Persona-based and Scenario-based Design of Virtual and Physical Companion Robots with Varied Kawaii (Cute) Attributes

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Abstract. In recent years, concerns about anxiety and other mental health issues in university students have been widely reported. Some college campuses have seen increased student requests to bring emotional support animals to campus, although these animals are hard to care for in shared living spaces that are common in college settings. This paper reports on a project that seeks to gain a deeper understanding of the role that kawaii (Japanese cuteness) plays in fostering positive human response to, and acceptance of, companion robots for use by college students. In the long term, this may lead to an understanding of techniques for designing companion robots that assist with student mental health. Specifically, in this paper, we report on a persona-driven and scenario-driven cross-cultural design of two kawaii companion robots and two non-kawaii companion robots. After describing the design process and presenting the companion robot designs, the paper reports on a user study that investigates and compares the desirability of the companion robots based on their level of kawaii. After reading a persona and scenario that provided the context for the design, the study participants viewed videos of the companion robots and answered survey questions regarding the designs. Additionally, participant facial expressions were recorded by iMotions software while the participants viewed videos of the companion robots.

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

1 Introduction and Motivation

1.1 Student Mental Health

As we have reported in more detail in [1], in recent years concerns about anxiety and other mental health issues in university students have been widely reported in the United States and beyond. Some college campuses have seen increased requests from students to bring emotional support animals to campus [1]. Unfortunately, these animals are hard to care for in shared living spaces common in college settings and can be problematic for other residents, for example if they are allergic to certain kinds of animals. In the long term, we are interested in exploring the possibility of using companion robots to provide emotional support to college students. As we summarized in [1] this builds on previous work in exploring the use of companion robots to assist the elderly.

This paper reports on a project that seeks to gain a deeper understanding of the role that kawaii (Japanese cuteness) plays in fostering positive human response to, and acceptance of, companion robots for use by college students. In the longer term, this may lead to an understanding of techniques for designing robotic companion robots that assist with student mental health.

1.2 Kawaii and Robotic Gadgets

As we have previously reported in [1, 2], 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 a single exact word that can be used as a counterpart in English [3] although "cute" is a common substitute. In the modern context, the notion of kawaii in Japan is embraced as a catalyst to evoke positive feelings [4], 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 beyond Japan [4] through kawaii products. Kawaii design principles and approaches to engineering [5] and are now incorporated into successful products that are used globally including in robotic gadgets [6, 7, 8].

Prior work done by several of the authors suggests that designing a robot to be more animal-like, rounder, shorter, and smaller increases participants' perceptions that the robot is kawaii/cute [2]. This work also suggests that designing a robot to be more kawaii/cute appears to positively influence human preference for being around the robot. These findings held across Japanese and American culture and across males and females [2]. Both males and females preferred smaller robots to larger ones; however, this preference was more significant for females. No other differences were found between genders or between cultures [2].

In [1], several of the current authors report on their findings in designing and evaluating companion robots for college students. The robots were intentionally designed to differ in specific attributes (color versus greyscale, round versus angular) that are well-known to impact perceptions of kawaii-ness. The study demonstrated, for example, that participants judged colorful robots to be more kawaii than greyscale robots and also judged round companion robots to be more kawaii than angular ones. These findings held for both males and females and for participants whose dominant culture was Japanese as well as for participants whose dominant culture was American [1].

Prior work that investigates the role of motion and sound in influencing perceptions of kawaii-ness 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 [9, 10]. 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 [9, 10]. The studies demonstrated that kawaii-ness can be expressed through motion. However, these studies did not consider visual attributes of the vacuum cleaners (e.g., color, shape) and the impact of these attributes on perceptions of kawaii-ness.

The first two authors have reported on perceptions of a standard Roomba compared to one that had been augmented with visual kawaii features (animal-like, colorful), as well as kawaii movements and sounds [11]. The visual effects, movement and sounds were each reported by some participants as contributing to the enhanced kawaii-ness of the augmented Roomba [11].

In this paper we now focus on the design and evaluation of companion robots for college students that vary in kawaii and non-kawaii visual attributes, sounds and movement. In addition, instead of limiting ourselves to virtual robots as we did in [1] and [2], we now report on physical robots that were rendered from virtual prototypes.

1.3 An Iterative Cross-cultural Design Driven by Personas and Scenarios

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 use cross-cultural design teams to gain a deeper understanding of the role that kawaii plays in fostering positive human response to, and acceptance of, robotic gadgets. More information about the goals of this grant-supported project may be found in [12].

