An Evaluation of Robot-directed Prompts to Facilitate Interactions with Learners with Autism Spectrum Disorder

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Background Literature

Students with autism spectrum disorder (ASD) often present with differences in the way they interact with their peers (Joseph et al., 2022; Lord & Evans, 2005). These students may have difficulty initiating and responding to interactions from their peers, maintaining conversations, and engaging in interactions around content to which they may not have an interest (Marans et al., 2005). These social barriers may have deleterious effects on membership in important school communities as these students may be more likely to be bullied, excluded from social activities by their peers, and have difficulty participating in the myriad of group learning activities presented during the school day. Further, they may have long term negative impacts on students' postsecondary outcomes related to obtaining and maintaining employment, living independently, developing strong social networks, and maintenance of mental health (Cage et al., 2018).

Over the last several decades, researchers have evaluated the effectiveness of TAII in improving a range of social communication outcomes for learners with autism. The majority of research on the use of social robotics has focused on basic interaction skills including joint attention, eye contact, and emotional expression but there is a dearth of research on the use of robots to improve complex social skills such as maintaining conversation.

The purpose of the current investigation was to explore the effects of an autonomous robot change agent on the conversational skills of six children with ASD. This study extends the available literature in two major areas. First, we implemented a robot-based intervention in the absence of a human instructor. The robot was programmed to detect lulls in the students' conversation and then emit content-related prompts to facilitate conversation (e.g., If you had a pimple, what would you name it?). If deemed effective, these autonomous robot change agents might be able to facilitate student interactions in school and other settings when an adult may not be available. Second, we targeted increases in the use of vocal responses and conversational turn taking between students. As aforementioned, the majority of research has focused on early social skills (e.g., joint attention) and have often involved interactions between children and robots. We sought to increase the rate of interaction between peers to provide opportunities for students to practice social skills and potentially contact natural reinforcers (i.e., peer responses) for engagement. If effective, robots may serve to support teacher delivered social skills instruction by prompting interactions outside of the instructional context.

Research Questions

1. What are the effects of a robot conversational prompter on the rate of vocalizations for students with ASD?

2. What are the effects of a robot conversational prompter on the rate of conversational turns for students with ASD?

Method

Participants

We recruited six male children (mean age = 11.4 years, SD = 0.86, range: 10.4-11.9 years) from the population of a university-affiliated autism center focused on providing multidisciplinary support for children diagnosed with ASD and their families. Participants were invited to participate in 12 sessions (one session per week) at the center if they met the following criteria: (a) chronological age range from 8 to 12 years old and (b) diagnosis of ASD. Participants were randomly assigned to three child-child dyads. The same children were included in each dyad for all 12 sessions.

Setting

We conducted all sessions at the university-affiliated center, in the same therapy room. The room contained a table, two chairs, and cabinets. Participants sat directly across from each other. During *robot* sessions, the robot was placed at one end of the table, facing participants and forming a triangulated position. (See Figure 1.) We conducted one session per week and each session lasted 6-8 min.

Measurement

We collected on the two dependent variables (a) utterances and (b) conversational turns using the Systematic Analysis of Language Transcripts (SALT) software.

Reliability

All 27 recordings were coded by one undergraduate student. To estimate inter-rater agreement, two more trained analysts (undergraduate students) remeasured a random selection of 15 recordings. The intraclass correlation coefficient (ICC) estimate and its 95% confidence intervals (CIs) were calculated using R (R Core Team, 2013) based on a mean rating from two raters, absolute agreement, 2-way mixed effects model. For the number of child1 utterances, the ICC value was 0.99 (95% CI: 0.98-0.99) and for the number of child2 utterances, the ICC value was 0.94 (95% CI: 0.84-0.98). For the number of child1-child2 turns, the ICC value was 0.96 (95% CI: 0.9-0.98); and for the number of child2-child1 turns, the ICC value was 0.95 (95% CI: 0.88-0.98).

Experimental Design

We used an alternating treatments design (Barlow & Hayes, 1978) to compare the differential effects of *robot* and *no robot* conditions on the utterances and social exchanges of children with ASD. We semi-randomly alternated the presentation of conditions in response to participants absences to potentially reduce sequence effects. Further, no participant was exposed to more than two consecutive sessions of the same type of conditions.

Robot Condition

At the beginning of each session, the experimenter asked participants to talk to each other, not touch the robot, and remain in their seats throughout the duration of the session. They also were told that the robot would produce verbal prompts but would not be able to respond. During each session, the robot produced a verbal prompt defined as a directive utterance (Tamis-LeMonda et al., 2012) under two conditions: (a) if both subjects were silent for more than 30 seconds or (b) if one subject was dominating the conversation by producing speech continuously for more than 1 minute. Prompts contained phrases designed to evoke conversation (e.g., If you had a pimple, what would you name it?).

Figure 1. Therapy room during *robot* condition. For the *no robot* condition, the same room is used but no robot is present.

No Robot Condition

At the beginning of each session, the experimenter asked participants to talk to each other, and remain in their seats throughout the duration of the session.

Results