Effects of previous exposure on children's perception of a humanoid robot

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Abstract. The study described in this paper investigated the effects of previous exposure to robots on children's perception of the Kaspar robot. 166 children aged between 7 and 11 participated in the study in the framework of a UK robotics week 2018 event, in which we visited a local primary school with a number of different robotic platforms to teach the children about robotics. Children's perception of the Kaspar robot was measured using a questionnaire following a direct interaction with the robot in a teaching scenario. Children's previous exposure to other robots and Kaspar itself was manipulated by controlling the order of children's participation in the different activities over the event. Effects of age and gender were also examined. Results suggest significant effects of previous exposure and gender on children's perception of Kaspar, while age had no significant effect. Important methodological implications for future studies are discussed.

Keywords: Robot perception, Child-Robot Interaction, Assistive robots.

1 Introduction

The study detailed in this paper was part of a UK Robotics week 2018 event, in which the University of Hertfordshire's Adaptive Systems Research Group members visited a local primary school with several different robotic platforms to teach the children about robotics. In total 175 children took part in the event, involving six classes in the school, 166 of which were involved in the study. Among other activities, every child had the opportunity to a) program the Kaspar robots [1, 2] using Scratch [3], b) teach the Kaspar robot via a semi-autonomous human-robot-interaction, c) learn how to use 3D CAD software (SketchUp) [4] at a basic level, d) learn about the principles of 3D printing and e) see how Artificial Intelligence algorithms on a small 3D printed 18 DOF hexapod robot, called Scampi, affected the autonomous behaviours of the robot. The study we present in this paper is focusing on one specific aspect of this event, namely on how children's exposure to the different activities affects their perception of the Kaspar robot, along with other factors such as age and gender.

2 Background and Motivation

The child sized humanoid robot, Kaspar, was built by the Adaptive Systems Research Group at the University of Hertfordshire to help children with Autism Spectrum Disorder (ASD) with their communication and social interaction skills. The robot possesses some distinct advantages when working with children with ASD. Kaspar's simple, minimally expressive features and the predictability of its behaviour make the interaction easy and enjoyable for them [1]. Kaspar has been successfully used in a number of long term studies - with positive developmental and therapeutic outcomes - involving more than 230 children over the years [5, 6]. However, the use of Kaspar should not be restricted to children with ASD. In fact, as Kaspar is getting increasingly used in different environments such as schools, it is also being considered as an educational tool for typically developing (TD) children. Recent evidence suggested that Kaspar could be used in robot-mediated interviews as well, showing that children respond to it in a similar way as to a human interviewer and pointing towards the prospect of using robots when human interviewers may face challenges [7, 8].

Although many robots are specifically designed to be used with children (e.g. for therapeutic and educational purposes), studies investigating attitudes, perception and preferences about robots are still generally focusing on adults [9-11]. As Woods et al. suggested [10], if robots are to be successfully used within activities involved in the education, children's perception of robots should be at the center of the research. Even so, very few studies have examined specifically children's perception of robots before [12]. In a previous study Woods et al. [10] tested children's perceptions of 5 different robots with regards to physical attributes, emotional traits and personality via a questionnaire study using a large sample of TD children. Results of this study indicated that children distinguished between emotions and behaviour when judging robots based on their images. Children judged human-like robots as aggressive, but animal-like and human-machine robots as friendly (supporting the Uncanny Valley [13]). However, as the authors also recognized, reliance on images of the robots could make it difficult to relate to the actual robot behaviour [10]. Hence, it is essential to expose children to real robots when measuring their perception of robots.

To our knowledge there has been only one study comparing the perception of robots of TD children (N=46) and children with ASD (N=18). This study involved Kaspar [11], and used a specifically designed "matching pictures game" to measure children's perception of robots. Pictures featured 6 social robots to be matched to one of the following categories: machines, humans, animals and toys. In addition, the authors measured the preference for a certain robot by ranking. Findings suggested that both groups of children perceived robots mainly as toys, although a big percentage of children with ASD, especially boys, also perceived robots as machines. According to the findings the best preferred robot by both groups of children (Keepon) had exaggerated cartoon-like features [11]. With regards to Kaspar, however, results of this study were somewhat controversial. While children with ASD rated Kaspar both high and low ranked, TD children rated Kaspar mainly low ranked, which the authors explained by the phenomenon of Uncanny Valley. However, again, it is important to note that pictures do not give any impression of a robot's size, or its movement and interaction capabilities, and while children are clearly attracted to a cartoon-like robot, the range of interactions supported by these robots also have to be taken into consideration.

