Children's Perceptions of a Learner-Robot

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Abstract

In the present article, we investigate children's perceptions of a robot in a one-to-one 'learning-by-teaching' scenario where a robot acts as a 'learner' and a child as a 'tutor'. In the scenario, the tutor-child corrects the handwriting errors of the robot. We test the scenario with the robot's three different competencies as study conditions: '*continuous-learning*'; '*non-learning*'; and '*personalised-learning*'. The preliminary results indicate that the robot's competencies did not affect children's perception of the robot's social role but affected their perception of robot's intelligence.

1 Introduction

Since child-robot interaction is inherently social [9], it becomes crucial to investigate different aspects of the social relationship between robots and children. The studies that incorporate interactions between children and humanoid robots are also believed to engage and motivate students [8, 10]. For example, Kanda et. al [5], used Robovie, a humanoid robot, as an English peer-tutor for Japanese students and concluded that the robot encouraged some of the students to improve their English and form relationships with them. Similarly, Hood et al. [2] used Nao robot[1] with the aim of improving children's writing skills and induce engagement while writing. However, *how do the children perceive these robots? How do these perceptions change over multi-session interactions?* Children's perception towards a robotic agent is related to several aspects such as the robot's role, physical or nonphysical behaviour, appearance, and indeed seems to be relevant in child-robot interactions [1, 3, 4, 7, 11]. In fact, Kennedy et al. [6] conducted a study where a social vs. asocial robot (Nao robot) taught prime numbers to children of 7 to 8 years of age. After the interaction, the children were asked to attribute a role to the robot out of 8 available options (brother or sister, classmate, stranger, relative , friend, parent, teacher, and neighbour). The results showed that the children consistently perceived the tutor-robot as a friend. Although, there has been some research done on children's perception of robots, it has not been explored that how children perceive the abilities of a robot in educational scenarios in multi-session studies, and how their perceptions change over time.

2 Study

The study was conducted in 'Escola 31 de Janeiro' in Parede, Portugal. 37 Portuguese speaking children participated in the age-group of 8 to 9 years (3rd grade) over a period

[1] Aldebaran robotics: `https://www.aldebaran.com/en`

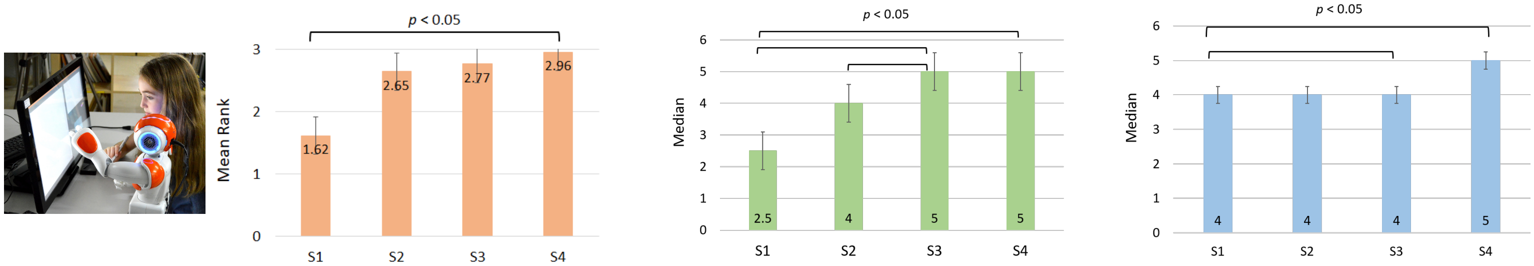

Figure 1. Experimental Setup(extreme left); Results of the children's perceived intelligence in PL condition(orange graph); perceived writing ability in the CL condition (green graph) and PL condition (blue graph)

of 6 to 7 week. Twelve children (M=8.2; SD= 0.43; 6 male and 6 female) participated in the *continuous-learning condition* (CL), 12 children (M=8.5; SD=.5 years old; 8 male and 4 female) participated in the *non-learning condition* (NL) and 13 children (M=8.5; SD=.49 years old; 5 male and 8 female) participated in the *personalised-learning condition* (PL). The material in the study included a computer with a touchscreen, stylus, tablet (for pre- and post-test), video camera, microphone, Nao robot (only torso part) and English alphabet (uppercase & lowercase) for a writing activity. Our study consists of a between-subjects design with three conditions: *continuous-learning* & *non-learning* and *personalised-learning*. The scenario involves a learner-robot (named Miguel) writes an incorrect letter on the touch-screen and asks help from a teacher-child for correcting it (Fig. 1). In the continuous-learning condition, the robot improves its writing at a constant rate (that is, it is actually becoming competent in learning how to write). In the non-learning condition, the robot does not improve its writing and consistently give poor performance. In the personalised learning, the robot adapts the child's performance (that is, it performs better if child performs better). Each child interacts four time with the robot with an interaction gap of 4-5 days. After the interaction, an experimenter asks the child to perform a pre-and post-test. Then, the experimenter interviews the child for 5-to-6 minutes regarding his/her perception of the robot's capabilities. One of the research question in the study is: *to explore children's perceptions towards a social robot in a multi-session study in an educational context*. In the next section, we present a few preliminary results regarding children's perception of the robot; however, further analysis needs to be done to explore children's learning gains.

