The Effect of a Robot on Children with Severe Autism During a Song Activity

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A thesis submitted to the faculty of
Brigham Young University
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Master of Science

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ABSTRACT

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Master of Science

This study is a small portion of a larger work examining the effects of low dosage robot use in interactive and social engagement therapy for children with autism. The purpose of this study was to investigate the participation of the subjects during song activities. Four children were used as participants, each receiving a total of 20 play-based treatment sessions targeting engagement and social interaction. The clinician incorporated the robot into these treatment sessions for 10 minute long segments within a 50 minute session. The current study analyzed these 10 minute segments with the robot, coding turn-taking behaviors. Results indicated that, at least for a time, the robot facilitated improvement in these behaviors for two of the four children. The other two children demonstrated no improvements. These results are discussed, and the limitations of the study and recommendations for future research are examined.

Keywords: autism, turn taking, social engagement, robots
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DESCRIPTION OF STRUCTURE AND CONTENT

This paper combines the format of the current journal publication format with the traditional thesis format. This includes updated university requirements and the standards for peer reviewed journals in communication disorders. Appendix A contains an annotated bibliography. Appendix B is composed of the coding system used in the data analysis system used in this project.
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Introduction

Autism is a developmental disorder that manifests itself before the age of 3, and falls within the broader umbrella category known as Pervasive Developmental Disorder. Autism consists of three main impairments, including difficulty with social interaction, problems in communication, and manifestations of restricted, repetitive, and stereotyped behaviors. These stereotyped and restricted behaviors may manifest themselves in a variety of behaviors, including fixation on a topic, rigid observance to specific routines, and odd body movements and postures. These behaviors may exhibit abnormality in either intensity and/or focus (American Psychiatric Association, 2000).

Social Development

Impairment in social interaction tends to manifest itself through various behaviors such as a lack of, or inappropriate use of facial expression, lack of body posture, or lack of gestures when interacting with others. These problems make it difficult for the child to regulate, control, and participate in an interaction. Thus, children with autism frequently find themselves socially isolated (American Psychiatric Association, 2000; McConnell, 2002; Osterling & Dawson, 1994).

One of the primary causes of poor social development in children with autism is a lack of joint attention (Chawarska, Klin, & Volkmar, 2008; Dautenhahn, 2003; Dawson, Meltzoff, Osterling, Rinaldi, & Brown, 1998; Mundy, Sigman, Ungerer, & Sherman, 1986; Osterling & Dawson, 1994; Robins, Dautenhahn, Boekhorst, & Billard, 2005; Robins, Dautenhahn, & Dubowski, 2006; Robins, Dickerson, Stribling, & Dautenhahn, 2004; Wetherby, 1986). For this particular study, joint attention will be defined as the establishment of “partners’ shared focus on the same object, entity, or event” (Seibert, Hogan, & Mundy, 1982, p. 248). This lack of joint
attention leads to further problems in the child’s social development such as a lack of initiating interaction with others, difficulty responding to bids for interaction, and the associated problem in turn-taking created by the afore mentioned issues (Mundy et al., 1986). An example of such behavior is that children with autism have very little spontaneous play in which they themselves initiate with another person, in addition to little participation in reciprocal play where another child attempts to instigate a play sequence (François, Powell, & Dautenhahn, 2009; Robins et al., 2005). It is through joint attention that a child learns other basic skills as well, such as eye contact, affect, intentionality, awareness of others, and indicating and referencing skills (American Psychiatric Association, 2000; Mundy et al., 1986; Osterling & Dawson, 1994; Wetherby, 1986). In fact, Wetherby and Prutting (1984) found that children with autism tended to use people as tools, or as a means to a desired end. These children did not interact for the purpose of receiving a social response, but rather to achieve an environmental end. Because of these impairments, peer relationships are difficult to establish and are not typically developed at the appropriate developmental level (American Psychiatric Association, 2000).

