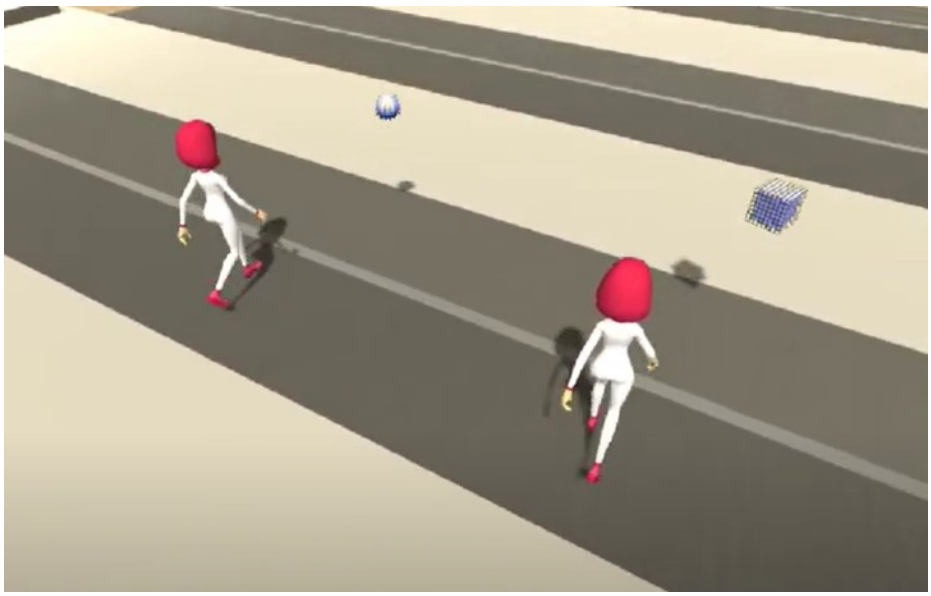

Fig. 5. Floating tour guide robots for the university campus

Fig. 6 shows the last pair of robots that are designed to operate on the university campus. These companion robots approach nearby people, like the people on the bench in

the figure, and entertain them, much like a dog or a cat might. The right robot is designed to be more kawaii because it is rounder. The video at *tinyurl.com/hcii2021companion* shows the robot pair in action.

Fig. 6. Companion robots for the university campus

2.4 Robot Designs for Train Station

Fig. 7 shows the first pair of robots that are designed to operate in the train station. These robots move around the train station and clean the floors automatically. The right robot is designed to be more kawaii because it is rounder. The video at *tinyurl.com/hcii2021floor* shows the robot pair in action.

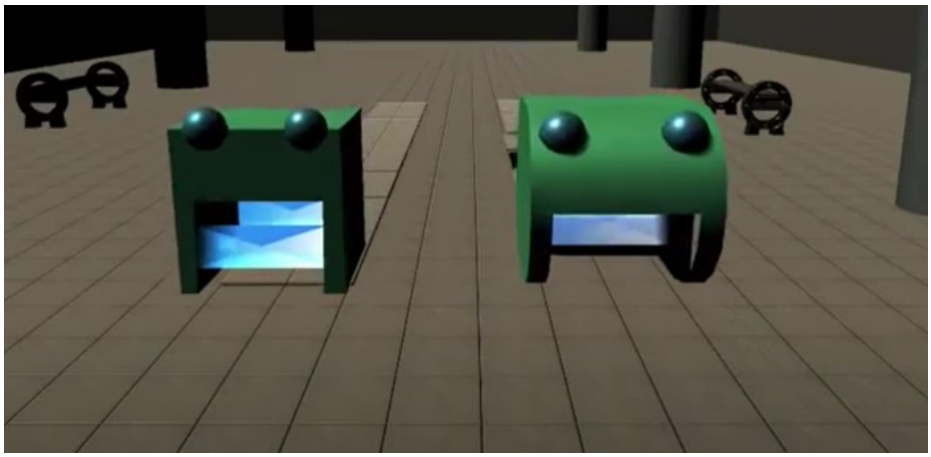

Fig. 7. Floor cleaning robots for the train station

Fig. 8 shows the second pair of robots that are designed to operate in the train station. These information kiosk robots provide passengers with information such as train schedules. The right robot is designed to be more kawaii because it is shorter. The video at *tinyurl.com/hcii2021kiosk* shows the robot pair in action.