With mentorship by faculty members and a graduate assistant at Shibaura Institute of Technology (in Japan) and by faculty members from DePauw University (in the United States), two cross-cultural design teams designed and implemented student companion robots, which were later evaluated by a formal user study. Each design team was comprised of four students -- two students from Shibaura Institute of Technology and two students from DePauw University. With support from the NSF IRES grant, the DePauw University student team spent approximately seven weeks in Japan collaborating on this project.

Each cross-cultural team was charged with using a persona and scenario to drive their design process. Specifically, each team was asked to design for a first-year college student named Sam, who was presented through the persona and scenario provided below in Table 1.

Table 1. Persona and Scenario for Design

Persona:	Sam is a first-year college student who is studying mathematics. Sam is having trouble getting homework completed on time and the stress of homework makes Sam sad.
Scenario:	Sam's companion robot says, "Sam, you look tired and sad. I know you have a lot of work to do so let me try to cheer you up." The companion robot makes some movements and sounds for about 30 seconds. Then the robot says, "Sam, now that you are happier please start your homework." Sam begins his homework and is pleased to be done.

Sam was specifically selected as the persona's name because it a gender-neutral name. A Japanese translation of the persona and scenario were also presented to the design teams, except that the name Sam was changed to じゅん (Jun) which is a gender-neutral name in Japanese.

The design teams focused their designs on enacting the following portion of the scenario, which is designed to cheer Sam up: "The companion robot makes some movements and sounds for about 30 seconds."

Each team was charged to design a pair of companion robots such that one robot had kawaii attributes and one robot did not have kawaii attributes. Each team first designed paper sketches of their robots and received feedback from the broader group of faculty and students. After iterating on the paper designs, the students implemented their designs using Blender and received feedback again. After iterating on their Blender designs, the Blender files were used to generate 3D printed companion robot bodies, which were decorated using supplies such as fabric and paint.

The decorated robot bodies were placed over Arduino-powered Zumo robots. Each team programmed their robots to make movements and sounds as described in the scenario. The kawaii robots were programmed to make cute movements and sounds while the non-kawaii robots were programmed to make non-cute movements and sounds (jerkier movements and harsher sounds).

1.4 Resulting Companion Robots

Figure 1 and Figure 2 present the two physical companion robots that were explicitly designed to be non-kawaii. We refer to these companion robots as "Spiky" and "Bug" respectively. Figure 3 and Figure 4 present the two companion robots that were explicitly designed to be kawaii, which we call "Panda" and "Penguin" respectively. The size of each of robot makes it possible for the robot to move around on the top of a desk as might be commonly found in a student's study area. Figure 5 presents a photograph of the Penguin robot next to some books and a coffee cup to provide a sense of scale. When study participants evaluated the four companion robots, they were shown next to these items to provide scale consistently across the four companion robots.

Fig. 1. Non-kawaii companion robot named “Spiky”

Fig. 2. Non-kawaii companion robot named “Bug”

Fig. 3. Kawaii Companion Robot named "Panda"

Fig. 4. Kawaii Companion Robot named "Penguin"

Fig. 5. Penguin Companion Robot with Items to Convey Scale

2 Evaluation

2.1 Purpose of the Evaluation

The goal of this evaluation was to investigate how the study participants perceived the cuteness and trustworthiness of each of the four companion robot prototypes, which attributes of each robot they found to be cute, which prototype they would prefer to use and which prototype they believed Sam would prefer to use based on their understanding of Sam's persona and the associated scenario.

In addition to self-reported survey data, the study used the Facial Expression Analysis module of iMotions software [13] to measure facial expressions (e.g., smiles, frowns, eye position) and associated emotions (e.g., anger, disgust, joy, sadness, surprise) that resulted when participants viewed the videos of each of the companion robots shown in Figure 1 through Figure 4. While the iMotions software recorded a wealth of data, we consider only the data associated with "joy" in this paper and even this consideration is preliminary.

The study design, data gathering and preliminary data analysis was carried out by the first, second and ninth authors.

2.2 Participant Recruiting

After obtaining Institutional Review Board approval for the study, we recruited participants who were undergraduate students at DePauw University in the United States. Participants had to be at least 18 years old and at most 28 years old. While all DePauw University students in this age range were eligible to participate, we expressed preference for students who had lived in the United States for at least ten years, or who had lived in Japan for at least ten years, or who had lived in Vietnam for at least ten years. This allowed us to gather data from participants who had either an American, Japanese or Vietnamese dominant culture.