Joint attention is also fundamental to a desire to share experiences and ideas with others, and thus ultimately is fundamental to communication as well. In fact, Robins et al. (2004) attribute the impairment of verbal and nonverbal communication to a lack of joint attention. The ability to share focus and attention of a common interest, emotion, or object with another communicative partner is one of the basic foundations from which language springs. It is through this joint attention that a child is able to learn to indicate and reference, creating a pathway for communication to emerge. Thus, without joint attention, the development of communication will suffer (Robins et al., 2004).
Communication

Related to problems in social interaction are difficulties with communication. The communication problems of children with autism are well documented. For present purposes, it can be said that individuals on the autism spectrum present a broad range of communicative abilities. Even those individuals who are able to speak tend to struggle with various aspects of communication (American Psychiatric Association, 2000). For example, even higher functioning individuals tend to struggle with poor grammar, the inability to use or understand abstract language, the inability to understand meaning in prosody, and/or use of echolalia (American Psychiatric Association, 1980). Most children with autism also have difficulties in reading nonverbal communication, such as facial expressions and gestures. It is difficult for individuals with autism to pick up on these cues, and they end up missing important aspects of messages (Robins et al., 2005, 2006). Because of these general deficits in social communication, there is a low degree of sociability and a lack of a desire to communicate with others, leading to very little person-to-person communication (Wimpory, Hobson, Williams, & Nash, 2000).

Intervention and Robotics

There are a wide variety of interventions for children with autism. Increasingly, technology is being incorporated into these interventions. One innovative line of work has seen the use of robots incorporated into interventions for children with autism (Dautenhahn, 2003). The inclusion of robotics and technology has shown a positive potential because, as Robins et al. (2006) discussed, children with autism “are able to establish and maintain an excellent, purposeful, and ‘intelligent’ relation to objects that do not threaten to interfere with their aloneness” (p. 502). Children with autism have trouble connecting and following human behavior because of the variance within human action. Individuals with autism tend to be hyper
attentive to small details, and can thus become easily over stimulated by these small variances. Because of this, those with autism tend to respond better to repetitive and predictable patterns of stimulus, such as those found in a robot (Dautenhahn & Werry, 2004; Goldsmith & LeBlanc, 2004; Pierno, Mari, Lusher, & Castiello, 2007; Robins et al., 2004). Using a robot in intervention creates a less complex, more predictable and simplified environment in which children with autism can be more readily and easily supported in order to learn (Dautenhahn, 2003; Robins et al., 2004). This environment has shown to elicit more socially appropriate behaviors from children with autism than more traditional styles of intervention.

Various studies have concluded that interventions with a robot can increase the level of engagement in children with autism (Acerson, 2011; Dautenhahn & Werry, 2004; Feil-Seifer, Kinner, & Mataric, 2007; François et al., 2009; Giannopulu & Pradel, 2010; Goldsmith & LeBlanc, 2004; Hansen, 2011; Ricks & Colton, 2008; Robins et al., 2004, 2005). For example, François et al. (2009) found that a robot elicited more imitation from the participants when nondirective play was implemented, and the child was able to interact with the robot in the manner of his/her choosing. These authors also found that the children were able to progress to higher, more mature levels of play in comparison to their baseline play level. Other studies have examined robots and their potential to improve socialization by using the robot as a source of joint attention, having the child interact with other people when with the robot, using the robot to increase eye contact, and using a robot to teach facial expressions and turn taking (Dautenhahn & Werry, 2004; Feil-Seifer et al., 2007; Goldsmith & LeBlanc, 2004; Ricks & Colton, 2008; Robins et al., 2004, 2005).

Robots with a wide range of physical appearance have been used to produce the results described above. Each kind used has shown to have their different advantages and disadvantages.
It has been concluded that the more human-like a robot appears, the less interest and the less interaction it elicits from the children. On the other hand, less human-like robots elicit more interaction and engagement (Ricks & Colton, 2008; Robins et al., 2006). This is because children with autism will frequently withdraw from humans, and anything with a human appearance. Thus robots that are nonhuman tend to be more engaging (Ricks & Colton, 2008). There is a line that needs to be drawn, however, because robots that do not resemble anything familiar to the child are not likely to be effective either. Effective intervention with a robot thus requires, a careful balance for maximum efficacy (Ricks & Colton, 2008; Robins et al., 2006).