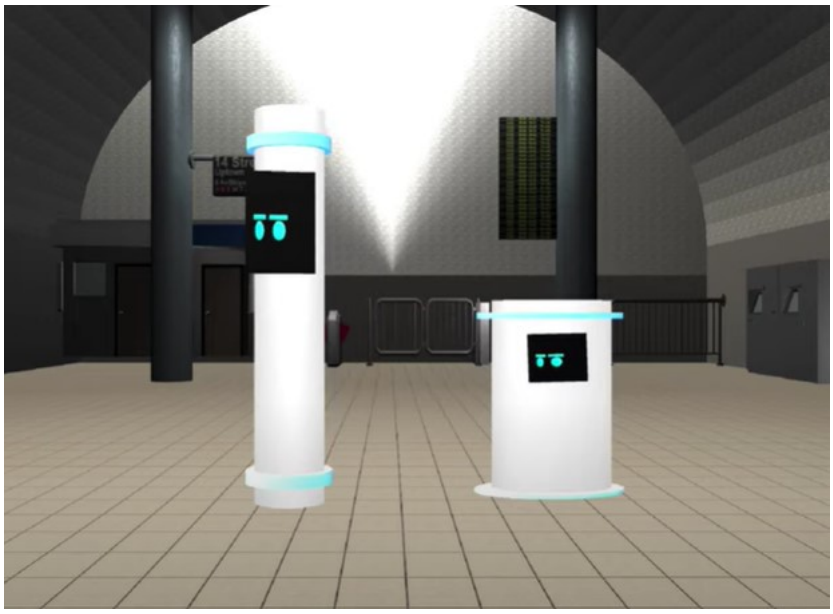

Fig. 8. Information kiosk robots for train station

Fig. 9 shows the third pair of robots that are designed to operate in the train station. The robots store the passenger's shopping packages and bring them to the train. The

right robot is designed to be more kawaii because it is softer. Although there is no visual difference between the robots, when the right robot rolls it makes a smoother sound than the left robot. The video at *tinyurl.com/hcii2021shop* demonstrates this sound.

Fig. 9. Shopping assistant robots for train station

Fig. 10 shows the last pair of robots that are designed to operate in the train station. These robots move around the train station and make announcements such as letting passengers know that trains are arriving or departing. The right robot is designed to be more kawaii because it is smaller. The video at *tinyurl.com/hcii2021announce* shows the robot pair in action.

Fig. 10. Announcement robots for the train station

3 Evaluation

3.1 Purpose of the Evaluation

We designed and administered an online survey to measure perceptions of the eight robot pairs. The survey, which was administered to Japanese and American males and females, was designed to help us answer three primary questions:

- Determine which robot from each pair the participants judge to be more kawaii/cute so we could see if commonly accepted kawaii design principles extend to our work.
- Determine whether participants prefer to be around robots that they judged to be more kawaii/cute.
- Determine whether there are any gender differences or cultural differences in the survey results.

The survey also gathered data to let us explore the participant's characterization of the robots with respect to adjectives other than kawaii/cute (e.g., scary, polite, soft). While we will touch on the results of this part of the study in the sections that follow, we will save detailed analysis of these results for future work.

3.2 Participant Demographics

After obtaining Institutional Review Board approval for the study, we recruited student participants from DePauw University (in the United States) as well as from Shibaura Institute of Technology, Chuo University, and the University of Tokyo (all in Japan). Participants had to be at least 18 years old. Because we were studying cultural differences, DePauw University students could not have lived outside of the United States for more than four months. Similarly, students from Shibaura Institute of Technology and the University of Tokyo could not have lived outside of Japan for more than four months. In effect, this limited participation to students who were fully raised in Japan or who were fully raised in the United States. Participants were also required to have a laptop or tablet to complete the survey. We did not allow participants to complete the survey on a phone because we wanted the embedded videos to be a reasonable size.

