Influence of Gender and Age on the Attitudes of Children towards Humanoid Robots

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Abstract. This study addresses the attitudes of children toward robots displaying various degrees of anthropomorphic appearance. Understanding the means by which children perceive and evaluate robots across the spectrum of anthropomorphism is a crucial issue within the field of robotics research. This study conducted two experiments to understand children's attitudes toward robots with various degrees of realism and examine whether gender or age influences the social and physical attraction children feel toward humanoid robots. The results of the study suggest that when designing robots for children, designers need not focus on creating an authentic human-like appearance. In addition, the influence of children's age on their attitudes toward robots is less significant than that of gender. Generally, children aged from 8 to 14 years have similar attitudes to and perceptions of humanoid robots. An interesting finding is the persistent differences between boys and girls, with respect to the ratings of their social and physical attraction to robots. Particularly, girls are more accepting of human-like robots, especially female robots, than boys are.

Keywords: Human-Robot interaction, child, interaction design, humanoid robot.

1 Introduction

With the advancement of robotic technology, it becomes a tangible future that robots could serve as assistants, companions, or perform other social roles in our environments. Accordingly, the manner people interact with robots is socially situated and multi-faceted. In addition to usability, social and emotional levels of interaction influence a person's acceptance of the roles of robots [1,2,3]. Being an assistant or companion, a robot is expected to communicate with humans in a smooth and natural way, using verbal as well as non-verbal communication. A study by Goetz et al. [4] showed that people anticipate humanlike robots to be best suited for interactive tasks, while mechanical-looking robots were best suited for routine jobs. Thus, robots designed with anthropomorphic characteristics are the embodiment of a human-computer interface, providing the basis for potential social relationships [5,6]. Attributing humanlike characteristics (such as a human appearance) to a robot can facilitate people's understandings of its behaviors or functionalities, leading to form a

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meaningful social interaction between human and robot. Such notions lead to an assumption that increasing the realism of a robot has practical benefits. While many researchers are exerting efforts to pursue a highly humanlike form for a social robot, we are interested in the degree of realism involved that people deem sociable and appealing. This study specifically addressed the attitudes of children toward robots displaying various degrees of anthropomorphic appearance, as numerous robots have been created to serve as social companions or learning partners for children.

Various robots are specifically designed for children, for educational, entertainment, and therapeutic purposes. Therefore, understanding children's perceptions of humanoid robots with various degrees of realism is essential. Studies related to Computers As Social Actors (CASA) have empirically proven that people tend to treat a computer as a social entity when the computer exhibits social cues adequately to elicit social responses from people [7,8]. This tendency should also apply to the way humans interact with humanoid robots, especially robots that exhibit humanlike appearances. Regarding research that concerns children's attitudes toward robots, the phenomenon of childhood animism should also be considered. Piaget [9] first used animism to describe children's tendency to endow inanimate things with life and consciousness. He outlined four stages of animism through which children normally go. At the first stage (age 4–6), a child attributes consciousness and life to anything that is in any way active, undamaged, or useful. A whole dish is alive; a broken dish is not alive. In the second stage (6－7), only objects that move are given life-like qualities. In the third stage (8－10), consciousness is attributed only to objects that move spontaneously. In the final stage (older than age of 11), a child restricts consciousness and life to plants and animals only. According to Piaget, animism probably demonstrates children's incomplete knowledge and understanding of the world, and changes in the course of development. Okita et al. [10] also revealed that elder children attribute less animistic properties to robots compared to younger ones, but the reductions occur in piecemeal fashion.

As mentioned above, the fact that children over-generalize animacy might lead them to accept a robot and treat it as a social partner, regardless of the degree to which it appears like humans. Children use their animistic intuition to attribute intelligence, biological function, and intention to the objects they encounter [11,12]. This raises the question as to whether robots that interact with children should have a humanoid appearance (an appearance that closely resembles human beings). Understanding the means by which children perceive and evaluate robots across the spectrum of anthropomorphism is a critical issue within the field of robotics research. The phenomenon of childhood animism diminishes gradually as children get older, leading to the prediction that age differences might affect children's perceptions of humanoid robots. In addition to age-related factors, gender differences served as a noteworthy factor in this study as gender differences related to child interaction with agents offered by computers were discovered [13]. Thus, this study further investigated whether age and age differences affect children attitudes toward robots with different degrees of apparent realism.

