Child and Adults' Perspectives on Robot Appearance

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Abstract

This study explored children's and adults' attitudes towards different types of robots. A large sample of children viewed different robot images and completed a questionnaire that enquired about different robot physical attributes, personality and emotion characteristics. A few adults independently rated the overall appearance of different robot images. Results indicated high levels of agreement for classifications of robot appearance between children and adults, but children only differentiated between certain robot personality characteristics (e.g. aggressiveness) and emotions (e.g. anger) in relation to how adults rated the robots' appearances. Agreement among children for particular robots in terms of personality and emotion attributes varied. Previously, we found evidence for the Uncanny Valley based on children's ratings of robot appearance. However, based on the adults' rating of robot appearances, we did not find evidence of the Uncanny Valley in terms of how children perceived emotions and personality of the robots. Results are discussed in light of future design implications for children's robots.

1 Introduction

Robots are being used within increasingly diverse areas and many research projects study robots that can directly interact with humans [1]. Robot-human interaction encapsulates a wide spectrum of factors that need consideration including perception, cognitive and social capabilities of the robot and the matching of the robot interaction with the target group [2].

Because of the potential benefit of using robots that are able to interact with humans, research is beginning to consider robot-human interaction outside of the laboratory. Service robots are used within a variety of settings such as to deliver hospital meals, operate factory machinery, and clean factory floors, which does involve some shared human environments. However, the amount of human-robot interaction with these service robots is still minimal requiring little social behaviour [3]. Robots said to be able to engage in more extensive social interaction with humans among others include AIBO [4], Kismet [5], Feelix [6], and Pearl [7]. It is suggested that social robots should be able to exhibit some "human social" characteristics such as emotions, recognition of other agents and exhibiting personality characteristics [8] both in terms of physical appearance and behavioural competencies.

An important consideration for the designers of robots involves the target population whether it is children, adolescents, adults, or elderly as the attitudes and opinions of these groups towards robot interactions are likely to be quite different. For example Scopelliti et al. [9] revealed differences between young and elderly populations towards the idea of having a robot in the home with young people scoring highly positive and older people expressing more negativity and anxiety towards the idea of having a robot assistant in the home.

Related to this is the issue of matching the appearance and behaviour of the robot to the desired population. Goetz, Kiesler & Powers [10] [11] revealed that people expect a robot to look and act appropriately for different tasks. For example, a robot that performs in a playful manner is preferred for a fun carefree game, but a more "serious" robot is preferred for a serious health related exercise regime.

Kanda & Ishiguro [12] offer a novel approach and aim at developing a social robot for children where the robot (Robovie) can read human relationships from children's physical behaviour. This example highlights the importance of Robovie being designed appropriately for young children. It seems that if a robot cannot comply with the user's expectations, they will be disappointed and unengaged with the robot. For example, if a robot closely resembles a human in appearance but then does not behave like one, expectations are being violated and there is the danger of the human-robot interaction breaking down. It could even lead to feelings of revulsion against the robot as in the 'Uncanny Valley' proposed by Mori [13].

One domain of robotics research which remains scarcely explored but is beginning to emerge is the involvement of psychologists and extensive use of methods and techniques commonly used in psychology research in assisting the design and evaluation of robots for different target groups [14-18]. Using a psychology approach allows the exploration of different evaluation techniques [19], to enquire about robot perceptions and issues such as anxiety towards robots [18], and to study the ascription of moral development towards robots [15]. It is our position that the input of psychologists could assist in the design of socially interactive robots by examining what social skills are desirable for robots, what the most suitable appearance is for robots in different roles and for different target groups, and assisting in the design of robots with personality, empathy and cognition.

This paper is part of a research project which is exploring children's perceptions and attitudes towards different robotic designs paying special consideration to both the physical properties and social, behavioural aspects of robots. Previous work related to this project has reported that children are able to clearly distinguish between emotions and personality when judging different types of robots [19]. For example, children judged humanlike robots as aggressive but human-machine like robots as friendly. The work proposed possible design implications for children's robots such as considering a combination of robotic features (e.g. facial features, body shape, gender, forms of movement) rather than focusing on certain features in isolation (e.g. just the face).