In total, 82 eligible students completed the survey. The results from one student are not included in the analysis because the student did not identify primarily as male or as female. Of the remaining 81 participants, there were 40 participants from Japan and 41 participants from the United States. There were 41 females including 20 from Japan and 21 from the United States. There were 40 males including 20 from Japan and 20 from the United States. The participants ranged in age from 18 to 24 with an average age of 21.

3.3 Study Procedure

The survey was originally developed in English and then translated to Japanese by the second author. We used the adjective, cute, for the English counterpart of "kawaii"

because it is one of the closest translations, although the interchangeableness has been argued [1]. The English version of the survey was administered to the participants from the United States and the Japanese version was administered to the participants from Japan. Each version was administered as a Google form that embedded the videos shown in Fig 3. Through Fig 10.

After accepting the conditions of an online informed consent, and confirming eligibility to participate in the survey, participants provided their age and gender. Participants then watched a sample video and confirmed that they could see the video and hear the associated audio.

Participants from the United States were asked about their familiarity with the Japanese term kawaii. Participants then watched a video (approximately 15 seconds long) of the first pair of robots (see Fig. 3) and answered twelve multiple choice questions about their perception of differences in the pair of robots. This process was repeated for a video that showed the second pair of robots (see Fig. 4) and then for subsequent videos until all eight videos had been presented.

3.4 Perceptions of Kawaii/Cute for all Participants

After watching each video, participants were asked to compare the left robot and the right robot with regard to each of the adjectives shown in Table 1.

Table 1. Adjectives that participants used to compare robot pairs.

Adjectives	
Kawaii	Cool
Cute	Beautiful
Approachable	Polite
Scary	Comfortable
Trustworthy	Soft

For each adjective, participants selected from one of five choices that compared the robot on the left side of the video to the robot on the right side of the video with respect to the adjective. For example, for the adjective “approachable”, participants selected from one of the following choices.

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.

For the purpose of the analysis presented in the remainder of this section, we collapsed responses 1 and 2 into a single category indicating that the participant found the left robot to be more approachable than the right robot. Similarly, we collapsed responses 4 and 5 into a single category indicating that the participant found the left robot to be

less approachable then the right robot. In other words, our analysis is based on the following three categories.

1. The left robot is more approachable than the right robot.
2. The left robot and the right robot have about the same level of approachableness.
3. The left robot is less approachable than the right robot.

This study is centrally concerned with the way perceptions of kawaii change when various attributes of a robot are changed. However, only 37% of the participants from the United States indicated that they had a good understanding of the Japanese word kawaii. The English word "cute" is generally considered to be a good proxy for the Japanese word kawaii. Therefore, in what follows, we compare responses from Japanese participants for the adjective kawaii to responses from American participants for the adjective cute.

We performed a series of statistical analyses with a significance level of 0.05. Table 2 shows the results of chi-square tests that compare perceptions of Kawaii/Cute for the left robot versus the right robot in each robot pair for all 81 participants. In the right column of the table, participant responses are summarized in the format x-y-z where x gives the number of participants who judged the left-robot to be more kawaii/cute, y is the number of participants who found no difference in the level of kawaii/cuteness between the two robots, and z is the number of participants who judged the right robot to be more kawaii/cute. For example, the data in the second row of the table indicates that 66 participants found the left robot (with the elephant face) to be more kawaii/cute than the right robot. On the other hand, 9 participants found no difference in the level of kawaii/cuteness while 6 participants found the right robot to be more kawaii/cute than the left robot.

The statistical analyses in Table 2 provide strong evidence that the perceptions of kawaii/cute are not equally distributed. Stronger preferences are indicated by the raw numbers for robots that were more animal-like (Fig. 3), that were rounder (Fig. 4, Fig. 5, Fig. 6, Fig. 7), that were shorter (Fig. 8), and that were smaller (Fig. 10).