Studies incorporating robots in the interventions for children with autism have been structured in different ways. Research involving nondirective play (where the child chooses and directs how to play and what to play with) has revealed that in this context, the children are likely to seek out and initiate some kind of play interaction with the robot. Such interactions include exploring the robot, manipulating the robot, imitating the robot, playing with others with the robot, etc. (Acerson, 2011; Colton et al., 2008; François et al., 2009; Giannopulu & Pradel, 2012; Hansen, 2011; Robins et al., 2005). It is unclear, however, how well this method generalizes the principles and behaviors that the child has learned from the intervention context to the child’s everyday life. It is suspected that because of the low level of realistic contextualization, it is difficult for the child to carry over these increased number of social interactions to the real world (Dautenhahn & Werry, 2004; François et al., 2009; Giannopulu & Pradel, 2010; Robins et al., 2004, 2005, 2006).

Other studies have looked into incorporating other people into robotic routines for children with autism. A few researchers have found that including some kind of triadic interaction with the child, the robot, and another person has the potential to improve the
generalization of social behavior from the robot to other humans (Acerson, 2011; Colton, Ricks, Goodrich, Dariush, Fujimura, & Fujiki, 2008; Dautenhahn, 2003; Goldsmith & LeBlanc, 2004; Hansen, 2011; Ricks & Colton, 2008). This is because the robot is used as a social mediator in these triadic interactions between the child and the interactional partner so that the clinician has more control in facilitating and shaping social interactions from the child. This creates more natural ways of interacting with the robot that better resemble interactions with other people in real life (Colton et al., 2008; Goldsmith & LeBlanc, 2004; Ricks & Colton, 2008).

**Current Study**

The current investigation is part of a larger study and is an extension from a previous work conducted in 2011 (Acerson, 2011; Hansen, 2011). The focus of both the current and previous research was to examine the effects of a robot in facilitating better social interactional skills in children with autism. Also critical was the generalization of those social behaviors to additional persons and contexts. Both studies were designed to provide a high level of affect into an interactive context in which the robot was used for short segments of intervention (low dose). In the initial work, two subjects with autism participated in 40 minutes of traditional therapy and 10 minutes of therapy with a robot twice a week. Therapy with the robot was highly interactive and included the child, the clinician, and one of the child’s parents along with the robot. Both participants showed improvements with one participant making marked improvements, and the other showing more modest improvements. These improvements were measured outside the robot’s presence in attempt to see how well the behaviors that were elicited with the robot generalized to other contexts (Acerson, 2011; Hansen, 2011). These promising results indicated that more research was warranted, creating the need for the current, follow-up study.
The purpose of this study was to further investigate the influence of low dose robot
treatment on social engagement by expanding the number of participants to four. Other research
from this work examines triadic interactions, interactions with a familiar adult and an unfamiliar
adult, interactions with a parent, and interactions during games with a robot (Blanchard, 2012;
Dodge, 2012; Stabenow, 2012). This paper will focus on triadic interactions with the robot
during song activities. The song activities in this study were set up in a way to encourage turn
taking, affect, and shared attention. Songs and rhymes are naturally highly structured, repetitive,
and predictable, allowing the cognitive load of the children to be reduced, and thus give a high
level of cues and support for the child to participate (Paul, 2007).
Method

The following section describes the participants, the robot used, the methods employed in the intervention, and the analysis system used to assess the effectiveness of the intervention.