The current paper considers the findings of Woods, Dautenhahn & Schulz [19] from a different perspective and examines the implications more deeply. We investigate whether adults and children agree on ratings of overall robot appearance and what children's perceptions of robot personality and emotions are in relation to adult views of overall robot appearance. Furthermore, we examine whether children among themselves agree about their perceptions of robot personality and emotion attributes.

The specific research questions that we were interested in were:

1. Do children differentiate robots in terms of personality and emotions based on adult ratings of robot appearance?
2. How do children perceive robot comprehension/understanding in relation to adult ratings of robot appearance?
3. To what extent do adults and children agree when classifying robot appearance?
4. To what extent do children among themselves agree on their ratings of robot appearance, personality and feelings?

The remainder of the paper is structured as follows. After introducing the experimental method, we address each research question in separate sections of the results section. The last section summarizes and concludes the paper.

2 Method

2.1 Design & Participants

159 children (male: N: 82 (52%) and girls: N: 77 (48%) aged 9-11 (years 5 & 6) participated in the study (M age = 10.19 years, SD: 0.55) which used a questionnaire based design and quantitative statistical techniques. Children viewed 5 robot images, completing the robotics questionnaire for each image. Five adults from the Adaptive Systems Research Group at the University of Hertfordshire also participated in this study in terms of devising the coding scheme for the robots and providing ratings of robot appearance.

2.2 Instruments

Robot Pictures

A coding schedule was developed to categorise 40 robot images according to the following criteria: a) movement, b) shape, c) overall appearance (e.g. human, machine, animal, human-machine, animal-machine, animal-human), d) facial features, e) gender, f) functionality (e.g. toy, friend, machine). Based upon the age and cognitive abilities of the children who took part in the study, 8 groups containing 5 robot images were formed containing different robot classifications derived from the coding schedule, (total N: 40 robot images).

Robot Pictures Questionnaire: 'What do you think?'

A questionnaire was designed to enquire about children's perceptions of different robot attributes. Section one referred to questions about robot appearance (e.g. what does this robot use to move around? What shape is the robot's body?). Section two asked questions about robot personality, rated according to a 5-point Likert scale and included questions about friendliness, aggressiveness, whether the robot appeared shy, and whether the robot appeared bossy. An example question was: Do you think this robot is (or could be) aggressive? The content and structure of the questionnaire was checked with a head teacher at one of the schools to ensure that it was age appropriate.

2.3 Procedure

The Robot Pictures Questionnaire was completed by groups of between 4-8 children from a number of primary schools. Children were seated in such a way that they would be able to answer the questionnaires confidentially without distraction from other children. A set of 5 robot images were distributed to each child. Each child completed 5 copies of the Robot Pictures Questionnaire for each of the images. In the lab, 5 adults independently rated the overall appearance (e.g. human, machine, animal, human-machine, animal-machine, animal-human) for the 40 robot images.[1]

3 Results

3.1 Children's perceptions of robot personality and emotion in relation to adult ratings of robot appearance

One-way analysis of variance was carried out to examine whether there were any significant differences between children's perceptions of robot personality attributes and emotions in relation to adult ratings of robot appearance. Significant differences were revealed for robot friendliness and overall appearance (F = 5.84, (5, 795), $p < .001$), robot aggressiveness and overall appearance (F = 4.40, (5, 795), $p < .001$) and robot anger and overall appearance (F = 3.27, (5, 795), p = .006). Post-hoc analyses revealed that human-machine looking robots were rated by children as being significantly more friendly than pure machine looking robots (human-machine $\underline{X}$ = 3.66, machine $\underline{X}$ = 3.13) and human-animal looking robots (human-animal $\underline{X}$ = 2.60). For robot aggressiveness and overall appearance, post-hoc analyses revealed significant differences between pure machine looking robots and human-machine looking robots (machine $\underline{X}$ = 2.88, human-machine $\underline{X}$ = 2.36). Pure machine looking robots were rated by children as being the most aggressive according to adult ratings of robot appearance. Post-hoc comparisons highlighted significant differences between pure machine looking robots, human-machine looking robots and robot angriness (machine $\underline{X}$ = 2.88, human-machine $\underline{X}$ = 2.42) with machine looking robots being rated by children as significantly more angry compared to human-machine looking robots. No significant differences were found between children's ratings of robot shyness, bossiness, happiness, sadness and fright with respect to adult ratings of overall robot appearance (See Figure 1 for mean values of children's perceptions of robot personality attributes and Figure 2 for mean values of children's perceptions of robot emotions in relation to adult ratings).