2.3 Participant Exclusions

In total, 49 participants started the study. Due to a computer crash, no data was collected from one of these participants, meaning that data was collected from 48 participants. In addition, there was a technical problem resulting in an absence of audio during the initial steps for one of the participants and the study was stopped. The partial data was excluded, and the study was restarted and completed successfully.

The Facial Expression module of iMotions software reports the quality of the video recorded while a participant views a stimulus. The quality is reported on a scale of 0% to 100% where100% means the recording was completely successful. The iMotions system flags data as unusable if the quality for a given recording is less than 80%. In this study we focus on data for four stimuli per participant, one stimuli for each companion robot shown in Figure 1 through Figure 4.

For one of the study participants, iMotions reported data quality of 46%, 99%, 93% and 56% respectively for the four stimuli and flagged data for the first and last of these stimuli as unusable. Manual inspection of the video recording for this participant demonstrated that the participant covered their face with their hands while viewing the first and last stimuli. Thus, the data for this participant has been excluded, leaving a total of 47 participants. For 13 of these 47 participants, iMotions reported data quality scores ranging between 97% and 99.75% as the mean across the four stimuli. For the remaining participants, iMotions reported data quality scores of 100% for all four stimuli.

2.4 Participant Demographics

The 47 participants ranged in age from 18 to 28 with a mean age of 19.6. There were 20 participants in the United States-culture group, 12 participants in the Vietnam-culture group and 7 participants in the Japan-culture group. The remaining 8 participant's primary countries of residence were Nepal (4 participants) and one each from China, Croatia, Ethiopia and South Africa. In total 22 females and 24 males participated in the study. The remaining participant self-identified their gender as other.

2.5 Study Procedure

Participants signed up to complete the study during a 45-minute time slot. At the agreed upon time, the participant came to the study room where they were met by the experimenter (ninth author). Participants were welcomed and asked to sit at a table on which were placed a computer monitor with an attached webcam, keyboard, mouse and speaker as shown in Figure 6. iMotions software was used to record the participant's facial expressions, via the webcam, during the study.

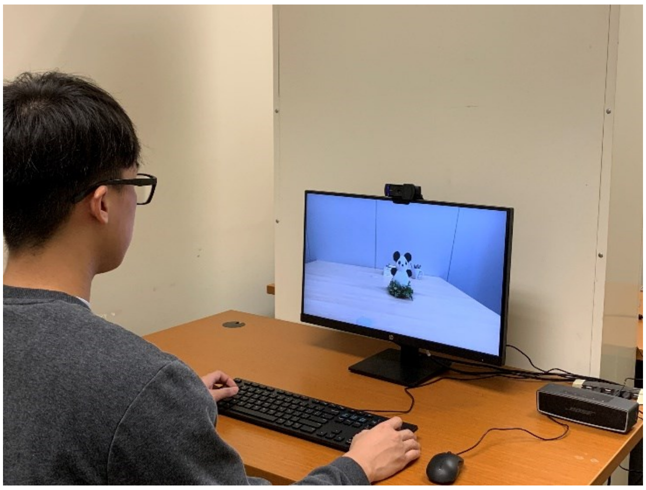

Fig. 6. Participant's View During Experiment

Although not visible in Figure 6, the experimenter was seated behind the partition shown in this figure. While the participant and experimenter could not see each other directly during the study, the experimenter could see the participant's face as tracked by iMotions and displayed on the experimenter's computer. The experimenter could also see the participant's computer screen on the experimenter's computer. The experimenter's screen is shown in Figure 7.