This is why in the current study we investigated children's perception of the Kaspar robot using a short questionnaire following a direct interaction with Kaspar in a simple teaching scenario. Additionally, we varied children's previous exposure to Kaspar and other robots before this interaction. Interestingly - to our knowledge - no studies have methodically examined the effects of previous exposure on the perception of social robots before, even though it can have important implications for the design of HRI experiments. In the current study, children either a) participated in the teaching scenario without any previous exposure to Kaspar and other robots, b) were previously exposed to an activity with Scampi, a robot substantially different to Kaspar, or c) were previously exposed to both Scampi and Kaspar. Our hypothesis here was that prior exposure to Kaspar improves the perception of the robot.

3 Methods

3.1 Participants

One hundred and sixty-six (N=166) children (83 male, 83 female) took part in the study, aged between 7 and 11 (49 children from Year 3, 59 children from Year 4 and 58 children from Year 5). Participants were randomly assigned to one of the three experimental conditions that manipulated their exposure order to the activities with the different robots, while maintaining age- and gender-balanced distributions.

3.2 Experimental Procedure

Children in each class were broken down into three groups. Each of these groups focused on a different activity for eighty minutes before having a break then rotating to the next activity until all of the children had taken part in all of the activities.
This research was approved by the University of Hertfordshire's ethics committee for studies involving human participants, protocol numbers: acCOM SF UH 02069 and cCOM/SF/UH/02080. Informed consent was obtained in writing from all parents of the children participating in the study.
A description of each of the activities is as follows (see also Fig. 1):

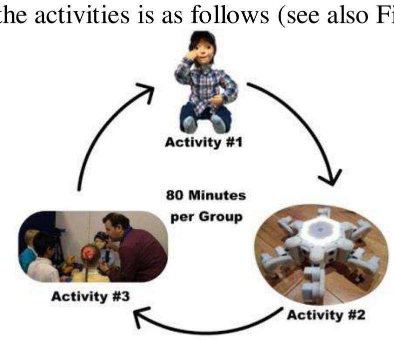

Fig.1. Children spent eighty minutes on each activity before rotating to the next activity.

Activity #1 - Programming the Kaspar robot

In this activity children were working in pairs. Each pair had access to a Kaspar robot, which they were able to program via Scratch [3]. A researcher and a school teacher assisted the children in programming the Kaspar robot to display five different emotions [14]. The children learned about the basic principles of how robots can be programmed. Details of this work can be found in a previous publication [14].

Activity #2 – Observing Scampi

In this activity the children were taught about the principles of Artificial Intelligence (AI). The children saw a number of demonstrations with the Scampi robot (Fig. 1) displaying a range of preprogrammed animal behaviours, after which they were divided into two sub-groups where they could control Scampi or play with some additional multi-function robots that could play tunes, follow lines or avoid objects.

Activity #3 – Teaching Kaspar

This activity focused on teaching the children about how robots are designed and manufactured. In this session the children had a 30 minutes lesson where they learned how to use a piece of Computer Aided Design (CAD) software called SketchUp [4] and as part of this they would design a house or a castle to learn the basic concepts of CAD. At the end of this lesson the children were broken into 3 groups where they rotated though three different activities, spending 10 minutes on each. These activities were: a) interacting with the Kaspar robot in a game where they could teach the robot, after which children filled out the post-interaction questionnaire (items of which were used as dependent measures in this study); b) thinking about how a number of robotic toys worked; c) learning about conductivity and which objects were conductive.

Since the study we are reporting in this paper is focusing on the results of the post-interaction questionnaire children filled out after interacting with Kaspar in the teaching scenario, we are going to provide a few more details on this interaction below.

The interaction involved small groups of 2-3 children at a time and Kaspar. During the interaction children had to teach Kaspar how to recognize different animal toys. Before the sessions Kaspar was programmed to know that there were six potential toys in the room with different names. However, it was the task of the children to teach Kaspar which name was associated with which animal toy. The children took turns to teach this to Kaspar. Teaching was realised by Kaspar autonomously pointing at each of the toys and saying one of the animal names to find out if that is the right one. The children answered by using a key fob and pressing either the green or the red button depending on Kaspar's actions (green = correct or red = incorrect). Kaspar continued to guess the names of the animal toys until it could name each one of them correctly. Details of technical realisation of this experiment were reported in the paper of Zaraki et al. [15]. Once the interaction was over, children were asked to fill out the post-interaction questionnaire (Table 1) in the presence of a researcher who made sure that all questions were clear to the children. Items 1-4 and Item 6 were measured on a 5-point Likert scale, depicted with happy/sad faces to make the choice easier for the children. Item 5 was a dichotomous question.