These results indicate that children's views of robot personality and emotions were quite distinguishable according to adult ratings of different robot appearances. For example, children perceived human-machine robots rated by adults as being friendlier and less angry than pure machinelike robots.

Children's views of robot personality and emotions in relation to different robot appearances were quite different compared to adult ratings [18]. Results of children's views of overall robot appearance in relation to robot personality and emotions provided support for the Uncanny Valley with pure humanlike robots being rated by children as the most aggressive, and a mix of human-machine robots as the most friendly. In contrast, when relating children's perceptions of the robots with adult ratings of robot appearance we do not find any evidence for the Uncanny Valley. Children perceived humanlike robots ('human-like' in terms of how adults rated their appearance) as being the most friendly and least aggressive. This could suggest that children use different criteria of the robots external features in rating human-like and human-machine like robots compared to adults.

3.2 Children's perceptions of robot comprehension and adult ratings of robot appearance

Chi-square analysis in the form of cross tabulations revealed a significant association between children's views of a robot being able to understand them and adult ratings of robot appearance (X = 122.45, df = 5 (795), p = 0.000). Children stated that human-like robots were most likely to understand them (87%), followed by human-machine looking robots (76%). Only 32% of children felt that a machine-like robot would understand them if they tried to talk to it (See Figure 3.) This result indicates that children and adults may have similar perceptions

[1] We are aware that this is an unrepresentative sample for an adult population, but it seemed suitable for this preliminary study, since we wanted to link children's perceptions to potential robot designer views, and members of the research group have been involved in robot design (though not in a commercial context).

about what types of robot appearances are linked to robots being able to communicate[2].

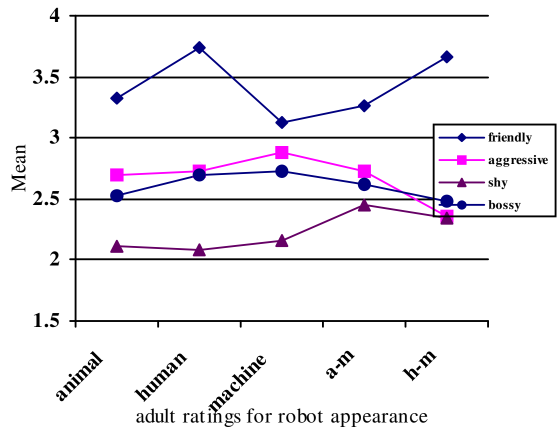


Figure 1: Adult ratings of overall robot appearance and children's ratings of robot characteristics[3]

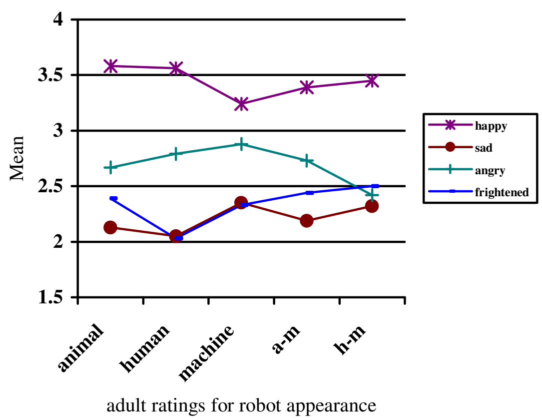


Figure 2: Adult ratings of robot appearance and children's perceptions of robot emotions

[2] Note, the term 'understanding' is a very generic and ambiguous concept, ratings might not necessarily be linked to communication skills. More research is needed to refine this work.

[3] Significance at P < .001 level for friendliness and aggressiveness in Figure 1. Shy and bossy were non-significant. (A-M = animal-machine, H-M = human-machine).

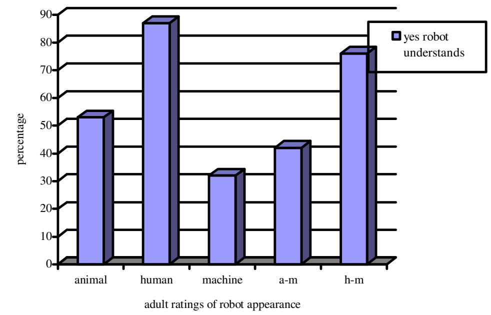


Figure 3: The association between children's perceptions of a robot understanding them and adult ratings of robot appearance.