Participants

Four children with severe autism (two males, two females) were selected to participate. Each child’s diagnosis was confirmed by psychological and developmental assessments completed at local institutions, and each child displayed severely delayed social communication and participated in very little joint attention. As would be expected, the children displayed minimal verbal language. Each of the children’s parents gave consent to participate prior to the start of the study. Parents were interviewed to collect information of the child’s functioning and history. Each child also went through a series of assessments to determine current level of functioning, including the administration of an audiologic examination, the Preschool Language Scale, Fourth Edition (PLS-4), and the Westby Playscale (Westby, 2000; Zimmerman, Steiner, & Pond, 2002). Observations were also made of the child’s play interactions. For two of the children, the PLS-4 was used as a criterion referenced test since their ages fell outside the standardization sample. The information gathered in these assessments was used to establish an appropriate treatment plan. The following information gives more details on each of the participants.

**LS.** LS was a male who was 9:1 (years: month) at the commencement of the study. He lived with his mother, father, and four older siblings (ages 11, 14, 16, 18). He was born in Japan, and lived there until he was 4.5 years of age; however, English had always been the primary language spoken in the home. His father worked outside the home, and his mother worked in the home as a homemaker. LS started a mainstream preschool at the age of 3, but transferred to a
developmental preschool designed for children with autism when he was 4-years-old. He attended a kindergarten for children with autism, and was in a self-contained classroom for children with autism and other severe disabilities at an elementary school at the time of the study.

LS’ mother reported that he interacted with his siblings, and had the opportunity to interact with people at church and his cub scout group; however, he rarely interacted with people outside of his family. LS was sensitive to sounds and textures and displayed repetitive motoric patterns of behavior. He had poor self-regulation, and would produce injurious behaviors toward himself as well as others in attempts to regulate himself.

LS’ spoken vocabulary consisted of 150 words at the start of the study. He would use one or two word utterances to communicate, and demonstrated extensive echolalia. He would use verbal language to protest and/or request actions or objects; however, he did not use social language (i.e. showing, referencing, commenting, etc.). LS would sometimes make eye contact with others, although it was difficult to interpret intention because it was considered to be meaningful at times, but seemed empty and blank at other times. LS would also demonstrate some affect, sometimes appropriately, sometimes inappropriately, also making it difficult to interpret as well. For example, at times, LS would laugh and demonstrate other aspects of positive affect when disregulated and upset, a time not typically associated with positive affect.

AH. AH was a female and was 4:1 at the start of the study. She was living with her mother and her father, with no siblings. English was the primary language spoken in the home, and both of her parents were employed outside of the home. AH was attending a developmental preschool for children with autism spectrum disorder at the time of the study. She had the
opportunity to interact with people at her school as well as those in her extended family and at church.

At the beginning of the study, AH’s communication consisted of one-word verbal approximations; however, she had very few non-word vocalizations. Her mother was attempting to teach AH some ASL signs. AH was able to imitate some of the signs, but would not use them spontaneously to communicate. She would express her wants and needs by crying and through physical manipulation of other people.

AH displayed repetitive motoric patterns with her hands, such as hand flapping, and manifested poor emotion regulation, especially when she was not able to communicate her wants and needs. When she became disregulated, she would cry and seek tactile input from others, such as a hug. She demonstrated very little symbolic play, which was only seen in restricted environments. She used very little eye contact, and on the few occasions eye contact was established, it was described as empty and blank. AH also manifested very little affect or initiation of interaction.

LR. LR was male and 5:5 years old at the beginning of the study. LR lived with his mother, father, and five other siblings (ages 3, 8, 9, 19, and 23). His father was employed outside of the home, and his mother was a homemaker. English was the primary language spoken. LR was attending a developmental preschool designed especially for children with autism.

LR displayed repetitive motoric behaviors, mainly that of hand flapping. He was sensitive to auditory and tactile stimulation, and had a tendency to fixate on objects. He rarely imitated the actions of others, and was noted to have a short attention span, especially for activities directed by other people.
LR had no verbal communication, and his vocalizations consisted mainly of continuous vowel sounds, with an occasional insertion of a short consonant sound once in a while. He communicated using physical manipulation of others. He had inconsistent and intermittent eye contact, as well as inconsistent affect, both of which were difficult to interpret.

