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Children's age influences their perceptions of a humanoid robot as being like a person or machine.

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Abstract. Models of children's cognitive development indicate that as children grow, they transition from using behavioral cues to knowledge of biology to determine a target's animacy. This paper explores the impact of children's' ages and a humanoid robot's expressive behavior on their perceptions of the robot, using a simple, low-demand measure. Results indicate that children's ages have influence on their perceptions in terms of the robot's status being a person, a machine, or a composite. Younger children (aged 6) tended to rate the robot as being like a person to a substantially greater extent than older children (aged 7) did. However, additional facially-expressive cues from the robot did not substantively impact on children's responses. Implications for future HRI studies are discussed.

Keywords: HRI, design,

1 Introduction

1.1 Background

With the increasing development of robots as toys, social companions, and tutors targeted towards children as users in human-robot interaction (HRI), understanding the means by which children perceive and evaluate robots is critical for HRI. Determining whether HRI is a special boundary-case for children or simply part of their existing interactions with non-living objects allows the use and testing of established developmental-psychology models of children's beliefs and behaviors. One such model considers children to develop naïve theories of animacy, transitioning from reliance on observing a target's behavior to knowledge of its biology [1]. Bio-inspired robotics can be used to explore such models, altering robots' appearances and behaviors to determine influence on children's perceptions of their animacy. It is important to consider the influence on HRI that humanoid robots' appearance and behavior has for child users, given that young children use their animistic intuition to attribute intelligence, biology, and goals to encountered objects [1].

Current research offers mixed indications of children's perceptions of robots as animate or machine. Children aged 3-5 have a piecemeal understanding of animacy in their beliefs concerning a robot dog; while they show refinements with age to their

attribution of animacy, they still keep mixed beliefs regarding its agency and biology [2]. With age, children are more likely to classify pictures of humanoid robots as being pictures of machines rather than living [3]. However, further HRI work indicates children of that age do not evaluate a robotic dog as different from a stuffed dog toy in terms of animacy, biology, and mental states [4]. In sum, factors influencing children's perceptions of humanoid robots as persons or machines still remain to be uncovered.

1.2 Use Case

The Expressive Agents for Symbiotic Education and Learning (EASEL) project explores human robot symbiotic interaction (HRSI) with a view to understand the development of symbiosis over long-term robot and child tutoring interactions.

Symbiosis is the capacity for both the robot and the human user to mutually influence each other's behavior both within and across repeated encounters. To suitably explore HRSI, a robot needs to be responsive to the behavior and affective states of the human user and adapt its own behavior in ways that have meaningful and measurable influence on the person. This responsiveness in a Synthetic Tutoring Assistant (STA) may range from broad changes, such as tailoring tutoring style to meet a student's learning requirements, to focused changes, such as a robot's use of simulated affect expression when giving feedback.

Early research in the EASEL project [5] indicates that the presence of life-like facial expressions from a humanoid robot (Robokind Zeno R50 [6]) during feedback from the robot regarding children's game performance has a differential impact based on demographics. One mechanism proposed for this effect is that the presence of facial expressions might encourage the user to respond to the robot as a social agent or person rather than a machine or object. Perceptions of the robot as a social agent or a machine may in turn have important influence on users' attitudes and behaviors during HRI. As outlined above, age is a key factor likely to influence the target demographics' perceptions of the STA as a social agent.

This paper explores the influence that a user's age and the presence of life-like facial expressions by the robot impact on user perceptions of the robot as a social agent. We anticipate that younger children will rate the humanoid Zeno R25 as being significantly more like a person than older children will. This difference is anticipated to be strengthened by the presence of life-like robotic facial expressions.

2 Method

2.1 Design

A repeated measures design was employed so that differences in responses to the facially-expressive and non-expressive states of the robot could be explored. Allocation to condition was counterbalanced so that any order effects of the repeated exposure to the robot could be accounted for. The study took place at a local primary

school across two days, allowing for approximately a day's break for participants between conditions.

2.2 Participants

Children from UK school years two and three were recruited from a local primary school to take part in the study by invite to play a game with Zeno the robot. 44 children volunteered to take part in the study and 39 completed both conditions. Of completers, there were 20 female and 19 male participants; 15 participants were from year 2 (age M = 6.38, S.E. = .07) and 24 were from year 3 (age M = 7.40, S.E. = .05). These age groups were identified in previous work as being engaged with the interaction and capable of completing self-report measures [5].

2.3 Measures

The primary measure for assessing the children's perceptions of the robot was a single item 100 point thermometer scale on which children pick a point for the robot ranging from 'Zeno is more like a machine' at the 0 point mark and 'Zeno is more like a person' at the 100 point mark. This measure had been pre-tested in a pilot study on adults and children and had been identified as suitable for children to articulate the differences between the two end points. Zeno had been described as a robot in the recruitment phase of the study and so use of the word 'robot' as an anchor point might have unduly primed children's responses.

This paper details part of a broader study concerning children's feelings, thoughts, and behavior in HRI, so it was necessary to use minimal items for measures to reduce overburdening participants with questions. Additional items used to control for children's interaction and understanding of the game consisted of: children's number of correct actions in the game and recognition of the robot's expression "Zeno was pleased / was disappointed / didn't mind, when I got an answer right / wrong".

2.4 Procedure

This study was developed to replicate procedure from a prior field-study [5] in a new, controlled testing environment. The experiment took place in a local primary school, where participants completed the game under the supervision of the research staff and one member of school staff. Information regarding participation was sent before recruitment and informed consent was obtained from parents.

During the game, children were free to position themselves within a designated 'play zone' (so that movements could be correctly detected by the system) marked out by tape starting 1.80m from the robot and extending to 3.66m away.