Table 1. Questionnaire items used as dependent measures

Questionnaire Item
1. Did you think Kaspar was capable of showing emotions?
2. Did you find Kaspar being capable of caring?
3. Do you think Kaspar can have real emotions and feelings?
4. Do you think Kaspar could be a real playmate to you? (Like one of your friends)
5. Do you think Kaspar is more like a toy or a friend? (Tick one of the boxes)
6. Playing with Kaspar was? (Rate from very boring to very fun)

3.3 Experimental conditions

Experimental groups were created based on the children's order of exposure to the different activities. Accordingly, participants of Group 1 took part in Activity #3 first, having had no previous exposure to either Scampi or programming Kaspar before interacting with Kaspar in Activity #3 and filling out the post-interaction questionnaire on their perception of Kaspar. Group 2 started with Activity #2 followed by Activity #3, and so filled out the questionnaire before taking part in Activity #1, programming Kaspar. Group 3 took part in both Activity #1 (programming Kaspar) and Activity #2 (observing Scampi) before interacting with Kaspar in Activity #3 and filling out our post-interaction questionnaire.

4 Results

4.1 Statistical analysis

IBM SPSS Statistics 21 was used for the statistical analysis. Since we collected ordinal and nominal questionnaire data, non-parametric procedures were used for the data analysis. Kruskal-Wallis test was used to examine the effects of previous exposure to robots and the effects of year groups. Post-hoc tests with Bonferroni corrections were used to identify specific differences among the three groups. Effects of gender were examined by Mann-Whitney U-test. Effects of exposure and year groups on the binomial nominal data of the Item 5 were tested by $\chi 2$ test, while effects of gender on the same item were tested by Fisher's exact test.

4.2 Effect of previous exposure

Significant effects of previous exposure were found on children's subjective perception of the Kaspar robot on Items 1, 5 and 6. Kruskal-Wallis test revealed significant differences in participants' rating of the robot on the items "Did you think Kaspar was capable of showing emotions?" ($\chi^2(2)=11.11$; $p=0.004$) (Fig. 2) and "Playing with Kaspar was ….. - Rate from Very Boring to Very Fun" ($\chi^2(2)=8.08$; $p=0.018$) (Fig. 3). Post-hoc tests with Bonferroni corrections showed significant difference between

Group 1 (starting with Activity #3 with no previous exposure to other robots) and Group 3 (taking part in both Activities #1 and #2 before interacting with Kaspar in Activity #3) in case of both of the above items (p=0.03 and p=0.014 respectively). No significant differences were found between Group 1 and Group 2 (taking part in Activity #2 first followed by Activity #3) suggesting that having had the experience of programming Kaspar made the children rate Kaspar higher on these items, while their exposure to Scampi only had no effect on their ratings.

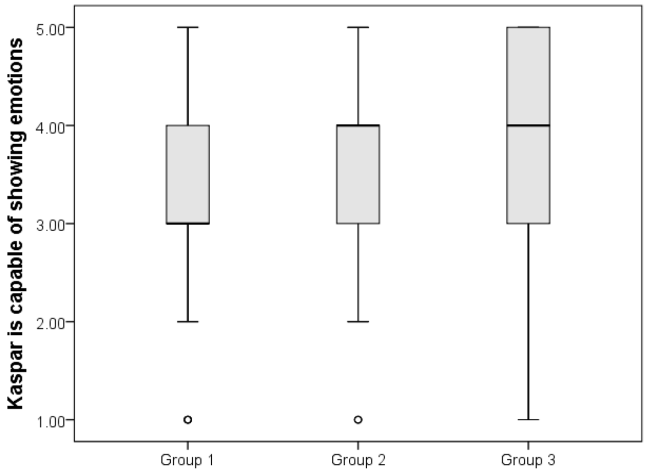

Fig. 2. Effect of exposure on Item 1 "Did you think Kaspar was capable of showing emotions?", ranging from 1=definitely no to 5=definitely yes.