**KR.** KR was female and was 8:1 years old at the beginning of the study. She lived with her mother, father, and five siblings (ages 3, 5, 9, 19, and 23). English was the primary language spoken at home. Her father was employed outside of the home, and her mother worked inside the home as a homemaker. KR went to a developmental preschool for children with autism, and then attended various elementary schools. At the time of the study, KR was in a self-contained classroom for children with autism at a local elementary school.

KR’s communication consisted of unintelligible jargon with prosody similar to that of adult English. She did have, however, four or five functional words in her vocabulary repertoire. She seemed to enjoy social interactions and displayed affect and some eye contact with others. Her affect, however, was frequently displayed at inappropriate times, and could not always be associated with anything in particular.

KR also displayed poor emotion regulation. In order to regulate herself, she would use self-injurious behaviors such as biting her hand. She would also throw objects and yell. She would also fixate on objects as well.

**Materials**

**Recording.** Each session was recorded using two cameras, each capturing a from differing viewpoint. A handheld camera was used to focus on the child’s face, recording emotions. The cameras used for this purpose were a Canon™ VIXIA HF20 with a 15x optical zoom and a VIXIA HG21 with a 12x optical zoom. The broader interaction in the room was
recorded by a stationary Network Camera™. All of the cameras were operated by university student volunteers.

**The robot.** The robot used in this study, which was referred to as Troy, was an upper body humanoid robot constructed by graduate students from the Department of Mechanical Engineering at Brigham Young University (BYU). Troy weighed 15 lbs, was 25 in. tall, and was 12 in. long—about the size of an average 4-year-old. Troy consisted of a face, two arms, and a torso. Troy’s face was made up of a small computer monitor 7 in. in length. The monitor displayed a face consisting of eyes, eyebrows, a nose, and a mouth which could be manipulated to portray happy, sad, or neutral expressions. The head was attached to the body with two radio controlled (RC) servo motors, allowing 2 degrees of freedom (DOF) in movement, and giving Troy the ability to move his head vertically and horizontally.

Troy’s arms were given four pairs of RC servo motors, a pair on each side of the torso, the shoulder, and the elbow areas, allowing four different DOF. This allowed the arms to be moved in four different directions—up and down in raised and lowered positions, in and out for adduction and abduction, medial rotation, and extension and flexion of an elbow structure. A speaker was encased in Troy’s torso allowing Troy to portray the perception of speaking capabilities. Troy was programmed to say hello to each participant using each child’s name, sing songs such as *Popcorn Popping on the Apricot Tree*, and to make both positive and negative affective sounds such as *who-hoo!* or *whoops*. These recordings were made by students from BYU’s Music-Dance-Theater and Mechanical Engineering Departments. During the sessions, Troy was placed on the floor across from each child, and was connected to a laptop computer placed on a nearby counter by cords attaching to Troy’s posterior side. BYU’s Computer Science Department created a visual programming graphical user interface in order to preprogram the
needed combinations of actions, facial expressions, and voicing for Troy. These commands for actions were controlled by the clinician using a Wii™ remote, which was programmed with the laptop computer and kept out of sight from the children.

**Procedures**

**Pre and post-treatment measures.** Pre and post treatment measures were conducted to gather baseline and follow-up data. Three baseline sessions were conducted for AH, four were conducted for LS, five were conducted for KR, and six were conducted for LR. Each subject participated in three follow-up sessions. All baseline and follow-up sessions were identical in their structure, consisting of a 5-7 minute play assessment with the child’s mother, a play assessment with an unfamiliar adult, a play assessment with the child’s assigned graduate clinician, and a triadic play interaction consisting of the child, the child’s graduate clinician, and a second graduate clinician.

In each of the play assessments with the participant and his/her mother, a farmhouse, a pretend pizza, a book, stuffed animals, and blocks were laid out in a therapy room, and the parent and child were left to play. The interaction lasted no longer than 10 minutes each session, after which the clinician led the parent to an observation room and carried on with the rest of the session.

