The Effect of Using Low Dose Exposure to a Humanoid Robot to Elicit Social Engagement Behaviors in Children with Autism Interacting with a Familiar Adult

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The Effect of Using Low Dose Exposure to a Humanoid Robot to Elicit Social Engagement Behaviors in Children with Autism Interacting with a Familiar Adult

Cambrie N. Roueche

A thesis submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of Master of Science

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Brigham Young University
June 2013

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ABSTRACT

The Effect of Using Low Dose Exposure to a Humanoid Robot to Elicit Social Engagement Behaviors in Children with Autism Interacting with a Familiar Adult

Cambrie N. Roueche
Department of Communication Disorders, BYU
Master of Science

This study examined the effects of low dose exposure to a humanoid robot on the social engagement skills of four children with autism during select activities with a familiar adult. Participants included two males and two females who ranged in age from four to nine at the commencement of the study. The current study was part of a larger investigation focused on the effect of exposure to a robot on social engagement with a variety of social partners and situations. Children participated in variable multiple baseline sessions followed by a varied number of sessions of traditional treatment. After traditional treatment, the children participated in 40 minutes of traditional intervention paired with 10 minutes of exposure to a robot designed to elicit social communication skills. The final sessions consisted of follow up assessments. Pre- and posttreatment data were compared and analyzed. Results showed variable performance for each of the participants. Findings and areas of future research are discussed.

Keywords: autism, robot, joint attention, social communication
ACKNOWLEDGEMENTS

First of all, I would like to thank my thesis committee including Dr. Brinton, Dr. Fujiki, and Dr. Colton. I could not have done it without them. I want to thank Ms. Robinson for helping me make it through the intervention with all these children and for teaching me new things as a clinician. I have to thank Kristi (Blanchard) Harrison, Sarai Dodge, and Alyssa Stabenow! They are my lifelong friends and I am so grateful to have learned from them all during this project. I want to thank and acknowledge the cohort because they cheered me on and inspired me to become better. I want to thank Karen Spence for helping me with formatting this thesis. She saved me hours of frustration! Finally, I want to thank my family because no matter how frustrated I was, they always encouraged me to just keep going and finish!
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Description of Structure and Content

This thesis is written in a hybrid format where traditional thesis requirements are combined with current journal publication formatting. The introduction section is current with the university requirements while the thesis content reflects style and length qualifications for research seen in peer reviewed journals for communication disorders. Appendix A contains diagnosis information for the participants. Appendix B provides information about each participant’s assessment information. Appendix C lists the outline used in baseline and follow up measures. Appendix D consists of the coding manual used during data analysis. Appendix E is comprised of an annotated bibliography.
Introduction

Autism spectrum disorder (ASD) is a term that incorporates a range of impairments including autistic disorder (autism), Asperger’s Syndrome, Rett’s Disorder, Childhood Disintegrative Disorder, and Pervasive Developmental Disorder–Not Otherwise Specified (PDD-NOS, also known as atypical autism). In 2001, Blackwell noted that ASD was the third most common developmental disability and affected more than 1 in every 500 children in the United States (Blackwell, 2001). Recent reports have suggested a marked increase in the incidence of ASD with as many as 1 in 88 children affected (U.S. Department of Health and Human Services, 2012). Causal factors for this apparent increase are not well understood, however (Wing & Potter, 2009). ASD is characterized by impairments in verbal and non-verbal communication, deficits in reciprocal social interaction, and the presence of restricted or stereotyped interests and repetitive behaviors (Raznahan & Bolton, 2008). Individuals identified with ASD manifest a marked variety of the features of presentation, and individuals demonstrate a wide range of severity of symptoms.

Although currently under revision, the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000) described areas of impairment that characterize ASD. One such area is a deficit in communication manifested by at least one of the following: a delay or lack of development of spoken language, a deficit in initiating or sustaining conversation, stereotyped or idiosyncratic language, or difficulties with pretend or social imitation play. A second area of impairment involves stereotyped interests and repetitive behaviors. These behaviors may be highly individualistic but demonstrate at least one of the following: preoccupation with a restricted interest that is abnormal in intensity or focus, rigid adherence to routines, repetitive motor
patterns (e.g., hand flapping), or “persistent preoccupation with parts of objects” (American Psychiatric Association, 2000, p. 75). A third area includes impairment in social interaction, with at least two of the following; a deficit in nonverbal behaviors such as eye contact or gestures during interaction, a lack of sharing enjoyment with others, “failure to develop peer relationships appropriate to developmental level, and a lack of social or emotional reciprocity” (American Psychiatric Association, 2000, p. 75). Deficits in these areas undermine the ability of children with autism to engage in social interactions and to form positive social relationships. In fact, children with autism often have difficulty developing the most basic and foundational interactional behaviors such as establishing joint attention with others (Mundy & Sigman, 2006).

**Joint Attention**

Joint attention is the ability to coordinate attention between interactive social partners with respect to objects or events in order to share an awareness of those objects or events (Mundy et al., 1986). Joint attention occurs when mutual focus on an object is accompanied by recognition that interest is shared by a partner (Bruinsma, Koegel, & Koegel, 2004). There are different types of joint attention that develop as a child matures. The first type consists of the child’s responding to joint attention (RJA). In this case, the infant follows the direction of gaze of a caregiver, follows a head turn of a caregiver, or follows the point of a caregiver (Mundy & Arca, 2006). The second type is referred to as initiating joint attention (IJA). In this case, the child uses eye contact or deictic (specifies a referent in a given context) gestures to initiate coordinated attention with the caregiver or social partner (Mundy & Arca, 2006). Another type of joint attention occurs when the child uses eye contact and gesture to get the attention of others to help with the retrieval of an object. This is considered a behavioral request (Mundy & Arca,
The development of these types of joint attention underpins social engagement and fosters growth in both social communication and language development (Dawson et al., 2004).

Children with autism often display difficulty with joint attention (Mundy et al., 1986; Osterling & Dawson, 1994). A failure to develop joint attention is associated with deficits in early language functions. Just as importantly, a failure to establish joint attention with others blocks a child’s ability to engage socially with others. Westby (2010) noted that without the basic social building blocks of joint attention and social-emotional referencing, or perceiving the link between an individual’s affect and the eliciting stimulus, children “fail to develop higher levels of theory of mind essential for social understanding and interpersonal relationships” (p. 156).

Social Engagement

For the purposes of this study, social engagement is defined as attending, expressing interest, and responding to another individual or individuals for the purpose of interpersonal interaction. Social engagement may be manifest by a number of behaviors including sharing of affect, eye contact, commenting, showing, and turn-taking (TiLAR Team, 2012). A typical child begins to develop these behaviors at a very early age and continues to improve and expand these abilities, thus becoming more socially competent. A child will learn how to regulate attention in a dynamic social exchange, self-monitor and integrate behavior of self with others, and express interest in others and positive emotions with peers and adults (Mundy & Sigman, 2006).

Children identified with autism typically demonstrate marked impairments in many aspects of social engagement (Paul, 2007). Even in very young children, these deficits may be evident in failure to make eye contact, to orient to speech, and to establish joint attention (Osterling & Dawson, 1994). According to Levy et al. (2009), this lack of social behavior (or
socialization) is manifested in the impaired use of non-verbal behaviors to regulate interactions, the delay of or a lack of peer interactions, a delayed initiation of interactions, the absence of seeking to share enjoyment, and a lack of social judgment.

Many interventions designed for children with autism focus on facilitating basic social behaviors, particularly joint attention, in order to increase social engagement. Interventions focused specifically on improving basic social engagement skills may cause an increase in social interaction (Scattone, 2007). Accordingly, a variety of treatment strategies have been employed to facilitate joint attention, interactive language, and reciprocal play in children with ASD. Recently, an unlikely but seemingly promising intervention approach has employed robots to increase social engagement in children with autism.

Robots in Autism Intervention

Preliminary investigations suggest that children with autism are interested in interacting with robots (Giannopulu & Pradel, 2010). Dautenhahn (2003) reported that when children are provided with an opportunity to either interact with a robot or play with a toy, “they demonstrated more interest in the robot and were more engaged in interactions with the robot than with the toy” (p. 446). Scassellati (n.d.) reported that robots foster a high degree of motivation and engagement in children with autism, and that these children seem to maintain interest in a robot whether or not the robot responds to the child’s actions.

Blomgren and Tenggren (n.d.) suggested multiple reasons why children with autism might benefit from interacting with a robot. They speculated that children with autism find robots less intimidating to interact with than humans, and are thus more relaxed during interaction. They also noted that many children with autism feel comfortable in predictable situations, and robots can generate a simple, fixed play routine. For example, Dautenhahn (2003)
reported that using technology “is a safe, predictable environment which can be used in an exploratory and creative manner” (p. 446). Goldsmith and LeBlanc (2004) reported that “robotics can allow presentation of a simplified social environment” (p. 172) to increase learning opportunities for a child with autism.

Social engagement behaviors tend to increase in children with autism when interacting with robots (Goldsmith & Leblanc, 2004). Miyamoto, Lee, Fujii, and Okada (2005) found that two children with autism were “able to communicate with robots as social agents” (p. 146). It has even been reported that a child’s mean length of utterance (MLU) may increase when interacting with a robot (Feil-Seifer & Mataric, 2008). During interactions with a robot, some children with autism engaged in dyadic play with the robot and demonstrated various prosocial skills such as “trying to feed the robot, putting a cap on its head, and kissing it” (Kozima, Nakagawa, & Yasuda, 2005, p. 346).

The generalization of these interactional skills to humans is not yet established but has been suggested by some researchers (Robins, Dickerson, Stribling, & Dautenhahn, 2004). In some cases, it has been reported that children with autism who interacted in sessions with a robot began to use it as the mediator or an object of shared attention when interacting with caregivers, researchers, and teachers (Robins, Dautenhahn, te Boekhorst, & Billard, 2005). Recently, researchers at Brigham Young University reported case studies of two children identified with ASD who demonstrated severe deficits in social communication. Each child participated in an intervention program incorporating a robot into treatment. Intervention consisted of highly interactive treatment activities designed to promote child social engagement behaviors in response to the robot and one or two other people (Acerson, 2011; Goodrich et al., 2012; Hansen, 2011). The robot intervention was considered low dose because the robot was employed for
approximately 10 minutes of each 50-minute session. Results of the 16-session intervention program showed a dramatic increase in social engagement behaviors in one child and a modest increase in the second child (Acerson, 2011; Hansen, 2011). These results are notable because pre-and postintervention measures consisted of interactions without the robot present.

The current study is part of a larger investigation designed to extend the previous case study. In the larger investigation, four children with autism participated in an intervention program incorporating a clinician-controlled robot (Troy) during 10-12 minutes of 50-minute intervention sessions. The goal of intervention was to facilitate social engagement behaviors in the children. Treatment tasks included highly interactive activities including the child, graduate clinicians, and a parent. Pre-and postintervention assessments were conducted in a number of interactional contexts. The current study focused on the social engagement behaviors that children produced in interactions with a familiar adult both before and after the intervention. Specific social engagement behaviors included eye contact, reciprocal action, language, and initiating of continued social engagement.