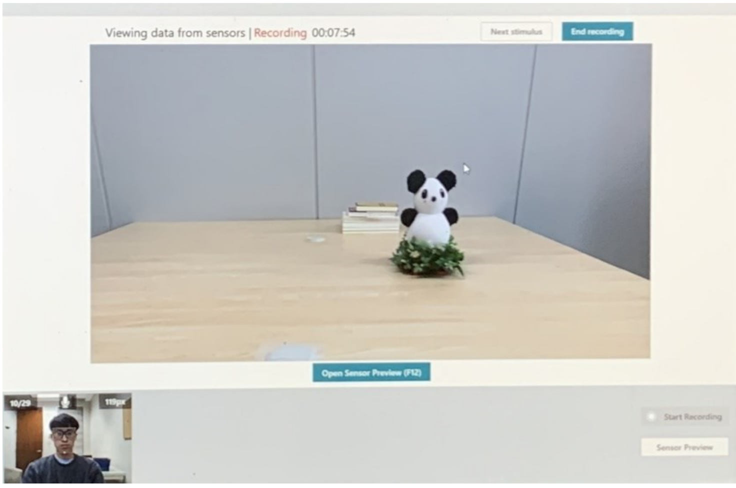

Fig. 7. Experimenter's Screen

After accepting the conditions of the informed consent, and confirming eligibility to participate in the study, participants began the online study presented on their monitor while iMotions recorded their facial expressions. Participants began by providing their age, the country they had lived in the longest, the number of years they had lived in that country, additional countries they had lived in (if any), the number of years they had lived in those countries, and their gender. Participants then watched a test video and confirmed that they could see the video and hear the associated audio.

Participants were then presented two still photographs and two thirty-second videos of robotic gadgets that are not related to the study we report on in this paper. Data gathered from this portion of the study will be reported elsewhere.

Next, participants read the description of Sam's persona and the associated scenario, which are both provided above in Table 1.

Participants then viewed the videos, and listened to the associated audio, for each of the four companion robots presented in Figure 1 through Figure 4. The videos, which were presented in random order, each had a duration of approximately 30 seconds and illustrated this portion of the scenario: "The companion robot makes some movements and sounds for about 30 seconds."

After viewing each video, participants were asked to answer the following seven questions. Note that we used the word "cute" instead of "kawaii" in the survey questions because the survey was administered in English and some participants may not have been familiar with the word "kawaii".

1. "Based on the video, if you find one or more aspects of the companion robot to be cute, please describe THE CUTEST ASPECT here. If you do not find any aspects to be cute, please write NONE." A text box was provided for participants to type their answer to this question.
2. "Based on the video, if you find any ADDITIONAL aspects of the companion robot to be cute, please describe ALL THE ADDITIONAL CUTE ASPECTS here." If you do not find any additional aspects to be cute, please write NONE." A text box was provided for participants to type their answer to this question.
3. "Based on the video, how cute is this companion robot?" Participants responded using a 7-point Likert scale where 1 was "Not at all cute" and 7 was "Very cute".
4. "Based on the video, how trustworthy is this companion robot?" Participants responded using a 7-point Likert scale where 1 was "Not at all trustworthy" and 7 was "Very trustworthy".
5. "Based on the video, if cost is not a factor, how likely do you think it is that **Sam** would want to use this companion robot?" Participants responded using a 7-point Likert scale where 1 was "Not at all likely" and 7 was "Very likely".
6. "Based on the video, if cost is not a factor, how likely do you think it is that **you** would want to use this companion robot?" Participants responded using a 7-point Likert scale where 1 was "Not at all likely" and 7 was "Very likely".
7. "You may optionally share any additional comments about your answers here. If you do not have any additional comments, please wrote NONE."

After watching all four videos, and answering the associated questions, participants were presented with a screen that presented photographs of all four companion robots. Participants were asked the following two questions:

1. “Based on the pictures and videos, which companion robot do you think **Sam** would prefer?” To respond to this question, the participants selected one of the four companion robots.
2. “Based on the pictures and videos, which companion robot would **you** prefer?” To respond to this question, the participants selected one of the four companion robots.

Finally, participants were debriefed and completed a payment form that allowed us to compensate them with a $20 Amazon gift certificate.

3 Results

3.1 Quantitative Survey Data

As described earlier, participants were asked to respond to several quantitative and qualitative questions after viewing the video of each of the four companion robots. Figure 8 summarizes participant responses to the question “Based on the video, how cute is this companion robot?” Participants responded using a 7-point Likert scale where 1 was “Not at all cute” and 7 was “Very cute”. In reporting responses for the Likert scale questions in the remainder of this section we will consider a rating of 1, 2, or 3 to be a negative rating, a rating of 4 to be a neutral rating, and a rating of 5, 6 or 7 to be a positive rating.

The data in Figure 8 is organized into four clusters of bars. The left-most cluster presents responses to the cuteness question for the Spiky companion robot video, which is one of the companion robots that was designed not to be cute. As shown in Figure 8, 37 of the 47 participants (79%) gave a negative rating when asked how cute Spiky was while only 5 out of 47 participants (11%) gave a positive rating in response to this question.