3 Results & Discussions

3.1 Children's perception of the robot's capabilities

As mentioned above, the experimenter asks a set of questions to children after finishing each session. Concerning perceived robot's intelligence and writing ability, the asked questions are stated as follows: (1) how many stars would you like to give for Miguel's intelligence? (2) How many stars would you like to give for Miguel's writing ability? These questions were presented on a paper in a child friendly manner and were based on 5-point Likert scale (1 point-*lowest*; 5 points-*highest*). Each point in the scale represents a star (*e.g.*, ⋆ ⋆⋆ ⋆⋆⋆ ⋆⋆⋆⋆ ⋆⋆⋆⋆⋆). For the analysis purpose, each chosen point by the children is considered as a score. A Friedman test was run to determine if there were differences in the children's perception of robot's intelligence and writing ability between the four sessions within each condition. Additionally, a Kruskal-Wallis test was conducted to determine the differences between the conditions.

Intelligence: Pairwise comparisons were performed with a Bonferroni correction for multiple comparisons. The results of the PL condition showed a significant difference in perceived robot's intelligence between the sessions, $X^2(3) = 15.15$, $p = 0.002$. Post hoc analysis further revealed statistically significant differences from Session 1 (Mdn = 4) to Session 4 (Mdn = 5) (p = .04)(see Fig. 1), but not between the remaining combinations of the sessions. In addition, no significant results were observed across the sessions in the CL and NL conditions. The results of Kruskal-Wallis test including the post hoc (Dunn's (1964) procedure with a Bonferroni correction) analysis revealed statistically significant differences in intelligent scores only after the last session between the PL (Mdn = 5, Mean Rank = 16.27, n = 13) and NL condition (Mdn = 4, Mean Rank = 9.46, n = 12) (p = .01). We did not find any significant differences in other combinations of conditions. The overall results suggests that the continuous-learning (CL) and non-learning (NL) competencies of the robot did not affect children's perception of robot's intelligence. But, when the robot adapts its writing skills according to the pace of the children in PL condition, they perceived it more intelligent compared to the children in the NL condition.

Writing Ability: There was a statistically significant difference in perceived robot's writing ability in the CL ($X^2(3) = 26.41$, $p = 0.00$) and PL condition ($X^2(3) = 18.27$, $p = 0.00$). We did not find any significant results in the NL condition. Further, Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied in the CL and PL condition, resulting in a significance level set at $p < 0.008$. In the CL condition, we found statistically significant difference in perceived robot's writing ability between combinations of sessions: Session 1 and Session 3 (Z = -2.98, p = 0.003); Session 1 and Session 4 (Z = -2.96, p = 0.003); Session 2 and Session 3 (Z = -3.00, p = 0.003)(see Fig. 1). Similarly, in the PL condition, we found statistically significant differences between: Session 1 and Session 3 (Z = -2.71, p = 0.007); Session 1 and Session 4 (Z = -2.73, p = 0.006)(see Fig. 1). Additionally, we did not find any significant differences between the conditions. Overall, these results indicate that the children were able to perceive the improvement in robot's writing skills between the sessions in the CL and PL condition, which is consistent with the actual writing skills of the robot in both condition. And, they they did not perceive the changes in robot's writing skills in the NL condition, which is again coherent with the robot's writing skills as it was not improving throughout the sessions. Moreover, the children were not able to differentiate robot's writing skills between the conditions.

3.2 Children's perception of the robot's role

For exploring their perceived robot's role as a social partner and a writer, the experimenter asked two categorical based questions: (1) How do you consider Michael as a? (*options: Classmate; Friend; Brother; Relative; Stranger; Parent; Neighbor; Teacher; None*); and (2) What do you think Michael writes like a? (*options: A child younger than you; Like you; Like your friend; Like your teacher; Like your parents; Like your brother or a sister (younger/older*); None). For both questions the children had to choose one option. A chi-square goodness-of-fit test was conducted to determine how children perceived the robot as a social partner and a writer.