Method

This study is part of a larger study investigating the social engagement behaviors of four children with autism. A variety of contexts were considered in the larger investigation. The focus of this study was each child’s interaction with a familiar adult during select activities.

Participants

Participants included two males and two females who were identified with autism based on the results of an assessment prior to the study. (See Appendix A for more details about each participant’s diagnosis.) Each child presented with marked deficits in social communication including limited ability to establish joint attention and marked delays in the development of
verbal and non-verbal communication. All participants were enrolled in special education services outside of the clinic at the same time of the study.

Before the study began, each child participated in various assessments performed by graduate student clinicians to evaluate current levels of functioning and to design treatment objectives. These assessments included an audiologic examination, the Preschool Language Scale—Fourth Edition (PLS-4), and the Westby Playscale. (Results from these assessments are reported in Appendix B.) The participants’ names have been changed for privacy purposes.

Ally. Ally was a 4;11 year-old female. She was an only child living with both parents. Her mother reported that Ally had frequent opportunities to interact with cousins, aunts, and uncles. Both parents were employed outside the home. English was the primary language spoken at home. Ally had attended a developmental preschool for children with autism for two years prior to the study.

Ally was primarily non-verbal at the time of the study. She demonstrated minimal verbal approximations, and she imitated certain signs following a visual prompt. She sometimes produced signs spontaneously, but these signs were not always appropriate within the context. Ally sometimes engaged in vocalization and sound play. When Ally wanted something, she hugged any person in the room or she initiated a behavioral request (IBR) to obtain her desires. She was often disregulated and frequently cried. She used minimal eye contact. She displayed affect and repetitive motoric patterns when she became excited. Ally sometimes demonstrated symbolic play such as feeding a doll with a toy bottle. She also occasionally performed similar actions on other people, however. For example, she attempted to manipulate two clinicians to make them hug each other.
**Lincoln.** Lincoln was a 5;5 year-old male. Lincoln lived with both parents and had five siblings at home (ages 23, 19, 9, 8, and 3 years). His father was employed outside the home and his mother worked within the home as a homemaker. English was the primary language spoken at home. Lincoln had attended a developmental preschool designed for children with autism since he was four years old.

Lincoln was non-verbal at the time of the study. He demonstrated monotone vocalizations using a variety of early-developing consonant sounds. Lincoln communicated his wants and desires by use of IBR and some eye contact. He displayed positive affect by smiling and laughing when engaged in activities. When he became frustrated, he moved away from people. He changed focus frequently, moved quickly from activity to activity, and showed repetitive motor patterns. Lincoln displayed minimal symbolic play skills and did not use objects appropriately. For example, instead of using a spoon to feed a baby, he continually hit the spoon against a bowl.

**Kami.** Kami was an 8;1 year-old female. She lived with both parents and had five siblings at home (ages 23, 19, 9, 5, and 3 years). Her father was employed outside the home, and her mother worked inside the home as a homemaker. English was the primary language spoken at home. Kami had attended a developmental preschool and kindergarten for children with autism and was placed in a public elementary school self-contained classroom beginning in first grade.

Kami displayed limited communication skills at the time of the study. She commonly vocalized using jargon with speech-like prosody. She occasionally interspersed four to five real words within the jargon, but the intent of the words was often difficult to assess. Kami displayed moderate attempts to establish interaction with eye contact. When she was frustrated or
disregulated, she threw materials, dropped to the ground, and/or yelled. Kami often bit her hand or performed repetitive behaviors with specific materials. These behaviors appeared to be attempts to self regulate.

**Louis.** Louis was a 9;1 year-old male. He lived with both parents and had four older siblings living at home (ages 18, 16, 14, and 11 years). His father was employed outside the home and his mother worked within the home as a homemaker. English was the primary language spoken at home. Louis was born in Japan and lived there until age 4;6. He then moved to the United States where he attended a developmental preschool and kindergarten designed for children with autism. After kindergarten, he entered a self-contained autism classroom in a public elementary school.

Louis demonstrated marked communicative impairment at the time of the study. His vocabulary consisted of approximately 150 words, but his utterances were frequently echolalic. He showed limited intentional communication with the exception of some verbal requests. Louis did not use language to share information or to comment. His social interaction was limited in one-on-one contexts, and he did not interact in groups. Louis was often disregulated and aggressive. He seemed sensitive to certain sounds and tactile stimuli, but deep pressure stimulation, such as gently squeezing him between large bean bags, helped him regulate his behavior.

**Procedures**

The current study is part of a larger study that utilized a single subject, multiple-baseline design to investigate the use of a robot as an intervention device to improve social engagement in children with ASD. The larger investigation included pre-and postintervention (baseline and follow-up) probes of social engagement in several interactional contexts. The current study
focused on pre-and postintervention assessments of social engagement behaviors elicited by an adult who was familiar to the child. For the purposes of this study, the child’s graduate clinician was considered to be a familiar adult.

Participants participated in a variable number of pretreatment baseline sessions and then proceeded on to traditional treatment sessions where the robot was not present. After these sessions were completed, the robot was included in the subsequent intervention sessions. During these sessions, approximately 10-12 minutes of each 50-minute session were devoted to highly interactive activities including the child, the clinician, and a parent. All the children received a total of twenty 50-minute intervention sessions. Following baseline and traditional intervention, a robot was introduced in intervention. Children received a variable number of treatment sessions with the robot, ranging from 14 to 17 sessions, during a four-month period from March to June. Participants were seen twice a week. During each session involving the robot, 40 minutes were devoted to traditional intervention, and 10 minutes were devoted to activities with the robot. These 10-minute segments were randomly placed within the session at the beginning, middle, or end. Table 1 shows the number of baseline, treatment, and follow-up sessions for each participant.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Ally</th>
<th>Louis</th>
<th>Kami</th>
<th>Lincoln</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Traditional Treatment</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Traditional Treatment with Robot</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>Follow-Up</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>
Pretreatment Baseline. Pretreatment baseline sessions consisted of a series of activities using a set of specified materials. Activities included the clinician’s initiating social engagement by rolling a ball to the child three consecutive times and saying, “roll it to me” each time. The clinician also pushed a car to the child three consecutive times and said each time, “push it to me.” In addition, the clinician presented each of three wind-up toys to the child three times. Before displaying the toys, the clinician stated, “watch this.” Each time the clinician initiated one of the activities described above, it was considered a probe for social engagement. Appendix C describes the pretreatment protocol in additional detail.

Several exemplars of each toy were used in a randomized order. These materials were varied from session to session. The order in which the activities and materials were introduced to each child was varied during the pre-and postintervention sessions.

Traditional intervention. Traditional intervention consisted of highly interactive, play-based activities. All treatment focused on increasing verbal communication, facilitating increased social interaction, and increasing the use of symbolic play skills. Traditional intervention was based on the SCERTS model by Prizant et al. (2003), which focuses on social communication, emotional regulation, and transactional support.

Robot intervention. These sessions consisted of 40 minutes of traditional treatment and 10 minutes of treatment with the robot. Graduate students in the BYU Department of Mechanical Engineering and Computer Science created the robot used in this study. Referred to as Troy, the robot was a 15-lb (6.8 kg) upper-body humanoid robot with an upper torso, head with face, neck, and two arms. He was designed to be the same size as a 4-year-old child and measured 25 inches (0.64 m) tall from his base to the top of the head (Ricks, 2010). He spoke simple prerecorded phrases, displayed basic facial expressions on a monitor-like screen, and performed human arm
movements that allowed for participation in interactions with the subjects and clinicians. Troy’s arms were designed with four degrees of freedom (DOF). There are two DOF in each shoulder for flexion, extension, adduction, and abduction. The other DOF made humeral rotation and elbow flexion and extension possible. These DOF served to “enable each robot arm to point in any direction and have a range of motion similar to that of a human arm” (Ricks, 2010). The robot performed actions such as waving at the child, singing a song with actions, pushing an object, or blowing a kiss.

Troy was connected to a laptop computer with cords that extended from the posterior torso. The laptop computer was placed on a countertop during the study, and it was out of the participants’ reach. On the laptop computer, there was a program that contained the desired actions, sounds, and facial expressions customized for each participant. The clinicians enacted these programs by the use of a Wii™ remote which was wirelessly connected to the program on the laptop. (For more in-depth information regarding Troy, see Ricks, 2010.)

During the 10-minute segments with the robot, the clinician, the caregiver, the child, and a second clinician all sat on carpet squares in a semi-circle formation around Troy. The main clinician controlled Troy’s actions and directed the social interactions with Troy. A second clinician, who was seated behind the child, provided hand-over-hand support during the interactions. The caregiver was present as a social partner for the participant. Activities primarily focused on turn-taking through sharing greetings, toys, or songs. The clinician completed the activity, and provided opportunities for the other members in the room to participate in and perform the activity. Throughout the activities, the clinician, caregiver, and Troy responded with high amounts of positive affect through facial, gestural, and verbal expressions.
**Posttreatment Follow-up.** Follow-up assessments for all participants were administered during three 50-minute sessions on consecutive treatment days following the twentieth treatment session. The follow-up assessments followed the same protocol as the pretreatment baseline sessions described above. In order to analyze data after the completion of intervention, there were two different video cameras recording each session. One camera was mounted on the wall and recorded a full view of the clinic room during each pretreatment baseline session. The additional camera was a Canon handheld camera controlled by an undergraduate volunteer who focused the camera on the participant’s face.

**Data Analysis**

Final Cut Express was used to organize the video data. Both the clinic camera and handheld camera views were synced side-by-side during analysis. The current study focused on the pre- and posttreatment video segments consisting of the familiar adult’s initiating reciprocal activities using a ball, a car, and wind-up toys. As indicated previously, the adult’s initiating of each activity was considered a probe. The analysis system in this study was designed based on the Early Social Communication Scales (Mundy et al., 2003), but it was revised to account for the fact that the participants were older and were free to move around the room.

Coders focused on behaviors that occurred after each probe. They noted social engagement behaviors manifest by four categories of behavior including eye contact, reciprocal action, language, and initiation. Eye contact consisted of the adult and the child’s making direct eye contact when facing each other with heads in alignment. Reciprocal action consisted of the child’s returning toys to the clinician in a turn-taking exchange. Language consisted of the child’s signing or speaking about the current activity. Initiating engagement was identified if the child began a reciprocal action following the probe. For example, it was considered an initiation
if the child responded to the probe and then subsequently made an additional request for interaction or returned the toy to the clinician to continue the reciprocal activity. After identifying each probe, trained coders checked for instances of these behaviors from a list and noted their presence or absence. (For a copy of the coding manual and guidelines used in analysis, see Appendix D.)

To guarantee consistency between coders, inter-rater agreement was established between coders prior to the commencement of the analysis. The four coders were graduate students participating in the larger research study. One graduate student with extensive knowledge of the coding system served as the expert coder. The other coders established reliability by comparing coding results against the expert coder’s results. After baseline and follow-up sessions were completely coded, 20% of the data were double-coded by a second individual to ensure coding consistency. Judges obtained 93% agreement for eye contact, 97% agreement for reciprocal action, 100% agreement for language, and 99% agreement for initiation.