The pair of robots in Fig. 9 do not have visual differences. The right robot in this pair makes a smoother sound when it moves, suggesting that the robot is softer which is typically associated with an increased perception of kawaii/cute. Approximately half of the participants, however, indicated that there was no difference in their perception of kawaii/cute between the left robot and the right robot. For those participants who did perceive a difference, more participants thought the left robot was more kawaii/cute than the right robot.

Table 2. Perceptions of kawaii/cute between left vs. right robot for all participants (N=81)

Robot Pair	Kawaii/Cute
Fig. 3 Vacuum Trash Removal Robots	Elephant face is more Kawaii/Cute
Left: Elephant face	66-9-6
Right: No face	X^2 (2, N=81) = 84.7, $p < .001$
Fig. 4 Vending Machine Robots	Round is more Kawaii/Cute
Left: Square	7-22-52
Right: Round	X^2 (2, N=81) = 38.9, $p < .001$
Fig. 5 Floating Tour Guide Robots	Round is more Kawaii/Cute
Left: Round	46-26-9
Right: Square	X^2 (2, N=81) = 25.4, $p < .001$
Fig. 6 Companion Robots	Round is more Kawaii/Cute
Left: Square	17-17-47
Right: Round	X^2 (2, N=81) = 22.2, $p < .001$
Fig. 7 Floor Cleaning Robots	Round is more Kawaii/Cute
Left: Square	7-11-63
Right: Round	X^2 (2, N=81) = 72.3, $p < .001$
Fig. 8 Information Kiosk Robots	Short is more Kawaii/Cute
Left: Tall	13-22-46
Right: Short	X^2 (2, N=81) = 21.6, $p < .001$
Fig. 9 Shopping Assistant Robots	About half selected “no difference”
Left: Harsher Sound	30-38-13
Right: Smoother Sound	X^2 (2, N=81) = 12.1, $p = .002$
Fig. 10 Announcement Robots	Small is more Kawaii/Cute
Left: Big	28-20-43
Right: Small	X^2 (2, N=81) = 20.2, $p < .001$

3.5 Perceptions of Kawaii/Cute Across Gender and Culture

To investigate gender differences and the differences that stem from cultural backgrounds, additional statistical tests were employed. A chi-square test of independence was performed to examine the relationship between gender (male vs female) of the participants and their perceptions of kawaii/cute for each of the eight robot pairs. The results show that there was no significant association between gender and how each robot pair was perceived.

Similarly, a chi-square test of independence was performed to investigate the differences in perception between two cultural backgrounds (American vs Japanese). A chi-square test of independence was performed to find the relationship between cultural background and the participants’ perceptions of kawaii/cute for each of the eight robot pairs. The result shows that the relationship between these two variables was not significant for any of the pairs.

3.6 Preferences for all Participants

After watching each robot-pair video, participants also answered a question that asked "Which robot would you prefer to be with?" Participants responded to this question by selecting one of the following three choices.

1. The left robot.
2. No preference.
3. The right robot.

Table 3 shows the results of chi-square tests that compares participant's preferences for being around the left robot versus the right robot in each robot pair for all 81 participants. In the right column of the table, participant responses are summarized in the format x-y-z where x gives the number of participants who prefer to be around the left-robot, y is the number of participants who found both robots equally preferable to be around, and z is the number of participants who preferred to be around the right robot. For example, the data in the second row of the table indicates that 45 of the participants preferred to be around the left robot (with the elephant face) as compared to the right robot. On the other hand, 20 participants had no preference for being around one robot as compared to the other while 16 participants preferred to be around the right robot.

Table 3. Preference for being around left versus right robot for all participants (N=81)