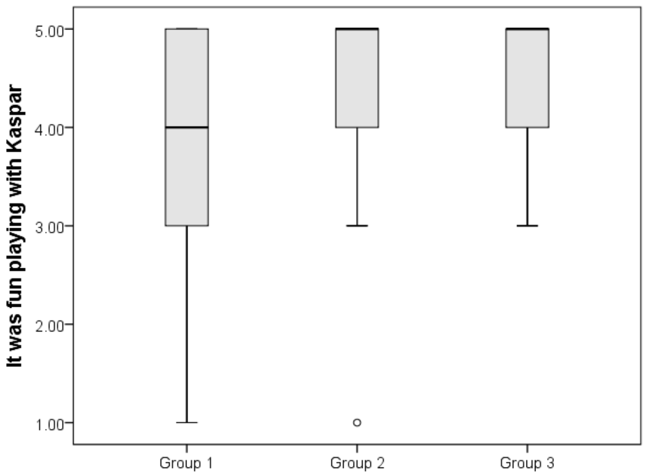

Fig. 3. Effect of exposure on Item 6 "Playing with Kaspar was? (Rate from very boring to very fun)?", ranging from 1=boring to 5=fun.

We found further significant effect of exposure on the item "Did you think Kaspar is more like a toy or a friend?" ($\chi^2(2)=7.69$; $p=0.021$). Adjusted residuals and p values after Bonferroni corrections revealed that the difference was explained by Group 1 (Group 1: Adjusted residual Z=2.72; $\chi^2(2)=7.39$; $p=0.007$; Group 2: Z=-0.73; $\chi^2(2)=0.53$; $p=0.465$; Group 3: Z=-2.00; $\chi^2(2)=4.00$; $p=0.046$; Bonferroni adjusted significance level: $p=0.016$). Children in Group 1 – interacting with Kaspar before the other activities - categorised Kaspar significantly less often as a friend compared to children who participated in the activities in a different order. Note, however, that all 3 groups categorised Kaspar mainly as a friend instead of as a toy (Fig. 4).

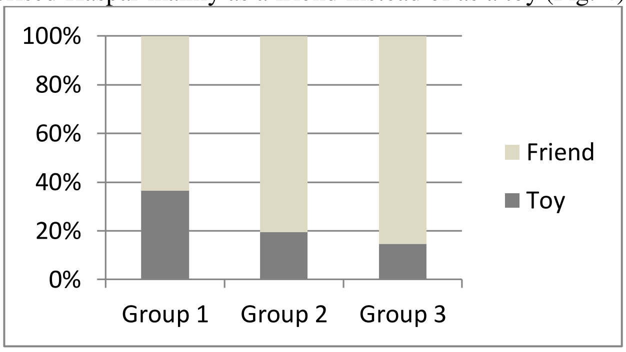

Fig. 4. Effect of exposure on the dichotomous Item 5 "Do you think Kaspar is more like a toy or a friend?".

No significant difference was found in case of any other items ("Kaspar being capable of caring": $\chi^2(2)=5.37$; $p=0.068$; "Kaspar being a real playmate": $\chi^2(2)=4.84$; $p=0.089$), although the item "Kaspar having real emotions" was marginally significant ($\chi^2(2)=11.11$; $p=0.057$). Note, that children of all groups rated Kaspar generally high on all items (Fig. 5).

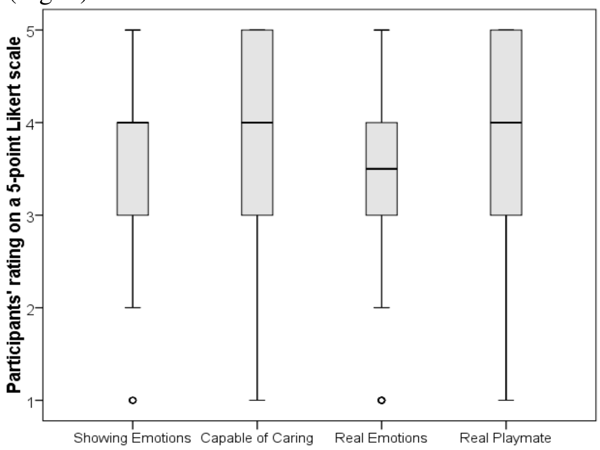

Fig. 5. Children's rating of Kaspar on Items 1, 2, 3, and Item 4. Since there was no significant effect of exposure on these items, this figure shows the medians for all participants (N=166).