To summarize, this study aimed at exploring children's attitudes toward humanoid robots with different anthropomorphic appearances. This research was interested in how children differentiate the degrees of realism of robots and examined whether or not these degrees of realism make a difference in their perceptions of humanoid

robots regarding social and physical attraction. This study conducted two experiments addressing the research questions listed below.

RQ1. Are children able to differentiate humanoid robots according to the degree of realism?

RQ2. Do children's attitudes toward robots differ with degrees of realism?

RQ3. Do individual differences such as gender and age affect the way children perceive robots?

2 Method

2.1 Experiment1

The first experiment was conducted as a pre-experiment. The experiment investigated children's perceptions and judgment of the degree of human likeness of robots in terms of appearances. To conduct the investigation, a number of robot resources developed by companies, institutes, research labs, and artists were accessed and 54 robots ranging from "barely human" to "fully human" were gathered. One of the 54 robots was gathered from a Japanese movie, in which the robot was played by an actress. Researchers have assumed that the head is the primary place of human-robot interaction. This assumption is empirically proven by research [14] that people's perceptions of humanness of whole robots and robot heads were correlated. The findings indicate that the form of the head plays an important role in the perception of humanness. Thus, this study adopted robot heads as the focus for examining children's perceptions of humanoid robots.

The 54 robot images obtained mostly from the internet were edited by re-scaling and removing variables such as background color, marks, and other objects to ensure that the images were presented in a standardized format. Three professional designers then examined the 54 images to screen out redundant or inappropriate images regarding the anthropomorphism scale and identified 34 images, including that of an actual person, for possible inclusion in the study.

Twenty-nine children aged approximately 10~11 were recruited to sort the 34 images by means of hierarchical clustering individual assessment. Upon beginning a trial, the experimenters shuffled the cards in the set to ensure a random presentation. To facilitate children participating in the study, they were asked to sort the 34 cards into three categories: low, middle, and high degree of realism. Each subset was then divided into three groups based on the same criteria. Thus, each participant sorted the 34 robot images into nine groups ranging from low human likeness to high human likeness. We then used hierarchical clustering methods (Ward's method in SPSS) to analyze the distance matrices for the robots. We obtained four groups to represent various degrees of human-like appearance perceived by the children. Based on ranking data, twelve robots were selected from the four groups to illustrate how children rate robots on an anthropomorphic scale, from "little resemblance to humans" to "highly human-like", (Table1).

Table 1. Twelve images of humanoid robots

											
R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12

(R1: NUVO/ ZMP; R2: Roborior/ Tmsuk; R3:Jonny 5/Lynxmotion; R4:Wakamaru/Mitsubishi; R5:ifbot/ Business Design Laboratory; R6:Nao/Aldebaran Robotics; R7: Nexi M.D.S. Robot /MIT Media Labs Personal Robots Group; R8: Robottina mod.009/Ziopredy; R9:Miss Rong Cheng /Chinese Academy of Sciences; R10: EveR-2 muse / Korean Institute for Industrial Technology; R11: Cybernetic human-HRP/AIST; R12: a character in a Japanese film of "Cyborg She")

2.2 Experiment2

Experiment 2 was conducted to understand whether or not children's attitudes toward robots differ with the degrees of realism and to examine the effects of gender and age differences on children's feelings toward the robots.

Participants. A large sample group of 267 children (N=267) was recruited, including 87 fourth graders (42 girls and 45 boys), 86 sixth graders (42 girls and 44 boys), and 94 eighth graders (45 girls and 49 boys) from five schools.