As further shown in Figure 8, responses were similar for the Bug companion robot, which was also designed not to be cute. For this robot, only 3 participants out of 47 (6%) responded with a positive rating. The Panda and the Penguin were designed to be cute and, as expected, many participants found them to be cute. Specifically, as shown in Figure 8, 26 of the 47 participants (55%) rated the Panda positively on the cuteness scale while 32 of the 47 participants (68%) rated the Penguin positively on this scale.

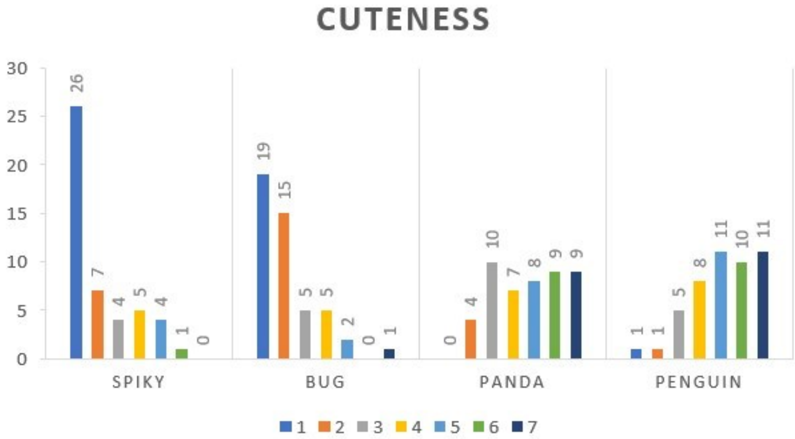

Fig. 8. Responses to Cuteness Likert Scale

Figure 9 presents participant responses to the question "Based on the video, how trustworthy is this companion robot?" Robots that were judged to be cuter as shown in Figure 8 were also judged to be more trustworthy as shown in Figure 9. For example, while only 3 out of 47 participants (6%) rated Spiky, which is the least cute robot, positively on the trustworthy scale, 26 out of 47 participants (55%) rated Penguin, which was rated as the cutest robot, positively on the trustworthy scale.

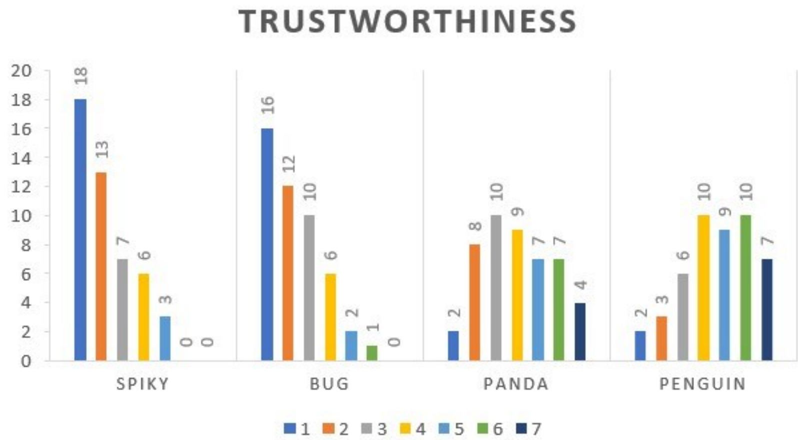

Fig. 9. Responses to Trustworthiness Likert Scale

Figure 10 summarizes participant responses to the question: "Based on the video, if cost is not a factor, how likely do you think it is that **Sam** would want to use this companion robot?" Once again, the data demonstrates that participants believe Sam is more likely to want to use the robots that were rated to be cuter as compared to the robots than were rated to be less cute. In particular, only 5 participants (11%) gave a positive rating when asked if Sam would want to use Spiky while 27 participants (57%) gave a positive rating for Penguin.