**Results**

As indicated above, the social engagement behaviors demonstrated by each child in sessions conducted before and after the intervention were analyzed. Specifically, the study focused on each child’s responses to bids or probes from a familiar adult during reciprocal activities using a ball, a car, and wind up toys. The pretreatment and posttreatment results for each child are described in the paragraphs below and summarized in the following tables.

**Participant 1: Ally**

The social engagement behaviors Ally produced in response to probes are presented in Table 2. Table 2 shows the percentage of probes to which she responded in each session as well
as the overall percentage in baseline and follow up. In addition, differences between baseline and follow up sessions are noted.

**Baseline session performance.** Ally participated in three baseline sessions, and she displayed instances of eye contact in response to 13% of the probes overall. Her performance was variable, however. Instances of eye contact were rare in the first session and completely absent in the second session when Ally was focusing on a toy present during the probes. In the third baseline session, she established eye contact in response to about a quarter of the probes. With regard to reciprocal activities, Ally participated in 83% of the activities during the first baseline session, but her performance leveled off to 33% in subsequent sessions. Ally did not respond to any of the probes by using language or by initiating further interaction.

**Follow-up session performance.** Ally participated in three follow-up sessions. She demonstrated eye contact in response to 18% of probes overall. In the first two sessions, she established eye contact in response to 27% of the probes, but in the third session, she did not establish eye contact at all. During all three sessions, Ally joined in turn-taking interactions in 33% of opportunities. As in the baseline sessions, Ally did not produce language or initiate interaction during the follow-up sessions.

**Participant 2: Lincoln**

Lincoln’s performance in baseline and follow-up sessions is presented in Table 3. The percent of probes to which he responded is presented for each session and for the baseline and follow up sessions overall. Differences between overall baseline and follow up sessions are noted.
<table>
<thead>
<tr>
<th></th>
<th>Preintervention Sessions</th>
<th></th>
<th>Postintervention Sessions</th>
<th></th>
<th>Post</th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Total</td>
<td></td>
<td>Post Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye Contact</td>
<td>13% (2/15)</td>
<td>0% (0/15)</td>
<td>26% (4/15)</td>
<td>27% (4/15)</td>
<td>27% (4/15)</td>
<td>0%</td>
</tr>
<tr>
<td>Reciprocal Action</td>
<td>83% (5/6)</td>
<td>33% (2/6)</td>
<td>33% (2/6)</td>
<td>50% (9/18)</td>
<td>33% (2/6)</td>
<td>33%</td>
</tr>
<tr>
<td>Language</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0%</td>
</tr>
<tr>
<td>Initiating Engagement</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0% (0/15)</td>
<td>0%</td>
</tr>
</tbody>
</table>
Table 3

*Lincoln’s Social Engagement Behaviors in Interaction with a Familiar Adult*

<table>
<thead>
<tr>
<th></th>
<th>Preintervention Sessions</th>
<th>Postintervention Sessions</th>
<th>Post Total</th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Eye Contact</td>
<td>77% (10/13)</td>
<td>73% (11/15)</td>
<td>53% (8/15)</td>
<td>53% (8/15)</td>
</tr>
<tr>
<td>Reciprocal Action</td>
<td>25% (1/4)</td>
<td>0% (0/6)</td>
<td>17% (1/6)</td>
<td>17% (1/6)</td>
</tr>
<tr>
<td>Language</td>
<td>0% (0/6)</td>
<td>0% (0/6)</td>
<td>0% (0/6)</td>
<td>0% (0/6)</td>
</tr>
<tr>
<td>Initiating Engagement</td>
<td>0% (0/6)</td>
<td>13% (3/24)</td>
<td>0% (0/6)</td>
<td>0% (0/6)</td>
</tr>
</tbody>
</table>
**Baseline session performance.** Lincoln participated in six baseline sessions. He demonstrated instances of eye contact in 51% of the probes during baseline, but his performance was variable. His first session showed the highest occurrence of eye contact (77%) with subsequent sessions decreasing in eye contact. He participated in reciprocal action exchanges in 12% of given opportunities, but once again, his performance was variable. For example, in sessions two and three, he did not respond to any of the probes for reciprocal action. Lincoln did not use signed or spoken language in any baseline session, but he initiated further engagement in response to 13% of the probes during baseline sessions three, four and five.

**Follow-up session performance.** Lincoln participated in three follow-up sessions. He demonstrated eye contact in 39% of the probes during the follow-up sessions, but his performance was highly variable and decreased notably from the initial follow up session to subsequent sessions. In the follow-up sessions, Lincoln participated in turn-taking in 44% of the probes, and his participation increased from 33% in the first session to 50% in the final two sessions. He showed no initiation of interaction or language during the follow-up sessions.

**Participant 3: Kami**

Kami’s responses to probes in baseline and follow up sessions are presented in Table 4. The percentages of probes to which she responded using the various social engagement behaviors as well as the overall percentage of probes to which she responded are presented. The table also notes differences between baseline and follow up sessions.

**Baseline session performance.** Kami participated in five baseline sessions. Her eye contact in response to probes was fairly consistent with the exception of session two where it
<table>
<thead>
<tr>
<th></th>
<th>Preintervention Sessions</th>
<th>Postintervention Sessions</th>
<th>Post Total</th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Diff.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye Contact</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33% (5/15)</td>
<td>27% (4/15)</td>
<td>27% (12/45)</td>
<td>0%</td>
</tr>
<tr>
<td>Reciprocal Action</td>
<td>67% (4/6)</td>
<td>67% (20/30)</td>
<td>56% (10/18)</td>
<td>-11%</td>
</tr>
<tr>
<td>Language</td>
<td>0% (1/15)</td>
<td>1% (1/75)</td>
<td>0%</td>
<td>-1%</td>
</tr>
<tr>
<td>Initiating Engagement</td>
<td>13% (3/24)</td>
<td>23% (27/120)</td>
<td>24% (17/72)</td>
<td>+1%</td>
</tr>
</tbody>
</table>
dropped dramatically. This decrease reflects, in part, a poor camera angle. That is, her face was not always visible on the recording, and her eye contact could not be determined. She participated in reciprocal action interactions in 67% of opportunities, but performance was also varied. For example, in session four, she participated in reciprocal action activities in 33% of probes but in the following session, her participation increased to 83% of the probes. She produced one spoken word in session two. Other than this session, she produced no spoken or signed language. During the baseline sessions, Kami initiated engagement in 23% of probes but her performance was variable. Her first session showed the lowest occurrence of initiating engagement (13%) with subsequent sessions increasing in initiation.

**Follow-up session performance.** Kami participated in three follow-up sessions. She demonstrated eye contact in 27% of the probes overall but performance was variable and decreased notably in the final session. Kami participated in reciprocal action activities in 56% of the probes overall. Her participation in reciprocal action was lowest in the first session (17%) but increased in following sessions. The overall participation in reciprocal action decreased from baseline to follow up, however. There were no instances of language during follow up sessions, but Kami did initiate interaction in 24% of probes. The first follow up session showed the lowest level of initiation (13%) with each subsequent session demonstrating an increase in initiating engagement.

**Participant 4: Louis**

Louis’s performance in baseline and follow up sessions is presented in Table 5. The percentage of probes to which he responded by using social engagement behaviors is presented for individual sessions as well as the baseline and follow up sessions overall. In addition, differences between the overall baseline and follow up sessions are noted.
Table 5

*Louis’s Social Engagement Behaviors in Interaction with a Familiar Adult*

<table>
<thead>
<tr>
<th></th>
<th>Preintervention Sessions</th>
<th></th>
<th></th>
<th>Postintervention Sessions</th>
<th></th>
<th></th>
<th>Diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Total</td>
<td>Post Total</td>
<td>Diff.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye Contact</td>
<td>27% (4/15)</td>
<td>67% (10/15)</td>
<td>+35%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14% (2/14)</td>
<td>43% (6/14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27% (4/15)</td>
<td>60% (9/15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20% (3/15)</td>
<td>57% (25/44)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reciprocal Action</td>
<td>33% (2/6)</td>
<td>50% (3/6)</td>
<td>+19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33% (2/6)</td>
<td>80% (4/5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>50% (3/6)</td>
<td>67% (4/6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>67% (4/6)</td>
<td>65% (11/17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>0%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating Engagement</td>
<td>0%</td>
<td>0%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
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<td>0%</td>
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</tr>
</tbody>
</table>
Baseline session performance. Louis participated in four baseline sessions. He displayed instances of eye contact in response to 22% of the probes overall, but his performance was varied. Instances of eye contact were the same in the first and third baseline sessions but lower in the second and fourth sessions. With regard to reciprocal action, he participated in reciprocal action activities in 46% of the probes overall, and his participation increased as the sessions progressed. He demonstrated neither language nor initiation of engagement with his communication partner in any baseline sessions.

Follow-up session performance. Louis participated in three follow-up sessions. He demonstrated instances of eye contact during 57% of the probes overall, but performance was variable. Instances of eye contact in the first session occurred in 67% of probes, but dropped to less than half by the second session. In the last follow up session, instances of eye contact increased to 57%. Louis engaged in reciprocal action activities in 65% of the probes overall, and performance was variable. He participated in these activities in 50% of probes in the first follow up session, in 80% in the second session, and 67% in the final session. As in the baseline sessions, he did not produce spoken or signed meaningful language, nor did he initiate engagement during follow up sessions.

Discussion

The current study was part of a larger study investigating the effect of using low dose exposure to a humanoid robot to elicit social engagement behaviors in children with autism. It was hypothesized that including the robot in treatment activities would increase social communication skills and generalize skills to a human interaction partner. Baseline and follow up assessment sessions were conducted for each participant in four different types of interactions without the robot (familiar adult-child, unfamiliar adult-child, parent-child, and triadic-child).
The current study focused on interactions between the child and a familiar adult in turn taking activities using a ball, a car, and wind up toys before and after the intervention program.

Despite having received extensive treatment programs since early childhood, each of the four participants in this study demonstrated significant and persistent developmental delays including severe deficits in social engagement. Previous reports suggested that introducing a robot in intervention might interest and engage the children (Diehl et al., 2011). Specifically, it was hoped that the robot might facilitate social engagement with human conversational partners (Goodrich et al., 2012).

The results from the current study were highly variable. Within the framework and time constraints of the study, it proved impossible to obtain stable baseline measures. In fact, the nature of these children’s difficulties undermined the effort to observe a consistent level of performance. Several factors seemed to influence their behavior, particularly their level of behavior regulation. The participants showed a wide range of behavior regulation from session to session, which impacted their ability to respond in interaction. For example, Ally’s performance seemed to vary according to her level of fatigue. If her baseline session took place after a long school day, she spent half of the session crying and did not participate in the activities. The participants’ levels of regulation varied in follow up sessions as well. For example, Louis arrived at the clinic for a follow up session and immediately began screaming and running down the hallways. His mother reported that he was having an unusually bad day. During one of Lincoln’s follow up sessions, he hid under the bean bag chairs in the therapy room while plugging his ears and closing his eyes. At the conclusion of this session, he kicked the materials and screamed. Not surprisingly, his social engagement behaviors within that session were infrequent.
Evaluation of Individual Participants

At the conclusion of the study, each child demonstrated clinical differences that were not necessarily measured by the follow up assessments. It is informative to consider each participant’s changes in order to understand possible effects of the intervention.