3.3 Agreement between adult and child classifications of robot appearance

As adult and children's views are likely to be from very different cognitive and social perspectives we were interested in examining the degree of agreement between adults' and children's ratings of robot appearance. Table 1 illustrates the percentage levels of agreement between children and adults with corresponding Kappa Coefficients. The lowest percentage agreement between children and adults was for pure human-like robots, and the highest level of agreement was for machine-like and human-machine looking robots, although all Kappa coefficients were highly significant indicating high levels of agreement between children and adults for robot appearance.

Robot Appearance	% level of agreement between children and adults	Kappa Coefficient
Animal	66.7	0.77 ($p < .001$)
Machine	77.8	0.79 ($p < .001$)
Human	40.0	0.54 ($p < .001$)
Animal-machine	75.0	0.48 ($p < .001$)
Human-machine	77.8	0.66 ($p <.001$)

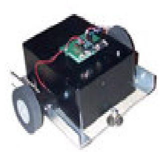
Table 1: Percentage level of agreement between children and adults for the appearance of robots.

3.4 Children's agreement for robot personality and emotions

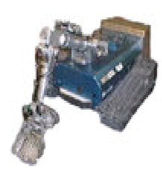
Kendall's W coefficient of concordance statistic was carried out for each of the 40 robots to examine the level of agreement between children's opinions of robot personality (friendliness, aggressiveness, bossiness, shyness) and robot emotions (happiness, sadness, anger and fright). Overall agreement across all robots was quite low although significant. The levels of concordance between children for particular robots varied considerably. The lowest level of agreement between children was for robot id number 28, and the highest level of agreement was for robot id number 59. Other robots that high levels of agreement were robots with id number 90 and 100 (see images below). See table 2 for Kendall's W coefficient statistic.

Robot Id	Low/high concor-dance	Kendall's W (KW) for robot per-sonality	Kendall's W (KW) for robot emotions
Overall (40 robot images)	Moderate	KW = 0.10 (p < 0.001)	KW = 0.12 (p < .001)
Robot 28	Low	KW = 0.02 (p = 0.67)	KW = 0.03 (p = .60)
Robot 59	High	KW = 0.45 (p < 0.001)	KW = 0.43 (p < .001)
Robot 100	Moderate	KW = 0.48 (p < 0.001)	KW = 0.21 (p = .01)
Robot 90	High	KW = 0.52 (p < 0.001)	KW = 0.53 (p < .001)

Table 2: Children's agreement for robot personality & emotions for different robots (Kendall's W values and corresponding significance levels).



Robot image no. 28: lowest levels of child agreement



Robot image no. 59: highest levels of child agreement

Robot image no. 100: high level of child agreement

Robot image no. 90: high level of child agreement

A one-way analysis of variance was carried out between children's ratings of overall robot appearance and the Kendall's W concordance rating. No significant differences were uncovered (F = 0.49, (4, 40), p = 0.75) indicating no differences between children's levels of agreement on robot personality and emotions and the different types of robot appearance. Thus, agreement across children was no better for human-like robots than for machine-like robots. Results of a Mann Whitney U test did not reveal any significant median differences but it was clear from an error plot that those robots rated as being human-like in appearance had less spread in variance even though it was still quite low on consistency. Other robot appearances had much more variance.

4 Discussion and Conclusions

Firstly, the current study explored the levels of agreement between adults and children for overall robot appearance. Secondly, we considered children's ability to differentiate between different robot personality and emotions according to adult ratings of robot appearance, and finally the level of agreement among children for robot personality and emotions was examined.

A summary of the main results indicated that:

- Children only differentiated between certain robot behaviours (aggressiveness and friendliness) and emotions (anger) in relation to the overall robot appearance ratings by adults.
- Overall, children and adults demonstrated high levels of agreement for classifications of robot appearance, particularly for machine-like and human-machine robots.
- In contrast to previous findings suggesting evidence for the Uncanny Valley based on children's ratings of robot appearance, this finding was not replicated with respect to adult ratings of robot appearance.
- An exploration of children's levels of agreement for particular robots and robot personality and emotion revealed varying degrees of agreement.
- No differences were found between children's levels of agreement on robot personality and emotions and the different types of robot appearance (i.e. agreement across children was no better for human-like robots, as rated by children, than machine-like robots).