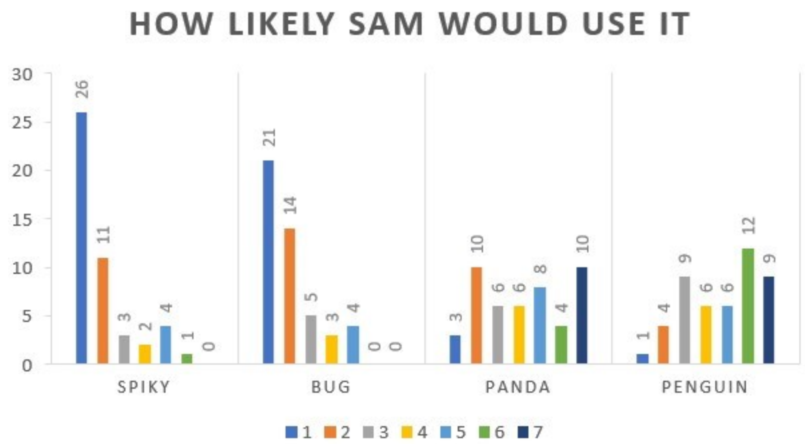

Fig. 10. Responses to Sam's Likelihood of Use Likert Scale

Figure 11 summarizes participant responses to the question: "Based on the video, if cost is not a factor, how likely is it that **you** would want to use this companion robot?" The data demonstrates that participants state they are more likely to want to use the robots that were rated to be cuter as compared to the robots than were rated to be less cute. For example, only 7 participants (15%) gave a positive rating when asked if they wanted to use Spiky while 23 participants (49%) gave a positive rating for Penguin.

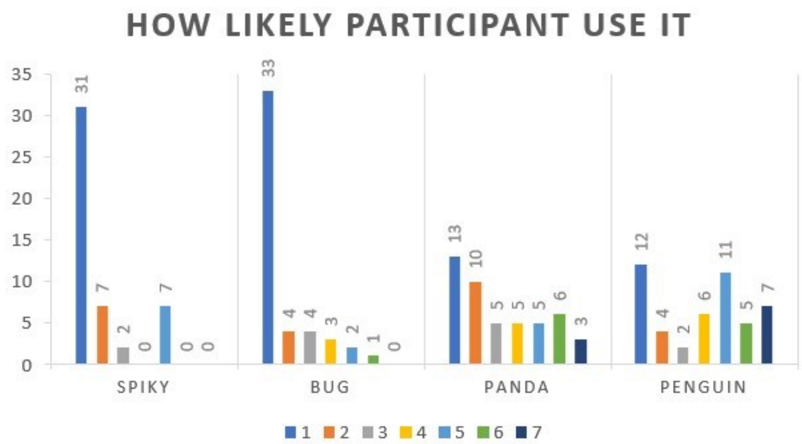

Fig. 11. Reponses to Participants Likelihood of Use Likert Scale

Participants were presented with pictures of all four companion robots and were asked "Based on the pictures and videos, which companion robot do you think Sam would prefer?" In response, 26 participants believed Sam would prefer the Penguin companion robot while 15 participants believed Sam would prefer the Panda companion robot. Only 1 participant believed Sam would prefer the Spiky companion robot and only 5 participants believed Sam would prefer the Bug companion robot. In summary, 41 out of 47 participants (87%) believed Sam would prefer to use one of the two companion robots that was designed to be cute.

Participants were presented with pictures of all four companion robots and were asked "Based on the pictures and videos, which companion robot would you prefer?" In response, 27 participants indicated a preference for the Penguin while 14 participants indicated a preference for the Panda. Only 2 participants indicated a preference for the Spiky companion robot and only 4 participants indicated a preference for the Bug companion robot. In summary, 41 out of 47 participants (87%) expressed a preference for one of the two companion robots that was designed to be cute.

3.2 Qualitative Survey Responses

After watching each companion robot video, participants were asked to indicate the cutest aspect of the companion robot as well as any additional cute aspects of the companion robot. The responses were coded for the two robots that were rated to be the cutest (Penguin and Panda). Most responses fall into one of three categories: visual characteristics, sounds, and movements. Table 2 provides counts of the number of times each category was mentioned as a cutest characteristic and also as an additional cute characteristic for the Penguin companion robot. The rightmost column of Table 2 sums the two columns to its left. Table 3 provides similar counts for the Panda companion robot.

Table 2. Coding of Cute Characteristics of Penguin Companion Robot

	Cutest Penguin Characteristics	Additional Cute Penguin Characteristics	Total Cute Penguin Characteristics
Visual	34	20	54
Sound	12	14	26
Movement	1	9	10

Examples of the characteristics mentioned for the Penguin companion robot are provided below.

- **Visual:** "The Penguin's Face", "It looks soft and friendly", "The fluffy, cozy style"
- **Sound:** "I find the noises it makes very cute and catchy", "The sounds", "The music and the ice it was on"
- **Movement:** "The sound and the movement of the robot", "The cute music and the way it just moving/dancing around", "Movement, music"

When a participant mentioned multiple characteristics as part of a single response, the response was coded in multiple categories. For example, one participant stated that an additional cute characteristic of the Penguin companion robot was “The music and the ice it was on”. This response was coded in both the Sound and Visual categories.