Measurement Tools. The dependent variables of social attraction and physical attraction were modified from a version of McCroskey and McCain's [15] social and physical attraction scale, as well as from relevant studies that adapted the same scale to measure users' attitudes toward computers, robots, or media [16,17]. Social attraction and physical attraction are two key dimensions of interpersonal attraction, have been found to be facilitators of interpersonal communication leading to the formation of friendships. Several humanoid robots are being developed to enhance attitudes of social acceptance among users in an attempt to build social relationships. For this reason, this study investigated whether or not different levels of anthropomorphic appearances influence children's social and physical attraction toward robots.

The social attraction scale consists of five items: 1) "I think this robot is friendly"; 2) "I like this robot"; 3) "I think this robot could be a friend of mine"; 4) "I would like to have a friendly chat with this robot"; and 5) "This robot would be pleasant to be with". The physical attraction scale consists of three items: 1) "I think this robot is good looking; 2) "I find this robot very attractive physically"; and 3) "I like the way this robot looks". The two sets were measured using a set of paper-and-pencil questionnaires, each item had a 7-point Likert scale that ranged from 1 ("very strongly disagree") to 7 ("very strongly agree"). The wording used in the questionnaires was discussed with teachers and the children to prevent any misunderstanding.

Stimuli and Procedure. The stimuli used for this experiment were the twelve robots obtained in Experiment 1. Each robot image was high-quality color printed on a single paper with the aforementioned questionnaires. The participants were asked to evaluate the images of the twelve robots by completing questionnaires, meaning that each participant received twelve sheets to finish the questionnaire survey. The order of the twelve sheets was randomized for each child. The experiment was conducted at select schools. Participants completed the questionnaire survey either in their classrooms or in a quiet place such as a school library.

3 Results

Internal consistency (Cronbach's) was calculated to assess the reliability of these scales. Cronbach's αfor the social attraction and physical attraction among the 4th, 6th, and 8th graders were all more than 0.7. According to Nunnally [18], Cronbach's α value of 0.7 is adequate for internal consistency reliability. The measures used in the study demonstrated adequate reliability.

Social Attraction. Table 2 shows the mean social attraction scores rated by participants in terms of their grades and genders. Figure 1 illustrates how boys and girls evaluated each robot's social attractiveness. Figure 2 shows the results according to the three grade groups, 4th, 6th, and 8th. The two figures present similar plots illustrating how the positive responses increase with the degree of realism until the point of R7, which thereafter resemble humans closely, but not perfectly. At that point, participants began to react negatively to robots before reaching the point of R11, which thereafter perfectly mimicked human appearance.

The analysis of variance was used to examine the effect of gender and age on the social attraction children felt toward the robots respectively, from "little resemblance to humans" to "highly human-like". Significant gender differences were observed among the rating of images R1, R6, R9, R10, R11, and R12 (all $ps < .01$). The boys were attracted to the image of R1 to a far greater degree than the girls were. With the exception of R1, the remaining images were rated more highly in terms of social attractiveness by girls as compared to boys.

A significant difference was found in the rating of R6 ($ps < .05$). Post hoc analysis indicated that 4th and 6th graders rated R6 higher in terms of social attraction than 8th graders did.

Table 2. Mean social attraction scores rated by participants

	R1	R2	R3	R4	R5	R6	R7	R8	R8	R10	R11	R12
boy	3.7	3.4	3.5	4.4	4.3	5.4	3.7	3.1	2.3	2.3	3.8	4.5
girl	2.9	3.3	3.1	4.1	4.7	5.8	3.8	2.7	3.0	3.0	5.1	5.6
4th	3.6	3.7	3.3	4.6	4.7	5.8	3.7	3.2	2.9	2.9	4.4	4.9
6th	3.2	3.2	3.4	4.4	4.5	5.7	4.0	2.8	2.6	2.6	4.4	5.0
8th	3.2	3.2	3.1	3.9	4.4	5.1	3.5	3.0	2.5	2.6	4.4	5.1