The finding that agreement between children and adults for classifications of overall robot appearance was generally high is a positive result for the future design of robots. As adults and children have different social and cognitive views of the world [20] we expected less agreement.

The levels of agreement demonstrated by children for robot understandability in relation to adult ratings of overall robot appearance was a positive finding as it suggests that robots can be designed in such a way that children are able to differentiate this dimension[4]. However, closer exploration is required to determine what the exact features are that allow children to distinguish in their minds whether a robot is able to understand them or not (e.g. is it the fact that the robot has a mouth or general human form?)

Results from this study point to the notion that children were only able to differentiate between certain robot personalities and emotions in relation to adult ratings of robot appearance. This could be attributed to a number of reasons including the fact that children aged 9-10 have a limited understanding of applying emotions and certain personalities to robots. The results showed that children differentiated between robot friendliness, aggressiveness and anger and robot appearance but not for more subtle personalities and emotions such as bossiness, shyness, fright. However, it was somewhat surprising that children did not distinguish between sadness and happiness as children should have a clear understanding of these two basic emotions at aged 9-10. Another explanation could be that robots are not yet able to convey subtle emotions and personalities such as shyness and fright, therefore making it hard for the user to recognise the possibility of such personalities. This question is worth further exploration for designers as it would certainly be a desirable feature for robots to be able to perform and exhibit subtle personalities and emotions. In future, this needs to be explored with some live interactions between children and robots and cannot be fully answered by the current study as only static images of robots were used which is a limitation of the present study.

It is important to consider children's overall agreement towards the personality and emotions of different robots as designers' intentions are usually to convey a particular type of personality in line with a particular robot. For example, AIBO has been designed to be a toy or a pet and designers wanted to convey it as being a friendly non-aggressive robot. From a designer point of view, one would hope that there would be high agreement between children for this robot being friendly, happy and non-aggressive. It would be disappointing if some children viewed it as a sad, aggressive and angry robot. The findings of the current study revealed that for particular robots there was high agreement among children towards the robots personality and emotions but for others agreement was extremely low. It was somewhat surprising that agreement across children for robot personalities and emotions were not affected by the overall appearance of the robot as rated by the children. One might have expected for example that children would demonstrate higher agreement for human-like robots compared to a mixture of human-machine like robots. This is worthy of further study as designers in the future could well want to design different robot appearances that have definite personalities and emotion patterns. To assist with the future design of robots, designers should perhaps compare the appearance of those robots that lead to highly consistent views with those that were inconsistent. This result highlights the importance of adults to include children in the design phase of robots, that are meant for a child target audience, from the outset of the planning stage to ensure that children's views are accurately captured [21].

The previous finding that children's perceptions of robot personality and emotions, according to their ratings of human-like appearance, fell into the Uncanny Valley could not be confirmed in relation to adult ratings of robot appearance. This is an interesting finding and emphasises the importance of considering children's views of particular robot appearances in addition to adults. The Uncanny Valley theory proposed by Mori [13] posited that as a robot increases in humanness, there is a point where the robot is not 100% similar to a human and the balance becomes uncomfortable or even repulsive. Children clearly felt uncomfortable with their views of pure humanlike appearances (according to how they judged 'human-like'), but did not experience this discomfort based on adult ratings of humanlike robot appearance. Note, while a large sample of children was used in the present study, only few adults participated in the study. A larger adult sample size would clearly be desirable for future work.

Overall, the study emphasises the importance of designers considering the input of children's ideas and views about robots before, during and after the design and construction of new robots specifically pitched for children. In order to overcome the limitations of the current study, future studies should consider children's attitudes using live child-robot interactions and should pay closer attention to the finer details of robot appearance that are necessary to communicate different personalities and emotions. Future studies could also consider comparing adult and children's views of robot personality constructs and emotions and how these relate to the appearance of robots. Finally, while in the present study adults with a robotics related background were considered 'potential robot designers', future studies involving professional robot designers are necessary

[4] Note, not all the robots included in our study were specifically designed for a child target audience.

in order to investigate in more depth the relationship between children's views of robots designed by adults.

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