Table 3. Coding of Cute Characteristics of Panda Companion Robot

	Cutest Panda Characteristics	Additional Cute Panda Characteristics	Total Cute Panda Characteristics
Visual	33	18	51
Sound	2	10	12
Movement	13	11	24

Examples of the characteristics mentioned for the Panda companion robot are provided below.

- **Visual:** “The eyes”, “The round shape of the panda”, “The panda face”
- **Sound:** “The music”, “The music and the green leaves”, “The background music tune”
- **Movement:** “That spin at the end was great”, “How the panda moves its body in the certain pattern”, “The Dance moves and the stuffed panda”

As indicated in Table 2 and Table 3 visual characteristics were mentioned most frequently as contributing to the cuteness of a companion robot for both the Penguin companion robot and the Panda companion robot. Sound was more frequently noted than movement for the Penguin, while movement was more frequently noted than sound for the Panda. In particular, 12 participants specifically commented on the spinning movement at the end of the Panda video, for example by writing: “That spin at the end was great.” Additional participants made more general comments such as “how the panda moves its body in the certain pattern” which may have also been influenced by the spin at the end of the video.

3.3 iMotions Facial Expression Analysis

The iMotions Facial Expression Analysis Software recorded a great amount of data although, in this paper, we only present preliminary data on its measure of “joy” among the participants. The iMotions software reported that the majority of participants expressed joy 0% of the time while watching the companion robot videos. As measured by the iMotions software, out of the 47 participants, 16 (34%) expressed any joy while watching the Spiky companion robot, only 13 (28%) expressed any joy while watching the Bug companion robot, only 14 (30%) expressed any joy while watching the Panda companion robot and only 16 (34%) expressed any joy while watching the Penguin companion robot. Even in cases where the iMotions software detected joy while a participant was watching the video the joy was sometimes only expressed for a small percentage of time the video was playing.

4 Discussion

The Panda and Penguin companion robots, which were the robots that were judged to be cuter than the Bug and Spiky robots, were also judged to be more trustworthy. In addition, participants generally believed that Sam would prefer to use the robots that were judged to be cuter and participants also indicated that they would personally prefer to use these robots. Importantly, almost half of the participants (49%) gave a positive rating when asked how likely they would be to use Penguin, which was the companion robot that was most likely to be judged to be cute. Additionally, more than half of the participants (57%) thought Sam would be likely to use the Penguin companion robot. Taken collectively, these results suggest that designing a companion robot to be cute can have a positive impact acceptance of the robot.

While the Panda companion robot and the Penguin companion robot both received positive ratings for cuteness, trustworthiness, and for the desire for Sam and the participants to use the companion robots, Penguin received higher scores than Panda. It is possible that Penguin was seen as more gender neutral due to Panda's accessories, which included flowers.

The majority of previous work on understanding kawaii-ness has focused on the visual characteristics of an object. Participants in our study were most likely to identify visual characteristics of a companion robot as cute. However, participants also frequently identified movement and sound as making contributions to the cuteness of a companion robot. We believe further study is warranted to better understand how visual characteristics, sound and movement can work together to convey cuteness.

While there was great variation in the way participants rated specific companion robots with regard to their cuteness, there was little variation in the iMotions software's measurement of the participant's expression of joy. This may suggest that a participant can recognize an object is cute, and can express a preference for that object, even if the cuteness is not strong enough to drive a change in facial expression. This is an area worthy of additional research.

5 Future Work

We plan to complete further evaluation of the quantitative and qualitative survey data, including statistical analysis, to examine whether or not there are differences in perceptions of cuteness based on gender or cultural background. In particular, it will be interesting to investigate whether gender differences resulted in the higher ratings for Penguin as compared to Panda as discussed in the previous section.

A number of participants mentioned that the Panda's companion robot's spinning was especially cute. A more focused examination of the iMotions joy data collected for that portion of the video is warranted. Additionally, we plan to investigate other data collected by the iMotions software such as measurements of a user's engagement or level of surprise. Finally, we would like to use iMotions to gather additional data while participants watch videos that are commonly accepted to be cute (e.g., puppies, babies) to see if this results in measurements of joy that we can use as a baseline.

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