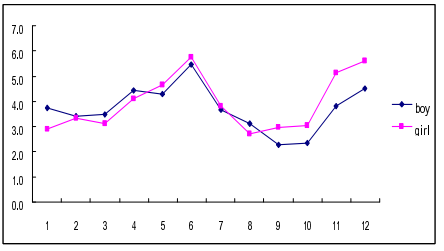

Fig. 1. Each robot's social attractiveness evaluated by boys and girls

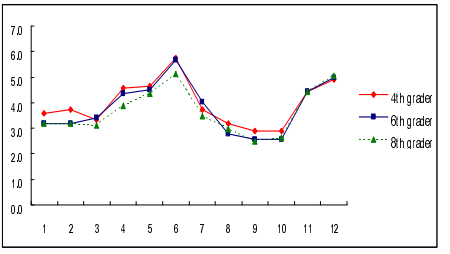

Fig. 2. Each robot's social attractiveness evaluated by different graders

Physical Attraction. Table 2 shows the mean physical-attraction scores rated by participants in terms of their grades and genders. Figures 3–4 illustrate the physical attraction children felt toward the twelve stimuli. Similar preferences for the twelve robots were observed regarding physical attractiveness. An ANOVA was performed to examine whether age or gender influenced children's attraction to the appearance of the robots in the twelve images. Significant gender differences were observed among the ratings for R1, R5, R9, R10, R11, and R12 (all ps $<$ .05). A similar pattern was observed in which boys liked the appearance of R1 far more than girls did, and girls liked the appearances of the other images more than the boys did.

Results show no significant age differences in children's physical attraction toward the twelve robots.

Table 3. Mean Physical attraction scores rated by participants

	R1	R2	R3	R4	R5	R6	R7	R8	R8	R10	R11	R12
boy	3.3	2.9	3.0	3.8	3.4	4.7	3.0	2.8	2.1	2.3	3.7	4.4
girl	2.7	3.0	2.6	3.7	4.0	5.4	3.2	2.5	2.6	2.8	5.1	5.6
4th	3.0	3.2	2.9	4.0	4.0	5.2	3.2	3.0	2.6	2.8	4.4	4.7
6th	3.1	2.9	3.0	3.7	3.5	5.3	3.0	2.5	2.3	2.4	4.3	4.8
8th	2.9	2.8	2.6	3.5	3.7	4.7	3.0	2.4	2.2	2.5	4.4	5.3