Social Role: As shown in Table 1, the results suggest that in all the conditions for each session, the children perceived statistically significantly different roles to the robot. And the preferred role as a social partner is a 'friend'.These results indicate that the children considered the robot as a friend irrespective of the conditions and sessions. Despite being told by the experimenter multiple times about their role and the robot's role, they perceived the robot as a 'friend' compared to other available options.

Writing Role: The results indicate that the children perceived the robot in a writing role statistically significantly different; but, only at a few sessions. They considered the robot as a writer which is younger than themselves in all the conditions. For example,

Table 1. Chi-square values are presented for each condition (CL, PL & NL) in the four sessions (Session1 - S1...Session4 - S4)

	S1	S2	S3	S4
CL	$X^2(3) = 13.50$, $p = 0.001$	$X^2(3) = 8.33$, $p = 0.004$	$X^2(3) = 9.5$, $p = 0.009$	$X^2(3) = 13.50$, $p = 0.001$
PL	$X^2(3) = 09.46$, $p = 0.02$	$X^2(3) = 9.30$, $p = 0.002$	$X^2(3) = 9.3$, $p = 0.002$	$X^2(3) = 15.3$, $p = 0.000$
NL	$X^2(3) = 13.50$, $p = 0.001$	$X^2(3) = 8.33$, $p = 0.004$	$X^2(3) = 9.5$, $p = 0.009$	$X^2(3) = 13.50$, $p = 0.001$

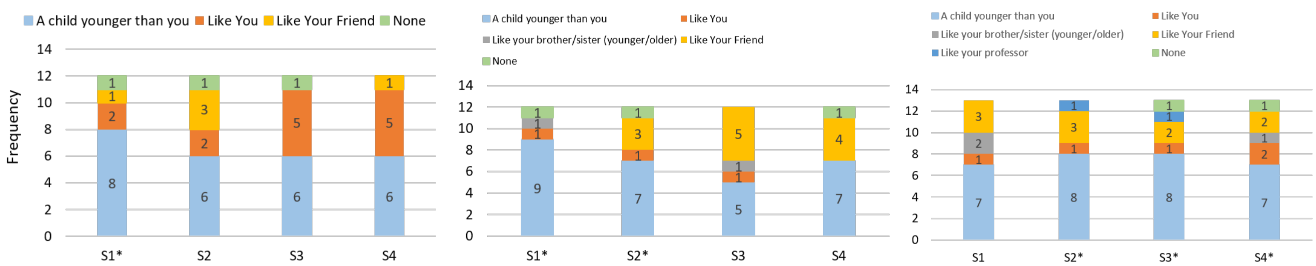

Figure 2. Results of the children's perceived writing role in all sessions (S1, S2, S3, and S4) for the three conditions: CL condition (Left); NL condition (Middle); PL condition (Right) (⋆ - Sig.).

in the CL condition, the children perceived the robot significantly different only in the Session 1 ($X^2(3) = 11.33$, $p = 0.01$). Similarly, in the NL condition, the first two sessions showed significant difference in perceived roles, Session 1 ($X^2(3) = 16.00$, $p = 0.001$) and Session 2 ($X^2(3) = 8.00$, $p = 0.04$). Nevertheless, in the PL condition, the last three consecutive sessions showed significant differences, Session 2 ($X^2(3) = 10.07$, $p = 0.01$), Session 3 ($X^2(3) = 14.3$, $p = 0.006$) and Session 4 ($X^2(3) = 9.69$, $p = 0.04$). Moreover, a chi-square test of independence was conducted between the conditions in each session to find the difference in perceived role as a social partner and writer. We did not find any significant difference. The above-mentioned findings in the CL condition indicate that in the first session, most of the children perceived the robot as a 'younger child'. As the robot improved its writing skills in remaining sessions, the children did not consider it only as a younger child but also more like themselves (see Fig. 2). In the PL condition, in the first two interactions, they perceived the robot as a 'younger child' but in the last two interactions their perceptions changed and they started considering the robot like their friend (see Fig. 2). Finally, in the PL condition, in the last three interactions children consistently preferred the robot as a younger child (see Fig. 2). In all the conditions, they consistently considered the robot as a younger child (specially in the initial interactions). It may be due to the help they provided to the robot and it's small size. Overall, this perception of being seen as a younger child seems to be positive for the scenario of learning-by-teaching.

4 Conclusions

We present the initial findings regarding children's perceived impressions, capabilities and role of the robot in a one-to-one peer-tutoring situation. The results clearly suggests that some of the children's perceptions change depending on the robot's skills; however some are unaffected by it. For instance, the learning competencies of the robot did not affect children's perception of the robot's social role; but they affect children's perception of robot's intelligence. Additionally, most of the results were only found in the last interactions with the robot, demonstrating the significance of multi-session studies.

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