Ally. Generally, Ally showed little change on the pre-and postintervention measures. Overall, she demonstrated a decrease in reciprocal action and slight increase in eye contact. There were no observed instances of language or initiating engagement. Despite these results, the robot appeared to impact Ally positively in the clinical setting. At the beginning of the study, she was often disregulated during clinical sessions, and she cried continually. When the robot was introduced, however, she calmed down and participated in other activities planned by the clinician even after the robot had been removed. For several subsequent sessions, she continued to show interest in the robot, but her interest waned in later sessions. This pattern of initial interest was evident in other activities. Ally sometimes attended to novel activities and toys and then lost interest quickly. Nevertheless, clinical observation suggested that Ally attended to activities longer during the session with her mother and the clinician after interacting with the robot. These gains were not captured by the postintervention measures, however.

Kami. Kami’s performance was highly variable. Overall, she demonstrated little change or a decrease in the social engagement behaviors studied. The decrease that was noted in reciprocal action was due to Kami’s having a particularly difficult session in the first follow up session. During this session, she was disregulated throughout; she moved quickly around the therapy room without focusing on one activity, she threw a bean bag chair at both the clinician and the camera person, and she bit her own hand. Not surprisingly, she did not participate in reciprocal action exchanges.
During the intervention sessions, Kami was usually interested in the robot. She was sometimes aggressive toward it, however. She physically hit the robot and attempted to take it apart. She sometimes behaved similarly toward other toys and objects. Even though she seemed to enjoy interacting with the clinician, she was sometimes aggressive toward her as well. Despite the lack of change in social engagement in pre-and postintervention measures, some of Kami’s best interactional behaviors were observed in treatment sessions where the robot was included.

**Lincoln.** Lincoln participated in six baseline sessions. His eye contact decreased over the baseline sessions, but his reciprocal action was consistent in the final three baseline sessions. His eye contact was variable in follow up sessions, but his reciprocal action showed a fairly consistent increase. Lincoln seemed to respond well to the robot, and clinical observation suggested that his increased reciprocal action was associated with his increased participation in collaborative interactions with the robot.

**Louis.** Overall, Louis showed an increase in social communication behaviors both in clinical sessions and in follow up sessions. His eye contact and reciprocal action increased from the commencement of the study. An unexpected result observed during follow up was improved self-regulation behaviors. For example, in one follow up session, Louis was disregulated, but he pulled a bean bag chair on top of himself instead of pulling the clinician’s hair as he had done in baseline sessions. Louis seemed to enjoy collaborating with his mother and the clinician when the robot was included. During these interactions, he could sit for an extended period and maintain interest in the joint activity.

**Influence of the Robot on Interactional Behaviors**

The primary goal of employing the robot in the intervention process was to encourage reciprocal exchanges between the child and human communication partners. Facilitating the
child’s interaction with the robot per se was not a treatment objective. Rather, it was hoped that the robot would serve as a bridge to enable interaction that would continue when the robot was not present. For this to happen, it was important that the children show an active interest in the robot. During the study, all the children showed interest in the robot initially. The intervention activities were carefully structured to stress the collaboration between the robot, the clinician, the mother, and the child. It was interesting to note that no instances were observed where the children attempted to interact with the robot without the clinician and the mother as part of the interaction.

Although all of the children seemed to enjoy the robot, the intervention seemed more effective at encouraging social engagement in some children as compared to others. For example, both Lincoln and Louis made gains in reciprocal activity posttreatment. Both of these boys enjoyed the interactions with the robot. Louis sometimes sat and participated in these interactions for relatively long periods of time. His ability to attend to those interactions including the robot was probably an important factor in his improvement. With regard to reciprocal activity, both Kami’s and Ally’s performance postintervention was disappointing. Kami appeared to enjoy the robot, but her aggression toward the robot often interrupted the reciprocal activity. Although Ally seemed to lose interest in interacting with the robot after several sessions, her initial interest was important in helping her regulate her behavior and direct her attention to subsequent activities.

Limitations and Recommendations for Future Research

Conclusions drawn from this study must be considered preliminary because of a variety of limitations. For example, none of the participants demonstrated a stable level of performance in baseline sessions. A number of factors may have explained the variability in their behavior.
The children had limited exposure to the clinicians and the BYU Comprehensive Clinic setting, and they may have been particularly sensitive to changes in new environments and people. For example, in the first assessment session (prior to the baseline sessions) Lincoln hid under a chair and refused to interact with the clinicians. In addition, the constraints of the study limited the time that clinicians had to learn how to provide the most appropriate support for each child. Thus, although the activities were consistent across sessions, the support provided by clinicians varied in subtle ways.

Perhaps the most influential factor explaining the variability in performance was each child’s behavior regulation. The children’s ability to calm themselves and to attend to activities varied from session to session. Various factors probably influenced their regulation, including fatigue. In subsequent research, behavioral regulation must be considered more carefully. It may not be possible to control each child’s level of regulation, but assessments might be developed to evaluate each child’s regulation on a session-by-session basis. That way, the children’s social engagement behaviors could be considered within the context of their overall behavioral regulation.

An additional limitation is that the study was conducted within a four-month period of time. Considering the severity of disability that these children presented, rapid changes in behavior would not be expected. The participants had limited time to interact with the robot and it is possible that if the children participated in a more extended period of intervention, they would show more gains. Robins, Dautenhahn, te Boekhorst, and Billard (2005) suggested a minimum period of six months of interaction before a breakthrough was observed in interaction between a clinician and a child with autism. If treatment were extended for a longer period of
time, however, it might well be the case that a wider variety of activities and robot capabilities could be important, especially for children like Ally.

The coding system used to analyze data from baseline and follow up sessions was designed to measure social engagement behaviors in response to specific probes. In order to assure reliable identification of behaviors, a fairly narrow focus and strict analysis were necessary. For each of the children in this study, however, there were clinically important events associated with the robot intervention that were not captured by the analysis system. In future research, a more qualitative analysis might be devised to enhance the quantitative assessment of behaviors.

**Conclusion**

The current study focused on the effects of traditional social language intervention paired with exposure to a humanoid robot to increase social engagement in children with autism. For two of the four children, the most improvement was seen in reciprocal action exchanges. Intervention procedures using the humanoid robot targeted these activities. Therefore, it may be the case that intervention including the robot in collaborative activities holds promise for some children with autism. The results from this study are preliminary, however. Future research should consider a more extended period of intervention before the introduction of a robot, a careful daily evaluation of each participant’s behavioral regulation, a longer period of intervention using the robot, a wider variety of robot capabilities, and a more in-depth qualitative analysis of child behavior.
References


TiLAR Team. (2012). *Coding Manual*. Unpublished manuscript, Department of Communication Disorders, Brigham Young University, Provo, Utah.


Appendix A

Diagnosticians for Each Participant

Table A1

*Diagnosticians and Measurement of Diagnosis for Each Participant*

<table>
<thead>
<tr>
<th>Diagnosticians</th>
<th>Measurement for Diagnosis</th>
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</thead>
<tbody>
<tr>
<td>Ally Psychologist</td>
<td>ADOS</td>
</tr>
<tr>
<td>Louis Special Education Teacher</td>
<td>CARS</td>
</tr>
<tr>
<td>Kami Pediatric Neuropsychologist</td>
<td>ADOS</td>
</tr>
<tr>
<td>Lincoln Pediatrician</td>
<td>Behavioral Observations</td>
</tr>
</tbody>
</table>

*Note. ADOS = Autism Diagnostic Observation Schedule. CARS = Childhood Autism Rating Scale.*
Appendix B

Assessments for Each Participant

Table B1

Assessments for Each Participant from February 2011

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Ally</th>
<th>Louis</th>
<th>Kami</th>
<th>Lincoln</th>
</tr>
</thead>
<tbody>
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<td>WNL</td>
<td>WNL</td>
<td>WNL</td>
</tr>
<tr>
<td>Westby Playscale</td>
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<td></td>
</tr>
<tr>
<td>Presymbolic Level I</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td>50</td>
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</tr>
<tr>
<td>PLS-4 Percentile</td>
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<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Appendix C

Outline of Baseline and Follow up Measures

**BASELINE/FOLLOW-UP**

**DATE**

**Parent**

5-7 minutes; book, farm, stuffed animals, pizza, blocks

**Familiar Adult**

**Baby**

Present baby with blanket [ ] [ ] [ ]

Present baby with food [ ] [ ] [ ]

**Push car**

Present the car; Push the car to the child
[ ] [ ] [ ]

Say “PUSH IT TO ME”

**Two Songs**

Isty Bitsy Spider [ ]

Popcorn Popping [ ]

**Windup Toys**

Present 3 wind-up toys individually; initiate toy 3x

#1 Wind-up toy [ ] [ ] [ ]

#2 Wind-up toy [ ] [ ] [ ]

#3 Wind-up toy [ ] [ ] [ ]

Say “WATCH THIS”

**Noisy Ball**

Roll the ball to client [ ] [ ] [ ]

Say “ROLL IT TO ME” or “MY TURN”

**Less Familiar Adult**

**Baby**

Present baby with blanket [ ] [ ] [ ]

Present baby with food [ ] [ ] [ ]

**Push car**

Present the car; Push the car to the child
[ ] [ ] [ ]

Say “PUSH IT TO ME”

**Two Songs**

Isty Bitsy Spider [ ]

Popcorn Popping [ ]

**Windup Toys**

Present 3 wind-up toys individually; initiate toy 3x

#1 Wind-up toy [ ] [ ] [ ]

#2 Wind-up toy [ ] [ ] [ ]

#3 Wind-up toy [ ] [ ] [ ]

Say “WATCH THIS”

**Noisy Ball**

Roll the ball to client [ ] [ ] [ ]

Say “ROLL IT TO ME” or “MY TURN”

**Triadic Interaction**

Present car, tambourine, music toy, and ball

Push to clinician then child [ ] [ ] [ ]

Give to clinician then child [ ] [ ] [ ]

Push to clinician then child [ ] [ ] [ ]

Give to clinician then child [ ] [ ] [ ]
Appendix D

Coding Manual used in Data Analysis

Coding Manual

Definitions

1. **Social Engagement**: attending to, expressing interest in, and responding to another individual or individuals for the purpose of interpersonal interaction.

2. **Invalid Probe**: probe is invalid if the clinician does not verbally say the proper phrases associated with the interaction. Take the 1st 3 valid probes.

3. **Eye contact**: to count must be able to see HEADS and clinician+child in at least one camera. If HEADS are aligned, count it as eye contact.