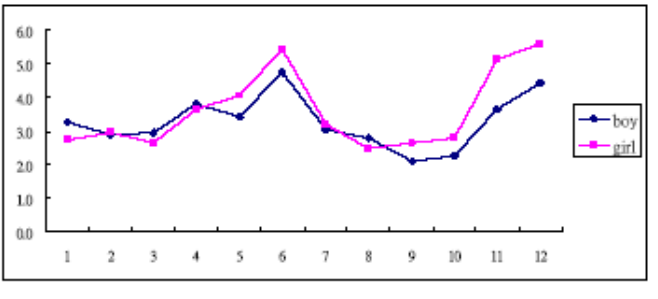

Fig. 3. Each robot's physical attractiveness evaluated by boys and girls

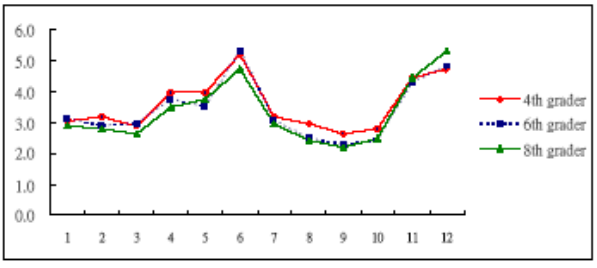

Fig. 4. Each robot's physical attractiveness evaluated by different graders

4 Discussion

The results from the current study show that the degrees of realism of robots make a difference in children's attitudes towards robots, echoing the theory of the uncanny valley, proposed by Mori [19]. Figures1– 4 show a continuously positive change of realism versus children's evaluation of social and physical attraction until a point of realism beyond which children's evaluation abruptly decreases. As the appearance becomes less distinguishable from a human, children's responses become positive once again. An uncanny valley was found in this study, indicating that children were less attracted to the images considered highly human-like but still distinguishable from humans, thereby evoking a feeling of discomfort in the observer. The study empirically supports related research that has argued that robots designed for children should not focus on creating a completely human-like appearance, unless they are perfect replicas and indistinguishable from humans. Results suggest that R6 and R12 received high evaluation from children in terms of social and physical attractiveness. Image R12 is a real person appearing young and pretty, while R6 is rated as a middle degree of realism. A striking finding is that the top of the first peak of the curve is slightly higher than the point at which R12 is located, differing from the results of Mori's uncanny valley where the highest score falls on the real human. This study attempted to identify the threshold of humanness that is appropriate for robots designed for children. The implication of the observation is that designing robotic appearances for children might consider combining human and machine features to restrict effort towards the first peak of the uncanny valley, rather than attempting to replicate human appearance perfectly.

The finding that children prefer R6 most among the stimuli is in line with Woods's [20] finding that children prefer robots with cartoon-like appearances. Humans, including children, are sensitive to the particular pattern of features that form a face. Using mere representations of cartoon-like faces can avoid the uncanny valley and cover a large aesthetic range [21]. Completely eschewing a human likeness is not necessary to avoid the uncanny valley. Uncanny faces can be modified with designs to increase acceptance by emphasizing features indentified with friendliness and youthfulness [21]. In terms of the robotic face design, DiSalvo et al. [23] suggested that head length and width influence perceptions of a robot's human likeness. They suggested that the head should be slightly wider than it is tall and the eye space should be slightly wider than the diameter of the eye. Designers might consider

exaggerated features and an encasement to hide mechanical parts to ensure that the robot appears not only humanlike but also product-like. Among the twelve robot images, the proportion of R6 most closely conformed to the aforementioned design guidelines, which could account for why R6 received the highest evaluation regarding social and physical attractiveness.

To examine the individual differences such as age and gender, the results show that the influence of children's age on their attitudes toward robots is less significant than that of gender. The results indicate that children, including 4^{th}, 6^{th}, and 8^{th} graders, have similar attitudes to and perceptions of humanoid robots. Those children aged from 8 to 14 years are in the third and fourth stages according to Piaget's theory of cognitive development. No age-related factors observed in this study imply how children's perception of digital objects or computational companions might be evolving because they were born in a digital era. This is a question remaining to be answered.

In contrast to no age-related factors found, an interesting observation involved the persistent differences between boys and girls with respect to the ratings of their social and physical attraction to robots. The differences were found in their attitudes towards robots with the lowest degree of human-likeness and a high degree. Boys reported higher social and physical attractiveness of the R1 robot, which is evaluated as the lowest degree of human likeness among the stimuli. A possible explanation could be that boys are usually more familiar with mechanical tools than girls are and boys were more likely to consider a robot with a mechanical appearance attractive. However, the preference changed while analyzing attitudes toward robots with high anthropomorphic appearances. Results show that girls felt more social and physical attraction to those high human-like robots than did boys. A study by Green et al. [24] indicated that women have greater tolerance in the acceptable range of facial proportion of people and robots. They concluded that traditional feminine nurturing roles because increased acceptance and males are generally more familiar with mechanical objects with a diminished need to anthropomorphize them. Greater female sensitivity to nonverbal cues such as facial expressions may be the result of socialization, gender patterns in emotional learning, or gender differences in the brain [25,26]. Interestingly, gender differences in the perception of facial expressions in the real world also influence the way children interact with humanoid robots. Another possible explanation for the tendency among girl participants to favor those humanoid robots with high degrees of anthropomorphism is that those robots are presented as being female. The findings echo some studies that females favor their own gender while males have no gender preference [27,28,29].

To summarize, this study observed the way children differentiate the degrees of realism of humanoid robots and obtained their attitudes toward robots with different anthropomorphic appearances. Findings regarding age and gender differences in their perceptions of humanoid robots were discussed. The results of this study could provide valuable references for designers and manufacturers of robots.

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