During the play assessment with an unfamiliar adult, a graduate student who had never interacted with the child before was brought in to engage the child. The adult was given wind-up toys, a ball, a toy push car, a baby and a blanket, and the same baby with pretend food, and was instructed to present these toys to the child and request the child to participate by saying “look” or “push it to me.” The adult waited for the child’s response. If the child made no response to this request for interaction, then the adult moved on to the next presentation of stimulus. If the
child did respond to the interaction, the adult continued to participate in the play routine in an attempt to sustain the interaction. This routine was also completed with the songs *Popcorn Popping on an Apricot Tree* and *The Itsy Bitsy Spider*. Each stimulus was presented consecutively three separate times. The play assessment with the children’s primary clinician was set up and executed in the same manner with the same materials and stimulus.

The triadic interaction was set up so that each of the three people involved in the interaction took turns through the activity. During this assessment, a ball, a push car, a tambourine, and a music-making toy were used one at a time to engage the child. The child’s primary clinician would perform an action with one of the toys (i.e., push the ball or car to somebody, shake the tambourine, or push the buttons on the musical toy) and then handed it to the second graduate clinician while saying, “Give to (name of secondary clinician).” The second clinician would demonstrate the same action with the toy before extending it to the child while saying, “Give to (name of child).” After this invitation to participate, the clinicians waited for the child to respond. After waiting momentarily for the child to play, the clinicians would then say, “Give to (name of the primary clinician)” and wait for the child to respond. If the child did not respond, then the primary clinician would take the toy and repeat the routine once again. This routine was repeated so the child had three different turns or opportunities to establish joint attention with each toy.

**Treatment.** Before intervention with the robot began, each child came to the BYU Clinic for two 50 minute sessions a week, and went through a series of traditional therapy sessions to see how he/she progressed participating in traditional intervention strategies. In these therapy sessions, each of the four graduate clinicians targeted their client’s goals through various
structured play activities using different toys and games. AH participated in three of these
treatment sessions, LS went through four, KR did five, and LR participated in six.
During these sessions, bean bags were made available in the therapy rooms for use when the
children became unregulated. When the children demonstrated behaviors indicating a lack of
emotion regulation (i.e., biting, pulling the clinician’s hair, crying, etc.), the clinician would
“squish” the child in between two bean bags, or gently squeeze the child’s arm to help him/her
calm down and regulate once more.

After these sessions, a 10 minute segment of each session involving Troy was then
incorporated into the traditional treatment. The robot segments of therapy were administered in a
different room from which the traditional therapy was given to avoid distraction. AH was the
only exception to this, because the change in rooms distressed her. Therefore her participation
with Troy occurred in the same room as her regular therapy. Troy was set on a counter and
covered with a blanket when not in use in these sessions with AH. AH’s sessions included 17
robot segments, LS’ included 16, KR’s included 15, and LR’s included 14 robot sessions.

These sessions with Troy consisted of the child, a volunteer graduate clinician to help
facilitate the child’s interactions with the robot, the child’s primary clinician, the child’s mother,
and Troy. The child sat across from Troy so that he/she was facing him with the secondary
clinician sitting directly behind the child. The clinician sat to the right of the child, manipulating
troy using the Wii™ remote. The child’s mother sat directly across from the primary clinician,
creating a square between the child, clinician, Troy and the mother. Once situated in the room,
Troy was directed to wave and say, “Hi (child’s name).”

An activity (i.e., singing a song, playing a drum, pushing a ball, etc.) would then
commence, with the clinician, the child, the child’s mother, and Troy all taking a turn. An
example of what this might look like would be Troy singing *Popcorn Popping on an Apricot Tree*, with the child’s clinician singing the song while doing the actions after Troy, followed by the child taking a turn with the help from the secondary graduate clinician. The secondary clinician facilitated the child by singing the song while using hand-over-hand manipulation to help the child do the actions in attempt to support him/her in engaging in the interaction. Lastly, the child’s mother would then take her turn by singing the song and engaging in the actions. A new activity was introduced once everybody had a turn and/or the child lost interest.