Rules

1. Read the directions before coding.
2. When in doubt, don’t code.
3. Don’t code your own client.
Familiar Adult

Baby with blanket

Probe begins: when the materials leave the clinician’s hands
Probe ends: 20 seconds after the probe began

Eye Contact: ☐ ☐ ☐ ☐

Symbolic play:
Child cuddles, hugs, kisses, or rocks baby with or without blanket,
Puts on blanket/wraps up baby,
Covers self or clinician

Self ☐ ☐ ☐ ☐

Toy ☐ ☐ ☐ ☐

Clinician ☐ ☐ ☐ ☐

Initiating: Following symbolic play, hands item back to clinician ☐ ☐ ☐

Language: Signs or speaks about baby or blanket topic ☐ ☐ ☐ ☐

Baby with food

Probe begins: when the materials leave the clinician’s hands
Probe ends: 20 seconds after the probe began

Eye Contact: ☐ ☐ ☐ ☐

Symbolic play:
Code Feed baby with bottle or spoon
Code Feeds self or clinician with bottle or spoon

Self ☐ ☐ ☐ ☐

Toy ☐ ☐ ☐ ☐

Clinician ☐ ☐ ☐ ☐

Initiating: Following symbolic play, hands item back to clinician ☐ ☐ ☐

Code if feeds self or baby and then feeds clinician
Don’t code if child feeds clinician and then self or baby

Language: Signs or speaks about baby or food topic ☐ ☐ ☐ ☐

Singing

Note: Coding begins at beginning of song and proceeds until 5 seconds post completion of the song

Eye Contact: ☐ ☐ ☐

Reciprocal Action: Participates with correct actions of song ☐ ☐ ☐

Reciprocal Action: Singing along with clinician ☐ ☐ ☐

Initiating: Request repeat of song or begins to sing song again within 5 seconds ☐ ☐ ☐
Ball

**Probe begins:** when clinician finishes saying: Push to me

**Probe ends:** Either 20 seconds after the probe or when a verbal bid is made to change the interaction.

**Code:** if the ball makes it back in ANY WAY to the clinician

**Don't Code:**
1. If the clinician physically takes item away
2. If the clinician moves significantly to receive the item

<table>
<thead>
<tr>
<th>Item</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye Contact</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reciprocal Action</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language: Signs or speaks about ball or about activity topic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating: At conclusion of probe, child says or signs “again” or “more”</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Push car

**Probe begins:** when clinician finishes saying: Push to me

**Probe ends:** Either 20 seconds after the probe or when a verbal bid is made to change the interaction.

**Code:** if the car makes it back in ANY WAY to the clinician

**Don't Code:**
1. If the clinician physically takes item away
2. If the clinician moves significantly to receive the item

<table>
<thead>
<tr>
<th>Item</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye Contact</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Reciprocal Action</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language: Signs or speaks about car or about activity topic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initiating: At conclusion of probe, child says or signs “again” or “more”</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wind-up Toys

**Probe begins:** when clinician finishes saying: Watch this

**Probe ends:** Either 20 seconds after the probe or when a verbal bid is made to change the interaction.

**Code:** If child gives toy to clinician independently

**Don't Code:**
1. If child gives toy back to clinician with a verbal prompt or a tactile prompt
2. If child doesn’t give toy to clinician

**Initiating prototypes:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Code 1</th>
<th>Code 2</th>
<th>Code 3</th>
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<tbody>
<tr>
<td>Eye Contact</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Initiating: Give to clinician independently</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Language: signs or speaks about wind-up toys or activity topic</td>
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</table>

**Initiating request:** Handing or making available to clinician *paired with eye contact* OR Handing or making available to clinician *paired with language* (signs or words)
Unfamiliar Adult

Baby with blanket

**Probe begins:** when the materials leave the clinician’s hands

**Probe ends:** 20 seconds after the probe

**Eye Contact:**

**Symbolic play:**
Cuddle, hug, kiss, or rock baby with or without blanket
Put on blanket/wrap up baby
Cover self or clinician

- **Self:**
- **Toy:**
- **Clinician:**

**Initiating:** Following symbolic play, hands item back to clinician

**Language:** Signs or speaks about baby or blanket topic

---

Baby with food

**Probe begins:** when the materials leave the clinician’s hands

**Probe ends:** 20 seconds after the probe

**Eye Contact:**

**Symbolic play:**
- **Code** Feed baby with bottle or spoon
- **Code** Feeds self or clinician with bottle or spoon

- **Self:**
- **Toy:**
- **Clinician:**

**Initiating:** Following symbolic play, hands item back to clinician

*Code* if feeds self or baby and then feeds clinician

*Don’t code* if child feeds clinician and then self or baby

**Language:** Signs or speaks about baby or food topic

---

**Singing**

**Note:** Coding begins at beginning of song and proceeds until 5 seconds post completion of the song

**Eye Contact:**

**Reciprocal Action:** Participates with correct actions of song

**Reciprocal Action:** Singing along with clinician

**Initiating:** Request repeat of song or begins to sing song again within 5 seconds
Ball
Probe begins: when clinician finishes saying: Push to me
Probe ends: Either 20 seconds after the probe or when a verbal bid is made to change the interaction.
Code: if the ball makes it back in ANY WAY to the clinician
Don’t Code: 1. If the clinician physically takes item away
2. If the clinician moves significantly to receive the item

Eye Contact:

Reciprocal Action: Returning ball to clinician

Language: Signs or speaks about ball or about activity topic

Initiating: At conclusion of probe, child says or signs “again” or “more”

Push car
Probe begins: when clinician finishes saying: Push to me
Probe ends: Either 20 seconds after the probe or when a verbal bid is made to change the interaction.
Code: if the car makes it back in ANY WAY to the clinician
Don’t Code: 1. If the clinician physically takes item away
2. If the clinician moves significantly to receive the item

Eye Contact:

Reciprocal Action: Returning car to clinician

Language: Signs or speaks about car or about activity topic

Initiating: At conclusion of probe, child says or signs “again” or “more”

Wind-up Toys
Probe begins: when clinician finishes saying: Watch this
Probe ends: Either 20 seconds after the probe or when a verbal bid is made to change the interaction.
Code: If child gives toy to clinician independently
Don’t Code: 1. If child gives toy back to clinician with a verbal prompt or a tactile prompt
2. If child doesn’t give toy to clinician

Initiating prototypes:

Eye Contact:

Initiating: Give to clinician independently

Language: signs or speaks about wind-up toys or activity topic

Initiating request: Handing or making available to clinician paired with eye contact OR
Handing or making available to clinician paired with language (signs or words)
**Triadic Interaction**

**Probe begins:** with first hand-off (First clinician passing toy paired with saying “Give to ____”)

**Probe ends:** 1. With **ANY** clinician taking the toy away from child (for the probe to end the clinician **MUST** have the toy in hand)
   2. A clinician making a bid to end the interaction (a bid consists of a change of phrasing “Can I have the toy?” etc. aka clinician trying to retrieve the item with some sort of verbal request)

**Code:** the item **INDEPENDENTLY** makes it back to the correct clinician

- **Eye Contact:**
  - [ ] [ ] [ ]

- **Reciprocal Action:** Returning item to clinician independently
  - [ ] [ ] [ ] [ ] [ ]

- **Language:** Signs or speaks about ball or about activity topic
  - [ ] [ ] [ ] [ ] [ ] [ ] [ ]

- **Initiating:** At a conclusion of a full probe, child says or signs “again” or “more”
  - [ ] [ ] [ ] [ ] [ ] [ ] [ ]
Appendix E

Annotated Bibliography


**Purpose of the study:** The purpose of this case study was to investigate the use of a humanoid robot in intervention targeting social engagement in two children with ASD. This study explored whether a generalization of social communication behaviors occurred when the robot was not present.

**Method:** Participants were two males, ages 3 and 8 years with moderate to severe deficits in social communication, joint attention, and language. Each participant received 16 individual therapy sessions two times a week for 50 minutes. 10 to 15 minutes of each therapy session included the robot, the child, the clinician, and sometimes the parent in highly interactive activities. Pre-and posttreatment sessions were analyzed to identify language, affect, imitation, and eye contact in interactions between the child and his parent and the child and a familiar clinician.

**Results:** The three-year-old child made marked gains in social engagement in posttreatment sessions and the eight-year-old child made modest gains. In the child-parent play assessment, both children demonstrated an increase of eye contact and use of affect in posttreatment sessions. The three-year-old child made extraordinary gains and the eight-year-old child decreased in language and imitation in posttreatment sessions. During the child-clinician play assessment posttreatment sessions, both children demonstrated an increase in language, affect, and eye contact. The three-year-old child demonstrated gains in imitation while the eight-year-old participant showed a decrease in imitation.

**Conclusions:** The low dose intervention using a robot was associated with dramatic increases in social engagement in the child-parent play assessment, both children demonstrated an increase of eye contact and use of affect in posttreatment sessions. The three-year-old child made extraordinary gains and the eight-year-old child decreased in language and imitation in posttreatment sessions. During the child-clinician play assessment posttreatment sessions, both children demonstrated an increase in language, affect, and eye contact. The three-year-old child demonstrated gains in imitation while the eight-year-old participant showed a decrease in imitation.

**Relevance to the current work:** The current study uses a similar treatment model and expands this study.


**Purpose:** This section of the DSM-IV described the diagnostic characteristics of a pervasive developmental disorder.

**Description:** These include impairment in reciprocal social interaction skills, communication skills, or the presence of stereotyped behavior or interests. Pervasive developmental disorder includes Autistic Disorder (Autism), Rett’s Disorder, Childhood Disintegrative Disorder, Asperger’s Disorder, and Pervasive Developmental Disorder Not Otherwise Specified. Autism is characterized by a qualitative impairment manifest by at least two deficits in social interaction, one deficit in communication, and one deficit in restricted repetitive and stereotyped patterns of behavior or interests. In addition, there is a delay or
abnormal development prior to 3 years of age in social interaction, communication, or symbolic play.

**Relevance to current work:** The participants in the current study were all diagnosed with autism.


**Purpose of work:** The authors of this work consisted of a panel of twenty members of the American Academy of Neurology. This work provides healthcare providers with guidelines related to screening and diagnosing children with autism in order to initiate intensive early intervention for these children.

**Summary:** In order to identify children with autism for early intervention, there are two steps that need to occur which are outlined in this article. The first step is known as Routine Developmental Surveillance. This is a screening done on all children and it identifies children who are at risk for any delayed or atypical development. After this initial identification process, there is then an identification process for children specifically at risk for autism. If by 18 months of age, a child is showing difficulties with eye contact, orienting to one’s name, joint attention, pretend play, imitation, nonverbal communication, or language development, then this child should be assessed for autism.

The second step is known as Diagnosis and Evaluation of Autism, which is a more in-depth assessment. Clinicians experienced in the field use assessment instruments, rating scales, and checklists to complete this evaluation. Speech, language, verbal and non-verbal communication, cognition, and sensorimotor are the areas of focus during the assessment. Specific recommendations include allowing sufficient time for conducting of parent interviews, performing direct, structured observation of social and communicative behavior and play, using recommended diagnostic parental and observation instruments, using a comprehensive, multidisciplinary approach, and reevaluating the individual within one year of initial diagnosis.

**Conclusions:** This article provides guidelines for the identification and assessment of young children with autism. In addition, it recommends that healthcare providers who see children with autism increase their knowledge in order to better identify, assess, and treat this population.

**Relevance to current work:** This article details characteristics that may be early indicators of autism in a child.


**Purpose:** The purpose of this article is to discuss the difficulties and advantages in using robots in intervention with children with autism.