Interaction with Zeno took the form of the well-known game of Simon Says, which initiated once children stepped into the play zone and was autonomously delivered by the robot, including instructions for the children, commands to obey (or not),

and feedback on the children's performance – reported as their score[1]. Children played a maximum of ten rounds and the game was repeated to present the alternate condition for the child on the next day of testing.

After each session, children completed a brief self-report questionnaire, including the critical measures described above. Participant experimenter interaction consistency was maintained across sessions for all tasks and the experimenter remained blind to condition throughout. The sole experimental manipulation coincided with Zeno's vocal feedback after each game turn by including happy or sad facial animations corresponding to the vocal feedback on the children's performance. By contrast, in the control condition, Zeno's facial expression remained static when delivering feedback.

3 Results

There was a significant main effect for age $F(1,37) = 7.92$, $p < .01$. Children in the younger age group rate Zeno as being more like being a person ($M = 77.27$, S.E. = 8.83) to a substantially greater extent than those in the older age group ($M = 41.58$, S.E. = 6.98). This is a large effect observed ($d = .95$), which post-hoc tests indicate to be sufficiently powered (.88).

There was no main effect for gender $F(1,37) = .71$ $p = .41$, as both boys and girls tended to rate Zeno as being a mix of a machine and a person (Ms = 48.61 & 58.68, S.E.s = 8.57 & 8.35 respectively).

Results did not materially change when controlling for number of correct responses, nor children's perceptions of Zeno's responses to their actions. There was a strong correlation in children's responses between the two conditions $r(39) = .77$, $p < .01$.

There was no main effect seen for the presence of robotic facial expressions $F(1,37) = .87$, $p = .36$ as children reported similar scores for rating Zeno as a person or machine in the facially-expressive condition ($M = 59.49$, S.E. = 6.07) and the non-expressive condition ($M = 55.36$, S.E. 6.03). Similarly, there was no observed interaction effects between the condition and age groups of participants $F(1,37) = .61$, $p = .44$ (See Figure 1), gender $F(1,37) < .01$, $p = .99$, nor order in which conditions were presented $F(1,37) < .01$, $p = .94$.

[1] Full details of the game's procedure can be found in [5], which was unchanged for this study

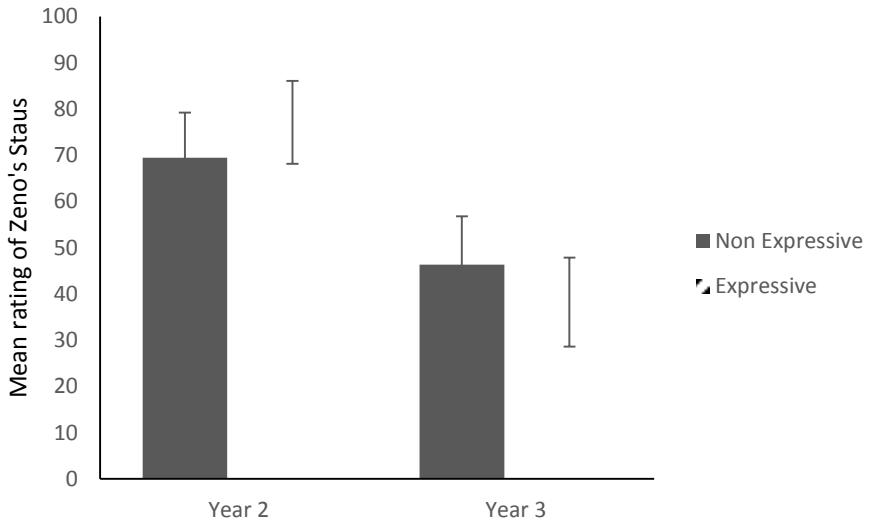

Fig. 1. Mean ratings of children's perceptions of Zeno as being like a machine (lower values) or like a person (higher values)

4 Discussion

In line with existing literature [3, 4], on average older children considered the Zeno robot to be significantly more like a machine than the younger children did. Critically, this large effect was demonstrated using a simple and accessible measure that could be included in future studies without overburdening young participants. Consistency in ratings between conditions was high; although the inclusion of expressions did not substantively affect children's ratings for either age group, this early work might have seen ceiling effects rating Zeno as like a person due to its apparent autonomous movement and response to the children. In particular for young children, these cues could be instrumental in their regarding a humanoid robot as being like a person [1].

While not formally recorded in the current study, think-aloud reasoning by the children on making a judgment included statements such as "He talks like a person but he's got oil and gears", (when rating as more like a machine) and "He's like a person because he knows when I move" (when rating as a person). These suggest possible use of behavioral cues and biological/mechanical knowledge to inform their judgements and further work exploring why children are making particular ratings is recommended.

The results have implications for the use of Zeno in the planned tutoring role as an STA [7] in both a social, tutoring capacity and a user-acceptance capacity. Firstly, it may impact on the potential for Zeno to act as a co-learner or tutor for scenarios concerning biology or health education. For example, user engagement in inquiry learning through comparative work on the differences between machines and people may be influenced by a child's perception of Zeno as like a machine or person. Second, a

child's perspective of whether Zeno is like a machine or person may impact on the type of behaviors the user expects form the robot. Sufficient differences between expected and observed robotic features or behaviors may give rise to unease, as predicted by models of the 'uncanny valley' [8] and potentially impact on user engagement. Further work exploring if and how children's perceptions of a robot's status as being like a person or machine can impact on the practical parameters within which HRI can occur is recommended, particularly with regards to user engagement.

Additional future work could benefit from longitudinal data collection to consider changes with age within individuals, or including older children to explore age-related trends in children's beliefs. Further adaptation of the study design could include comparison of robots with closer or further resemblance to humans or animals in appearance or behavior to explore cues children draw upon to inform their perceptions of robots and potentially their interactions.

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