4.3 Effect of age and gender

Year groups had no significant effect on any of the items ("Kaspar being capable of showing emotions": $\chi^2(2)=0.28$; $p=0.86$; "Kaspar being capable of caring": $\chi^2(2)=1.98$; $p=0.37$; "Kaspar having real emotions": $\chi^2(2)=0.66$; $p=0.71$; "Kaspar being a real playmate": $\chi^2(2)=0.45$; $p=0.79$; "Kaspar is more like a toy or a friend" ($\chi^2(2)=3.09$; $p=0.21$; "fun playing with Kaspar": $\chi^2(2)=0.78$; $p=0.67$).
Girls categorised Kaspar significantly more often as a friend (vs being a toy) than boys (Fisher's exact test p=0.033). In addition, there was a marginally significant effect on the item "Did you find Kaspar being capable of caring?", girls rating this item marginally significantly higher than boys (U=2446.5, p=0.051). No further gender effect was found ("Kaspar being capable of showing emotions": U=2928.5, p=0.78; "Kaspar having real emotions: U=2827.0, p=0.93"; "Kaspar being a real playmate": U=2602.5, p=0.27; "fun playing with Kaspar": U=2449.0, p=0.07.)

5 Discussion

Findings showed significant effect of exposure on children's perception of Kaspar. Children who have been exposed to the Scampi robot and have had the opportunity to program Kaspar to express simple emotions before interacting with it in the teaching scenario, rated Kaspar higher on several items and categorised it significantly more often as a friend than children who have not been previously exposed to the other activities. We have to note, however, that this change in perception could be related to several factors other than children's experience of programming Kaspar, such as the time spent on each activity. In Activity #1children had more time to interact with Kaspar than in Activity #3. Additionally, in Activity #1 children worked in pairs, which allowed them to acquire more hands-on experience with Kaspar, which could further explain why participating in Activity #1altered their perception. It is also important to note, that children's perception of Kaspar was generally very positive after the interaction with Kaspar in the teaching scenario even without any previous exposure, with 63.4% of children categorising Kaspar as a friend instead of a toy. This positive perception of Kaspar may seem to contradict earlier findings of Peca et al. [11], who found that Kaspar was among the least preferred robots by TD children (although our results are not directly comparable to theirs). These seemingly contradictory results may provide further evidence for the effect of exposure and emphasize the importance of measuring perception of robots based on real human-robot interactions as opposed to using images only, especially with children. A robot's appearance only does not convey enough information on its movements or expressive behavior.

No significant effect of Year groups was observed, which is in line with earlier findings of Tung et al. [16] who found that the effect of children's age on their attitude towards robots with various degrees of anthropomorphic appearance was less significant than the effect of gender. We have to note however, that using Year groups is not the best way to measure age effect and using the actual chronological age of the children might have shown a different result. In addition, our Year groups were not perfectly balanced in numbers, which we could not control. Regarding the gender effects on children's perception of Kaspar, we found that girls categorised Kaspar significantly more often (55.8%) as a friend than boys (44.2%) and rated Kaspar slightly more capable of caring (51.3%) than boys did (48.7%). These results further strengthen Tung et al.'s [16] findings that girls are more accepting of human-like robots, than boys. Interestingly, Peca et al. [11] did not find any significant gender effect among TD children, they did find however significant gender effects among children with ASD. With regards to Kaspar it appears that among children with ASD boys mainly categorised Kaspar as a human while girls categorised it mainly as a toy.

Although this study offered a real human-robot interaction scenario for gauging perception of children against the Kaspar robot, it still has several limitations. These limitations involve the lack of objective behaviour analysis that could provide more reliable results than subjective ratings of questionnaire items. A further limitation is the lack of behaviour manipulation of the robot, which could give us a much clearer picture of how robotic behaviour affects the perception of robots. Additionally, our three activities took place on the same day, and thus our study did not assess impact of novelty versus repeated exposure, which also leaves room for further exploration.

6 Conclusion

Our results emphasize the importance of using actual robots when measuring perception of robots as it is a complex question - dependent on several factors - that cannot be solely based on robot appearance only. In addition, the findings have important implications to all HRI studies, informing the HRI community that caution has to be taken when recruiting participants for a human-robot interaction study, considering participants' previous exposure to robots as it can influence the results greatly.

The positive perception and attitude towards Kaspar that TD children showed in this study supports the potential usability of Kaspar in several different scenarios in the future. Kaspar could work as an educational tool for TD children as well as for children with ASD, or as previous studies suggested, it could potentially even provide advantages in robot-mediated interviews with children in challenging situations [7, 8].

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