**Summary:** There are a variety of advantages to using a robot in intervention. First of all, a robot is less intimidating to a child with autism than a real person. Therefore, the child can relax and enjoy the interaction. Second, children with autism may feel uncomfortable in unpredictable environments such as a social interaction. However, a robot can be programmed to be a predictable communication partner. In addition, children with autism enjoy technology. This enjoyment is a basic condition for successful learning.
There are difficulties in using a robot in intervention. A robot interface must be carefully considered. If there are too many bright colors or flashing lights, it may distract the child from the interaction. Some children with autism treat toys and objects roughly. A robot must have a robust design to withstand rough handling. Another difficulty is that a professional needs to be present when a robot is used in order to adjust the robot between sessions. Finally, to be an effective therapy tool, continual assessment must occur. The feedback from the child interacting with the robot is observational data. Researchers may not know if the project is moving in the right direction because of the lack of direct feedback.

**Conclusion:** Research suggests that using robots in therapy for children with autism has many benefits. It is important to consider the needs of children and therapists in designing robots and implementing them in therapy.

**Relevance to current work:** This article outlines factors to consider when using the robot as an intervention tool.


**Purpose:** The purpose of this article was to review the literature about joint attention in typical children and children with autism.

**Summary:** Joint attention is defined as “a cluster of behaviors that share the common goal of communication with another person about a third entity in a nonverbal way, including eye gaze alternation and gesturing” (p. 169). Two different types of joint attention include responding to joint attention or initiating joint attention. Due to space limitations, this paper focuses on initiating joint attention in typical children and children with autism.

In typical child development, the emerging of joint attention correlates with the development of intentional communication. This is later followed by real expressive language. Overtime, a child’s communication matures from a dyadic interaction to an interaction where a child divides his or her attention between an object and a partner.

The literature shows that children with autism demonstrate difficulty using eye contact while looking at or referencing someone else. When these children do develop joint attention, it typically is in the form of a behavioral request, where the child uses joint attention to request or protest an object or an action.

**Conclusion:** In order to help children with autism develop intentional, expressive communication, it may be important to help a child develop joint attention first. Therefore, joint attention may be an appropriate goal to target in intervention programs.

**Relevance to current work:** This article describes the development of joint attention and how joint attention is important to develop social communication skills.


**Purpose:** This article identified different roles that robots can play in a therapeutic environment. It focused on research gathered from the Aurora project, which uses robots to help a child learn social behaviors.
**Description and conclusions:** There are three different ways to use a robot in intervention with a child with autism. First, the robot can be viewed as a therapeutic playmate to teach social skills. The robot practices activities with the child such as turn taking and following the child. There may be a slight attachment between the child and robot, but the robot is not meant to replace humans. In addition, a robot can be used as a social mediator. In this case, the robot acts as a tool to mediate social interaction between children and adults. The robot is used to teach the child social skills, but it is eventually phased out of interaction after the child generalizes the skills. The final role a robot plays in intervention is a social agent or social actor. In this case, the robot is used to teach social stories by playing the role of the actor. Ideally, this would allow interaction between the robot and the child during the social story. Using a robot instead of a human has many benefits including the simplicity and predictability of the robot in interaction. The author calls for further research.

**Relevance to current work:** The current study uses a robot as a social mediator to facilitate specific social engagement skills with children with autism.


**Purpose:** The purpose of this study was to consider the relationship between language ability and social behaviors including social orienting, joint attention, and attention to another’s distress. Children with autism were compared with typical children and children with developmentally delays.

**Method:** There were three groups of children who participated in this study. Participants included 72 children who had Autism Spectrum Disorder, 34 children with developmental delays, and 39 children with typical development. Children were observed in three different sessions, and a parent also attended each session. The child sat next to or on the parent’s lap across from the examiner, and the examiner used toys and materials to elicit behaviors including social orienting (turning to locate the source of a sound), joint attention, and attention to distress.

**Results:** Results suggested that children with autism showed impairment when compared to typical or developmentally delayed peers in social orienting, joint attention, and attention to distress. Children with autism were less likely to orient to both social and nonsocial auditory stimuli. The presence of joint attention was judged to be the most sensitive in discriminating children with autism from children in the other groups. Children with autism also demonstrated lower ability than did children in the other groups to attend to other’s distress. Joint attention was the best predictor of language ability.

**Conclusion:** It was important assess children for impairments in joint attention and social orienting. Joint attention was the best predictor of language ability and should be considered in planning intervention goals.

**Relevance to current work:** This study focuses on the role of joint attention in language development in children with autism.

Purpose: This article is a literature review of studies on using robots in diagnostics and intervention in children with autism. Specifically, it addresses questions regarding the best role for a robot in therapy and who among individuals with autism might be best suited for therapy using a robot.

Method: Literature was obtained by searching the ISI Web of Knowledge, PsychINFO, and IEEE Xplore. Studies reviewed met specific requirements including being published in a peer-reviewed journal or conference proceeding and involving data collected on someone with autism. Data needed to be result of direct therapy, provide implications for diagnosis, or be a study that compared type, speed, and frequency of child responses to a robot. These qualifications resulted in 15 journal articles and five conference papers.

Each article or paper was grouped within one of four categories. Categories included response to robots or robot-like characteristics, robots used to elicit behavior, robots used to model, teach, or practice a skill, and robots provide feedback and encouragement.

Results: The overall conclusion for the category of responding to robots or robot-like characteristics results was that some children with autism prefer robots to toys, initially show preference for robot characteristics in social interaction, and respond quicker to movement of a robot than to the movement of a human. Many of the studies were simply explanatory, however, and the data were inconsistent within the studies.

The category of eliciting behaviors with a robot showed that robots could be used to elicit a variety of behaviors in varying individuals with Autism Spectrum Disorders. Most of this research was mainly theoretical, however.

Work with robots used to model, teach, or practice a skill showed that children with autism have a larger interest in a robotic partner than a human partner. In the particular study, however, children with autism imitated verbal and non-verbal skills better with a human communication partner.

The authors found a lack of information on using a robot to provide feedback and encouragement in a therapeutic setting for children with autism.

Conclusion: Even though there are promising therapeutic implications for using robots in intervention in children with ASD, there is little research in this area. Further research is needed to provide more information on the efficacy of this type of intervention.

Relevance to current work: The current work is a study using robots in intervention in children with autism.


Purpose: The purpose of this poster presentation was to describe how a socially assistive robot was developed for therapy with children with autism.

Description and results: The authors used a socially assistive robot as an intervention partner for children with autism. The purpose of the robot, however, was not to teach social skills but to be a social catalyst for human-to-human interactions. For example, a robot was used to blow bubbles to allow a parent and child with autism to interact. The authors performed a pilot experiment with five participants (four with ASD, one typically developing) to assess if a randomly controlled robot or an interactive robot elicited more social engagement. The children
produced more social behaviors including an increased length of utterance when the robot was responsive to the child’s actions.

**Conclusion:** This research suggested that interactive robot behaviors can be used effectively to elicit social interaction with a child with autism and another human.

**Relevance to current work:** The current study uses an interactive robot controlled by a clinician during intervention.


**Purpose:** The purpose of this study was to examine interactions between a child with autism and a mobile robot during free game play. The authors hypothesized that children would spend the majority of time in the room interacting with the robot.

**Method:** This study included four participants with autism whose ages ranged from seven to nine years old. GIPY-1 had two circles for eyes, a triangle for a nose, and an oval for a mouth. It was shaped like a cylinder with a height of 30 cm and was controlled by an operator using a wireless remote. The robot was placed on the floor facing the doorway. GIPY-1 was able to move forward, move backward, and rotate in a circle. The analysis focused on the time of interaction between the child and the robot based on four behaviors including eye contact, touch, manipulation, and posture.

**Results and Conclusions:** The average time participants spent interacting with GIPY-1 was 79% across the four participants. Eye contact was consistent between the participants but all other observed behaviors differed. The authors concluded that children with autism showed interest in interacting with robots.

**Relevance to current work:** The current study uses a robot during speech and language intervention to elicit social communication skills.


**Purpose:** The purpose of this article was to review the research and support for using various technological interventions with children with autism. It also discussed possibilities for future research.

**Summary:** There are two types of technological interventions used with children with autism. Some options are designed to be an indefinite tool for use while other are used as a temporary instructional aid used until a certain goal is met. Devices to provide auditory and tactile prompting are one of these options. For example, devices such as intermittent timers or buzzers that may turn on after a designated period of time to act as a reminder for the child to complete skills such as staying on task or saying something to a peer. Using video in intervention is another option. Videos require little technological knowledge or instruction and are easily accessible for use. Videos may provide engaging activities to teach or model social skills. Computer based intervention activities may be used to can target a wide variety of goals. These activities may be used to increase motivation and attention and decrease inappropriate behavior. Another option is virtual reality, which provides opportunities to experience a computer-generated world in which people can react to the child as controlled by a programmer. This type
of program could be used to teach specific targets of behavior and may result in improved attention and performance. Finally, the use of robots in intervention is discussed as an option. Interaction with a robot may create a simplified social environment to help children with autism acquire social skills. A robot may be used to teach specific skills or serve as an object of shared interest between a child and a communication partner. Research suggests that children with autism are interested in interacting with a contingently controlled robot.

**Conclusions:** Various technologies have been implemented in intervention in children with autism. These technologies are promising, but future studies should assess whether these treatments are cost-effective or more effective than traditional interventions.

**Relevance to current work:** This article describes benefits and possible uses of robots in intervention with children with autism.


**Purpose:** The article describes a robot designed to assist in therapy for children with Autism. It defines the role a robot can play as part of an intervention team, and reports a case study.

**Summary:** At the Brigham Young University Comprehensive Clinic, the therapy team consisted of a primary clinician, secondary clinician, therapy supervisor, and the caregivers. The typical therapy sessions lasted fifty minutes. Forty minutes of each session consisted of intervention activities designed to encourage the child to respond to joint attention or initiate joint attention with the clinician or caregiver. The remaining ten minutes of each session employed a robot. During the sessions, the robot’s role in therapy was to engage the child’s attention, encourage dyadic interactions between the child and robot, and facilitate triadic interactions between the child, the clinician, or caregiver, and the robot. The intervention was designed to eventually phase out the robot to allow the child use those interaction skills with the clinician or caregiver.

The article also describes the design and user interface of the robot (named Troy). Troy was designed to be the same size as a four-year-old child; he is twenty-five inches tall with two arms twelve inches in length. Troy’s arms have four degrees of freedom to allow for full range of motion. He can perform simple actions such as pushing a toy car or ball, waving hello, or singing a song with actions. His head was a seven-inch computer screen surrounded by plastic that showed simple emotions such as happy, sad, or neutral. He was connected to a laptop out of the child’s reach and controlled by the clinician using a Wiimote. His behaviors were designed to promote turn-taking and imitation. The user interface allowed for controlling of the robot in the middle of the session by the clinician as well as possible programming changes between sessions.

**Conclusions:** In order for a robot to be part of a therapy team, the therapists must be able to program the robot because an engineer will not be present during daily therapy decisions. This article reported on a therapy design that allowed for these changes to be made by the clinicians.

**Relevance to current work:** This article provides a design of how to use a robot as part of an intervention team for children with autism.

**Purpose:** The purpose of this study was to evaluate the effectiveness and results of using a humanoid robot in intervention for two children with Autism Spectrum Disorder.