**Data Analysis**

The videos from the two cameras taken during each session were synced together. Only the segments of song interactions with the robot intervention sessions were analyzed for this paper in order to judge improvement and generalization in this category. In most of the sessions for each of the children, a short segment was devoted to taking turns singing a song during the 10-minute robot period. The songs that were sung consisted of: *If you’re Happy and you Know it Clap your Hands*, *Popcorn Popping on an Apricot Tree*, and *Three Little Monkeys*. The amount of time that was spent in this song activity was recorded. During this time, each time a child took a turn was also recorded. A turn was coded as each time the child participated in the song either through singing along with the words, and/or making the gestures that went along with the song. It was also noted if the child took a turn with assistance or without assistance, since a facilitating clinician would frequently use hand-over-hand assistance to help the child participate in the gestures of the song.

The children’s overall level of engagement throughout the song activity was judged as well. This was determined and rated based on the following 5-point scale:

1 – Fully Engaged
2 – Mostly Engaged
3 – Moderately Engaged
4 – Minimally Engaged
5 – Not Engaged

In order for the child to receive a rating of fully engaged, the child had to be compliant, on task, and take every possible turn throughout the segment unassisted. To be mostly engaged, the child had to take at least one turn with or without assistance. The child could show anticipation of a turn, and the child could not be off task for longer than 2 seconds, could not act out, and had to display at least five instances of engagement (i.e. taking an assisted or unassisted turn, eye contact). To fall under the category of moderately engaged, the child had to have less than five instances of engagement, and he/she had to demonstrate some indication of awareness of the activity (i.e. clapping, repetition, echolalia from the activity, etc.). To be minimally engaged, the child had to be often off task, which could be disruptive, although the child could still take turns. For the not engaged category, the child had to be completely non compliant to the extent that the interaction had to be aborted. This coding system is presented in the coding manual found in Appendix B.

Reliability

Three graduate clinicians learned the coding system, and coded the data in the videos; however, before any coding took place, interjudge reliability was established. One person was considered the expert coder, and the other two investigators reached reliability with the expert coder. Reliability was established on 10% of the database to ensure consistency. The percentage of reliability for each of the coders is shown below in Table 1.
Table 1

*Reliability between expert coder and other coders*

<table>
<thead>
<tr>
<th>Session Number</th>
<th>Coder 1</th>
<th>Coder 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH Robots Session 4</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>AH Robot Session 7</td>
<td>94%</td>
<td>94%</td>
</tr>
<tr>
<td>LR Robot Session 4</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>LR Robots Session 8</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>KR Robot Session 5</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Results

After the coding process, each child’s behaviors for each category were individually charted into a graph on a session by session basis. These categories included gestural turns taken with assistance, gestural turns taken without assistance, and verbal turns taken by each child. Each child’s total turns in each category for each session was divided by the amount of time the song segment lasted, thus these behaviors are portrayed as the mean number of turns taken per minute throughout the song segment. The rating for the level of engagement was also included in the graphs as a number separated from the other data in each session. The results for each child are presented individually.

LS

LS participated in 16 robot sessions. Each of these sessions included a song segment, with the exception of sessions 4, 5, and 16. The data for each individual robot session are portrayed in Figure 1. LS took no turns in the first two sessions, after which his facilitating clinician gave him additional support, and he took more gestural turns with assistance. This is seen in the third session where he went from previously taking 0 turns per minute to 2.9 assisted gestural turns per minute. In these first two sessions in which no turns were taken, LS was still moderately and minimally engaged due to eye contact made with the clinician and his mother within the duration of the song segment. Between sessions 10 and 14, LS engaged in gestural turns without assistance ranging between 0.3 and 0.89 turns per minute. He also took verbal turns in the last 4 sessions ranging from 0.6 and 1.3. These were the only sessions in which he verbally took a turn. LS’ rating for level of engagement was variable with no consistent pattern.
Figure 1. LS’ scores for turn taking within a song segment. The blue bars display the number of gestural turns LS took per minute without assistance. The red bar displays the number of gestural turns LS took per minute with assistance. The green bar displays the number of verbal turns he took per minute. The number next to each session represents the rating of the level of engagement he displayed in each session.
AH