Robot Pair	**Preference to be around Left vs. Right**
Fig. 3 Vacuum Trash Removal Robots	Elephant face is preferred
Left: Elephant face	45-20-16
Right: No face	X^2 (2, N=81) = 18.5, $p < .001$
Fig. 4 Vending Machine Robots	Round is preferred
Left: Square	7-24-50
Right: Round	X^2 (2, N=81) = 35.1, $p < .001$
Fig. 5 Floating Tour Guide Robots	No significant difference
Left: Round	35-23-23
Right: Square	X^2 (2, N=81) = 3.6, $p = .165$
Fig. 6 Companion Robots	Round is preferred
Left: Square	20-14-47
Right: Round	X^2 (2, N=81) = 23.1, $p < .001$
Fig. 7 Floor Cleaning Robots	Round is preferred
Left: Square	11-20- 50
Right: Round	X^2 (2, N=81) = 31.2, $p < .001$
Fig. 8 Information Kiosk Robots	Short is preferred
Left: Tall	16-15-50
Right: Short	X^2 (2, N=81) = 29.7, $p < .001$
Fig. 9 Shopping Assistant Robots	Smoother sound is preferred
Left: Harsher Sound	29-12-40
Right: Smoother Sound	X^2 (2, N=81) = 14.9, $p < .001$
Fig. 10 Announcement Robots	Small is preferred
Left: Big	16-12-53
Right: Small	X^2 (2, N=81) = 38.2, $p < .001$

As shown in Table 3, for six of the seven robot pairs where there is a visual distinction between the robots, the results show strong evidence that one of the robots in each pair is preferred. In each of these cases, the participants prefer to be around the robots that they judged to be more kawaii/cute. This includes cases when the robots were more animal-like (Fig. 3 and Fig. 7), when they were rounder (Fig. 4, and Fig. 6), when they were shorter (Fig. 8), and when they were smaller (Fig. 10). For the robot pair shown in Fig. 5, while the statistical results did not show differences in preference for the rounder and more kawaii/cute robot, the tendency is in the expected direction.

As noted previously, the pair of robots in Fig. 9 do not differ visually. The right robot in this pair makes a smoother sound when it moves. Participants indicated preference for being around the robot that sounds smoother.

3.7 Preferences Across Genders and Cultures

Further analyses were conducted to investigate the relationships between gender (male vs female) and preferences. A chi-square test of independence was performed to examine the relationship between gender (male vs female) of the participants and their preferences for each of the eight robot pairs. The results show that there was no significant relationship between gender and how each robot was perceived for 7 of the 8 robot pairs. The exception, as described below, is for the robot pair shown in Fig. 10.

A two-variable chi-square test demonstrates a significant difference between male participants and female participants with respect to preferences for the pair of announcement robots shown in Fig. 10. While males and females both prefer the smaller robot on the right side of the figure, this preference is more significant for females X^2 $(2, N = 41) = 8.1$, $p = .017$.

Similarly, a chi-square test of independence was performed to investigate the differences in perception between cultural backgrounds (American vs Japanese). A chi-square test of independence was performed to find the relationship between cultural background and the participants' preferred robots. The result shows that there is not significant association between cultural backgrounds and preferences for any of the eight robot pairs.

4 Discussion

This study demonstrates that designing a robot to be more animal-like, rounder, shorter, and smaller increases participant's perceptions that the robot is kawaii/cute. More importantly, the study shows that designing a robot to be more kawaii/cute appears to positively influence human preference for being around the robot. These findings hold across Japanese and American culture and across males and females.

While both males and females prefer smaller robots to larger ones, this preference appears to be more significant for females. However, no other differences were found between genders or between cultures.

5 Future Work

In this paper, we have only reported the results of initial chi-square tests, but for future work, we will conduct post hoc tests to more clearly explore relationships among robot pairs.

In this paper we have confined our formal analysis to the adjectives kawaii and cute. The data suggests that the adjectives "approachable," "beautiful," "comfortable" and "soft" may be correlated with the adjectives "kawaii/cute" and we will explore and report on these relationships in future work. Conversely, the adjectives "trustworthy" and "polite" do not seem correlated with kawaii/cute and many users saw do difference between left and right robots with respect to trustworthy and polite. These adjectives seem to be more relationship-based and may require more context than a short video provides. We will explore these adjectives in conjunction with kawaii as an emotional process in future work.

The survey instruments used in this study could easily be translated into languages other than English and Japanese, which would allow us to extend this work to other cultures.

We also plan to measure reaction to real robots rather than videos of robots. Finally, we plan to use biosensors to gauge participant reactions rather than relying on surveys.

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