**Method:** Participants were two males, ages three and eight years with moderate to severe deficits in social communication, joint attention, and language. Each participant received 16 individual therapy sessions two times a week for 50 minutes. 10 to 15 minutes of each therapy session included a robot, the child, the clinician, and sometimes the parent in highly interactive activities. Pre-and posttreatment sessions were analyzed to identify language, affect, imitation, and eye contact in interactions between the child and an unfamiliar adult and the child and two adults in a triad.

**Results:** The three-year-old participant showed a marked increase in social engagement behaviors and the eight-year-old participant showed a modest increase. In the triadic assessment, both children demonstrated an increase of eye contact, language, and imitation. The eight-year-old child showed an increase in use of affect while the three-year-old only showed a slight increase in affect in posttreatment sessions. Both children demonstrated gains in the triadic intervention. During the child-unfamiliar adult assessment posttreatment sessions, both children demonstrated an increase in language, affect, and eye contact. The three-year-old child demonstrated gains in imitation while the eight-year-old participant showed a decrease in imitation. Both of these children exhibited gains in social engagement skills but the three-year-old participant showed the biggest gains.

**Conclusions:** Both children showed increases in social engagement behaviors. The three-year-old participant showed more consistent, promising results but the eight-year-old participant improved as well. These results suggested that using a robot in intervention in children with Autism Spectrum Disorder could result in an increase in social engagement skills with these children.

**Relevance to current work:** The current study uses a similar treatment model and expands this study.


**Purpose:** The purpose of this study was to describe a robot used in a daycare center for children with disabilities.

**Method:** The authors wanted to see the long-term effect of a small robot, named Keepon, on the social skills in children with autism. Keepon was small, yellow, and spongy. He had two eyes, a nose, a head, and a torso. The robot could turn and look at different things as well as display emotions such as happiness, excitement, and fear through body movement. Keepon was kept in the playroom area of a day care center for children with developmental disabilities.

**Results:** Many children stayed away from Keepon at first but showed interest overtime. Some children eventually engaged in dyadic interaction with Keepon as the study progressed.
Keepon also elicited triadic interactions between a child and her caregiver or nurse. After a child developed a relationship with Keepon, some children played imitation games with this robot.

**Conclusion:** The simply designed robot, Keepon, was used in therapeutic activities with children with autism. Over the course of the study, some children demonstrated pro-social behaviors, dyadic interactions, and triadic interactions with caregivers. The authors conclude that robots “have the potential to stimulate autistic children’s sense of wonder…and to help them engage in interpersonal communication in the real social context” (p. 346).

**Relevance to current work:** The current study uses a robot to elicit social interaction behaviors in children with autism.


**Purpose:** The purpose of this article is to provide an overall review of information on autism for those in medical professions. It describes epidemiology, clinical characteristics, assessment, neurobiology, causes, genetics, and treatments of autism.

**Summary:** Autism is characterized by “a severe and pervasive impairment in reciprocal socialisation, qualitative impairment in communication, and repetitive or unusual behavior” (p. 1627). The article reports that prevalence might be increasing because of policy and practice changes rather than an actual increase. However, no one knows the etiology of this disorder other than that there is a genetic link. Specific clinical characteristics are detailed in the article, but the authors recommend early assessment in order to obtain early intervention. Assessment should be completed using the gold standards for testing such as the autism diagnostic observation schedule (ADOS) or the revised autism diagnostic interview (ADI-R), as well as an assessment from an inter-disciplinary team to ensure all of the child’s needs are addressed. After a child is assessed, there are a wide variety of interventions available for the child addressing the various deficits present in autism. These are described in this article.

**Conclusions:** This article provided a summary of research findings about autism. The authors concluded that early identification, improved understanding of brain mechanisms, development of more effective treatments, and strategies to help the families of children with autism are needed.

**Relevance to current work:** The children in the current study all have been diagnosed with autism.


**Purpose:** This article reported observations of the interactions between children with autism and a robot over a six month period.

**Method:** Participants included two boys and three girls with autism. These children participated in five sessions with a robot that lasted 5-10 minutes once a month for six months.
During sessions, the robot either produced simple phrases or acted intentionally without speaking. For example, in one session a robot pushed blocks off of the table.

**Results and conclusions:** Only two children interacted with the robot. One child interacted with the robot, but when the robot did not comply with the child’s direction to repeat an action, the child became uncooperative with the robot in future sessions. The other participant vocalized when interacting with the robot. She produced appropriate greetings when interacting with the robot. The authors concluded that robots were able to communicate with children with autism as social agents.

**Relevance to current work:** The current study uses a robot in intervention in children with autism as a social mediator.


**Purpose:** This article outlines the rationale, background, and administration of the Early Social-Communication Scales (ESCS).

**Background:** The ESCS is a measure designed to provide measures of individual differences in nonverbal communication skills in typically developing and developmentally delayed children between eight months and thirty months of age. It is a structured observation that is videotaped and lasts from 15 to 25 minutes. Three types of behaviors are coded including joint attention behaviors, behavioral requests, and social interaction behaviors. Coders also can mark whether the child initiated a bid for interaction or responded to a bid from a tester.

**Administration:** Administration is structured to be generally consistent between testers and children with flexibility according to the communicative bids of the child. There is an optimal room set up where the tester sits across the table from the child and parent (if parent is present). During administration tasks, both the tester and parent are encouraged to keep verbalizations to a minimum. This article provides specific instructions for each specific probe.

**Coding and Scoring:** Basic coding in the ESCS consists of performing a frequency count of joint attention, behavioral request, and social interaction behaviors. Under each of these categories, specific behaviors are marked as lower or higher level behaviors. For example, lower level behaviors in initiating joint attention include eye contact and alternates. Higher level behaviors include a point, point and eye contact, or a show. Scoring specifics are outlined in the paper.

**Relevance to current work:** The current study’s coding system was loosely designed off of the ESCS as explained in this document.


**Purpose:** The purpose of this article was to discuss the development of and relationship between joint attention and social competence by identifying various models that explain this relationship.

**Summary:** Processes involved in joint attention contribute to the social interaction and social cognition of an individual across his or her lifetime. It impacts social relationships and
language development. There are multiple types of joint attention that typically develop between three months old and eighteen months old. These include initiating joint attention (IJA), responding to joint attention (RJA), and initiating behavior regulation/requests (IBR). Although delayed, children with autism typically develop IBR and RJA. They may struggle with IJA across their lifespan.

Based on previous research, there are four models to demonstrate the link between joint attention and social competence. The caregiver/scaffolding model proposes that an adult or caregiver provides types of social interactions that allow infants to develop joint attention skills. Another model, named the social-cognitive model, suggests that as an infant’s brain matures, the ability to understand others’ thoughts, feelings, and intentions helps develop joint attention skills. A differing approach, called the social motivation model, notes that joint attention develops due to the reward of sharing with others. Social motivation contributes to the development of joint attention. A final approach is the neurodevelopmental executive function model. An individual has a social executive capacity to monitor the actions of oneself and the actions of others. This monitoring system may contribute to the development of joint attention.

**Conclusion:** This current research is beginning to describe the relationship between the developing of social competence and joint attention skills.

**Relevance to current work:** The current study targets joint attention and the eliciting of better social engagement behaviors.


**Purpose:** The purpose of this study was to examine the joint attention and individual and combined discriminating capabilities of non-verbal communication and play with objects across typical children, developmentally delayed children, and children with autism.

**Method:** Participants included 18 children with autism, 18 children with developmental delays, and 18 typically developing children. Testing took place individually across three sessions in the same examination room for all participants. The first session consisted of the ESCS to assess social communication and an IQ test. During the second session, the child participated in an unstructured play task and a scale testing for language. In the final session, the examiner administered a structured play task, which focused on functional acts and symbolic acts in play.

**Results:** Results showed that children with autism showed deficits in comparison to the other two groups in initiating joint attention and following the direction of an experimenter’s pointing. These children also showed deficits in initiating requests such as pointing to a toy out of reach. The best discriminator between a child with autism and the other groups was eye contact with the experimenter while mechanical toys were active. Object play was not as discriminating as the non-verbal communication.

**Conclusion:** Deficits in non-verbal social communication behaviors were the most effective at differentiating children with autism from typically developing children or children with developmental delays.

**Relevance to current work:** The current work targets goals of joint attention and appropriate object play in intervention in children with autism.

**Purpose:** The purpose of this chapter was to discuss the role that the three types of joint attention have in developing social competence. The authors also discussed the development of joint attention in typical children and in children with autism.

**Summary:** Social engagement and social competence involve a prosocial behavioral style that is based on three abilities including (a) a capacity to monitor, relate, and integrate the behavior of self and others, (b) an ability to maintain attention and regulate emotions during social interactions, and (c) an ability to interact agreeably with people. Joint attention plays a role in the development of social competence, cognition, and language.

There are a variety of types of joint attention. Responding to joint attention (RJA) is when an infant can follow a point or a head turn of another person. Another type of joint attention occurs when an infant initiates an interaction by using a gesture, eye contact, or showing to another individual. This is called initiating joint attention (IJA). The final type of joint attention is known as initiating behavior regulation/requests (IBR), occurs when a child initiates joint attention in order to obtain an object instead of for social purposes. This is the most common type of joint attention observed in children with autism. The initiating of joint attention is often chronically disturbed in these children and the responding to joint attention is often delayed in development. Neurodevelopment shows that IJA and RJA may develop in different parts of the brain, which explains the difference in development of these behaviors.

**Conclusions:** The authors concluded that an infant’s tendencies to IJA predict future aspects of social engagement in all children. Diagnostically, a child with a lack of IJA may be at a developmental risk.

**Relevance to current work:** The current study targets the increase of IJA and RJA in the participants.


**Purpose:** The purpose of this study was to compare the behaviors of 11 children with autism and 11 typically developing children on their first birthdays in order to identify early diagnostic characteristics. This study was done to help with earlier diagnosis of autism.

**Method:** This study focused on examining videotapes from a child’s first birthday and coding a variety of behaviors seen in the child’s actions. Participants included 11 children with autism (10 boys and one girl) and 11 typically developing children (10 boys and one girl). The coders looked for social, affective, joint attention, and communicative behaviors. Social behaviors included looking at another’s face, looking at the face of another while smiling, seeking contact with an adult, and imitating the behavior of another. Affective behaviors consisted of distress and tantrums. Joint attention behaviors included pointing, vague pointing, showing an object to another, and alternating gaze between an object and another’s face. Communicative behaviors consisted of babbling, saying a word, using a conventional gesture such as waving good-bye, and following verbal directions of another.

**Results:** The study showed that differences between normal children and children with autism can be identified by age 1. Differences can be identified by the social behaviors, joint
attention behaviors, and autistic behaviors. More specifically, how often a child looked at another person was the best predictor of autism.

**Conclusions:** This study showed that there were differences between typical children and children with autism by age one. This knowledge should cause increased diagnosis at an earlier age for a child.

**Relevance to current work:** This study discussed early diagnostic indicators of autism including joint attention and eye gaze.


**Purpose:** The purpose of this chapter was to discuss specific characteristics in language development for a variety of specific disabilities, including Autism Spectrum Disorder (ASD).

**Summary:** It is more important to evaluate a child’s language abilities than to know the etiology of a language disorder. Being aware of the etiology is helpful, however, because a diagnosis is often needed for services and helps provide hints about what areas to examine during assessment. As a clinician, it is useful to be informed about certain diagnoses in order to understand a child’s medical history.

The chapter reviews common characteristics of specific disorders. These include mental retardation, hearing impairment, blindness, deaf-blindness, alcohol and drug related disorders, behavioral-socioemotional disorders, aphasia, traumatic brain injuries, specific language impairment, and childhood apraxia of speech.

In addition, it discusses many aspects of autism. The author reports that social difficulties are at the center of autism. The disorder is primarily a problem with communication, not language. This difference in social communication development begins in early childhood when a lack of joint attention behaviors is present. Prognosis relates to performance on IQ tests and language ability. Intervention approaches are different for each child depending on if he or she is verbal or nonverbal.

**Conclusions:** This chapter gave specific information on a variety of disorders in order to best prepare clinicians for intervention with a variety of clients including children with autism.

**Relevance to current work:** This chapter provides background knowledge regarding ASD.


**Purpose:** The purpose of this article was to describe the rationale and design of the SCERTS model approach to intervention with children with autism.

**Summary:** The SCERTS model is focused on targeting the most significant deficits in autism with a three-tenet goal program. Social Communication targets the development of joint attention and enhances capacity for symbol use in these children. The next tenet is Emotional Regulation, which addresses self-regulating, mutual regulating, and enabling the child to recover
from disregulation. Finally, Transactional Support consists of the supports received at school, at home, and among professionals, and promotes consistency across all of these groups.

**Conclusion:** This model is a comprehensive intervention approach for children with ASD and their families. It targets core deficits such as social communication, emotional regulation, and transactional support.

**Relevance to current work:** The current study uses the SCERTS model in traditional intervention with the participants.


**Purpose of work:** The purpose of this article is to provide a brief, general review of autism for the medical audience. It describes characteristics, prevalence, etiology, assessment, management, and prognosis of the disorder.

**Summary:** All disorders that qualify as part of the autism spectrum are variable in presentation but include the following three characteristics: impairments in verbal and non-verbal communication, deficits in reciprocal social interaction, and the presence of restricted interests and repetitive behaviors. Prevalence of autism has increased but etiology is unknown other than a genetic link. Proper assessment should include observation of the child and the use of appropriate screening tools administered by a multidisciplinary team of experienced clinicians. For best management of autism, people close to the child must be informed to design an environment to best fit the child’s needs. In addition, some pharmacological interventions may work but should be administered with care due to side effects. Finally, autism typically persists into adulthood.

**Conclusions:** This article was an overall summary of information about autism targeted to those in the medical field.

**Relevance to current work:** This article provides a description of the characteristics of autism.


**Purpose:** This master’s thesis described a robot designed for use in intervention with children with autism.

**Rationale:** Previous research suggested that intervention using a robot holds promise for children with autism. The current study described the robot designed and built by the team at Brigham Young University for use in intervention with children with autism. The robot was designed to elicit social engagement skills and to promote generalization of those skills to interactions with humans.

**Design:** A robot, referred to as Troy was designed to help children with autism “become more engaged in their therapy sessions” (p. 23). Troy was the same height as an average 4-year-old child and weighed 15 lbs. Troy was a stationary robot with an upper-body, two arms, a neck, and a head. Each one of Troy’s arms had four degrees of freedom to allow for full range of motion. Troy produced prerecorded phrases, words, and songs through speakers in his back or from speakers in a laptop computer. He was connected to a laptop computer where the clinician
could program the desired activities for each session and control him wirelessly using a Wiimote. Troy’s face was a 7” computer screen that displayed basic emotions including happy, sad, and neutral. During clinical sessions, Troy performed basic turn taking actions such as waving hello, pushing an object in a turn-taking exchange, blowing a kiss, etc.

**Relevance to current work:** In the current study, Troy is the robot used to encourage social engagement in children with autism.


**Purpose:** This was a longitudinal study designed to investigate effects of consistent, repeated exposure to a robot on social engagement skills in four children with autism.

**Method:** Four children with autism ranging in age from five to ten years participated in this study. A small robot (doll), named Robota, was placed on a table and controlled through a laptop by an experimenter. The robot was designed to perform simple to more complex movements as the children progressed through the study. Four child behaviors were monitored (eye gaze, touch, imitation, and proximity), and qualitative data were recorded.

**Results and Conclusion:** Results were variable, but increases in the children’s social interactive behavior were reported. Over time, the participants used the robot as the focus of joint attention in an interaction with the investigator. This study did not assess if the social interactive skills were generalizable when the robot was not present.

**Relevance to current work:** The current study uses a humanoid robot in interventions with four children with autism to elicit social interaction skills.


**Purpose:** This paper is part of the Aurora project, which focuses on “development of new interactive robotic systems that encourage basic communication and social interaction skills” (p. 162). More specifically, this study presents a qualitative analysis of the joint attention behaviors between a child with autism and an adult when the robot is the object of shared attention.

**Method:** Participants were four children (five to ten years) who were diagnosed with autism. These children all used few vocalizations and demonstrated difficulty with social engagement and interaction. During the sessions, children interacted with a robot (doll) placed on a table and connected to a laptop controlled by the experimenter. The sessions ended when the child wanted to leave or became bored. Each participant attended as many individual sessions as possible during a 12-week period of time. Video footage was analyzed for three out of the four children.

**Results:** All the children laughed, smiled, or giggled during the sessions, suggesting they enjoyed the robot. One of the children demonstrated a moment where he initiated to the experimenter using a communicative gesture by moving into the experimenter’s line of vision
and by gazing at the gesture. Two of the children showed moments where they responded to joint attention and visually followed the experimenter’s point.

**Discussion and outlook:** The results suggested that a robot could serve as a social mediator between a child with autism and a communicative partner. The children with autism showed joint attention skills where the robot was the object of focus in joint attention between the child and the adult. Specifically, instances of joint attention occurred in response to the robot’s behaviors.

**Relevance to current work:** The current study employs a robot as a social mediator in intervention with children with autism.


**Purpose:** The purpose of this article was to discuss how social robots will affect the identification and treatment of children with autism.

**Conclusions:** Scassellati claimed that using robots in intervention is beneficial because children with autism are highly motivated and show interest when interacting with robots. The author and colleagues created a humanoid robot named ESRA. They conducted a small pilot study to look at typical children’s interest in a robot compared to that of children with autism. The pilot study suggested that in some cases, the children with autism attended to the robot for longer periods of time than did they typically developing children. In addition, the author discussed other uses for robots in identifying autism. Robots could be used to track a child’s eye gaze, the focus of attention, and the child’s proxemics to a robot.

**Relevance to current work:** This article provides evidence that children with autism were interested in robots and suggested ways in which robots could be employed in assessment and intervention.


**Purpose:** This article provided a review of social skills interventions used with children with autism over the past 15 years.

**Summary:** Traditionally, interventions for children with autism have been focused extensively on academic skills. These children may never develop social skills to interact with others, however, unless they receive direct intervention targeting these skills. In years past, social skills goals focused on orienting to other people and appropriate eye gaze, but more recent approaches include training on play, perspective taking, and conversational skills. This article includes a discussion of research on interventions developed over the last 15 years to focus on social skills. It also discusses how to implement these techniques and a relevant list of references. These interventions include video modeling, priming, self-management, written scripts, Social Stories, and pivotal response training.

**Conclusions:** A child with autism may improve his or her social skills if trained specifically in these tasks. The interventions should begin in early development and continue throughout adulthood. Over the last ten years, interventions have become more sophisticated. Some are easy to implement while others require the assistance of an expert.
Relevance to current work: This article discusses the importance of direct training of social skills intervention for children with autism.


Purpose of the study: This study was completed in order to determine the prevalence of Autism Spectrum Disorders (including Autistic Disorder, PDD-NOS, Atypical Autism, or Asperger Disorder).

Method: The Autism and Developmental Disabilities Monitoring (ADDM) Network is a system that estimates prevalence of ASDs in children who are 8 years old across 14 different sites in the United States. In the first phase, this organization gathers information about possible diagnoses of Autism from multiple sources including pediatric health clinics, specialized programs for children with disabilities, and public schools. During phase two, trained clinicians review the evaluation information to confirm the diagnoses of autism in the children. Because of the consistency of these diagnostic measures over the years, "comparisons to results for earlier surveillance years can be made" (p. 1).

Results: The approximate prevalence of children with Autism Spectrum Disorders in the year 2008 according to the ADDM sites was 11.3 per 1,000 (1 in 88) children.

Conclusions: These results indicated an increase of children with ASDs in the 14 sites in comparison to the years 2002 and 2008.

Relevance to current work: This article provides information about the prevalence of Autism Spectrum Disorders.


Purpose: The purpose of this chapter was to describe the social-emotional bases of communication development. In addition, the author discussed factors that influence development, guidelines to assess and intervene in development, in children with impairments such as Autism Spectrum Disorder. In particular, the development of initiating and responding to joint attention were discussed.

Summary: Theory of mind (ToM) is an essential step, which typically occurs early in life in the development of social interactions. It refers to the ability of a child to recognize that other individuals have thoughts and emotions that are different from his or her thoughts. ToM is related to intersubjectivity, which is a person’s mind interfacing with a mind of another person’s through communication. Intersubjectivity is developed using joint attention. Joint attention is defined as an “integration of information about self-experience of an object or even with information about how others experience the same object or event” (p. 137). There are three types of joint attention such as initiating joint attention (IJA), responding to joint attention (RJA), and initiating behavior requests (IBR). RJA occurs when a child follows the gaze or head turn of a communication partner but IJA is when a child initiates an interaction with a social partner.
RJA and IJA serve social acts whereas IBR is eye contact or gestures used to obtain an object or desire. Social competence develops when children use joint attention. Children with autism demonstrate delays in developing RJA and IBR and continue to demonstrate deficits in IJA for a lifetime.

**Conclusions:** The author concluded that joint attention facilitates language development, which allows individuals to communicate information and to develop relationships. In order to best do this, interventions and interactions with caregivers should focus on facilitating behaviors that will improve social competence, such as joint attention.

**Relevance to current work:** The current study focuses on increasing both initiating joint attention and responding to joint attention in child with autism.

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**Purpose:** The purpose of this chapter was to discuss possible reasons for the reported rise in the prevalence of Autism Spectrum Disorders (ASD).

**Summary:** Prevalence is defined as the number of people in a specific population who have a condition at a specified time. When autism was first described, it was considered a rare condition. There has been a marked increase in the prevalence of autism, however. This article detailed a wide variety of possible reasons for the increase in prevalence of ASD. The first reason was due to changes in diagnostic criteria due to the evolution of terminology over time and differences in diagnostic criteria used in prevalence studies. Another reason was the differences in methods used in various studies to assess prevalence including the size of target populations and methods of case finding. Increased awareness of ASD may have caused an increase in prevalence as well.

**Conclusions:** The majority of the research reported that the increase in prevalence of ASD in the population was due to changes in the diagnostic criteria and the increasing of awareness and recognition of ASD. Future research is needed to determine an actual increase of prevalence.

**Relevance to current work:** The current study uses four participants who were all diagnosed with autism.