AH participated in 17 sessions with the robot. A song segment was included in each of these sessions with the exception of session 4 in which other activities were selected in place of singing songs. The data for each of AH’s sessions are presented in Figure 2. AH’s performance was variable, however, her assisted gestural turns showed an overall increase up through the 7th session with 1.0 assisted turns per minute in session one and 6.4 assisted gestural turns per minute in session 7. Within this period, AH’s gestural unassisted turns peaked in session 5 with 1.2 unassisted gestural turns per minute. These behaviors then decreased for the remainder of her sessions with the robot. AH did not demonstrate any verbal turns during these song segments in any of the sessions. In instances where the rating of the level of engagement was significantly higher than the number of turns taken, as demonstrated in session 16, she still demonstrated signs of engagement such as eye contact or shared affect, even though she did not take any concrete turns.

LR

LR participated in 14 robot sessions, all of which included a song segment. The data for each of his sessions are presented in Figure 3. No obvious trends from LR’s performance were found. He participated in the first three sessions with a relatively high number of gestural turns, both assisted and unassisted, ranging from 1.2 to 2.1 turns per minute. His level of performance and number of turns taken dropped after the third session to 0.2 turns per minute and stays around this number with only small fluctuations through the rest of the sessions. He took no turns in session 5 but was still moderately engaged. Session 13 was an exception in which LR showed his peak performance and demonstrated 2.5 assisted turns per minute. He took no verbal
turns in any of the sessions, and he was either moderately or minimally engaged throughout all of the sessions.

**Figure 2.** AH’s scores for turn taking within a song segment. The blue bars display the number of gestural turns AH took per minute without assistance. The red bar displays the number of gestural turns AH took per minute with assistance. The green bar displays the number of verbal turns she took per minute. The number next to each session represents the rating of the level of engagement she displayed in each session.
Figure 3. LR’s scores for turn taking within a song segment. The blue bars display the number of gestural turns LR took per minute without assistance. The red bar displays the number of gestural turns LR took per minute with assistance. The green bar displays the number of verbal turns he took per minute. The number next to each session represents the rating of the level of engagement he displayed in each session.
KR

KR participated in 15 sessions with the robot. Only sessions 1 and 14 did not contain a song segment. KR’s performance in each session is portrayed in Figure 4. Her participation was variable, and again, no trends were seen in her performance in these song segments. KR took no turns in session 4. She was not engaged, and the song segment had to be aborted due to KR’s misbehavior. This level of engagement was also the case for session 13 as well, however, she did that 1.0 unassisted turns per minute. KR took no verbal turns in any of the sessions. Her peak level of performance was seen in sessions 3 and 9 in which she demonstrated 2.29 unassisted gestural turns per minute and 1.74 assisted gestural turns per minute in session 3 and 3 assisted turns per minute were observed in session 9.
Figure 4. KR’s scores for turn taking within a song segment. The blue bars display the number of gestural turns KR took per minute without assistance. The red bar displays the number of gestural turns KR took per minute with assistance. The green bar displays the number of verbal turns she took per minute. The number next to each session represents the rating of the level of engagement she displayed in each session.
Discussion

This study represents a small excerpt from a larger project looking at the effects of a humanoid robot on the social engagement of four children with autism. The focus was on the children’s interactions during song activities with a robot, clinician, and mother. Each child’s participation within this small window of time was individually measured from session to session. A discussion of these results and their implications follows.

Reflections on Children’s Performance

The treatment with the robot during song activities appeared to be more effective for some of the children than for others. The robot did appear to be helpful for LS, who showed increases in turn taking from the first robot session to the last robot session. This was demonstrated in the increased number of verbal productions produced as well as the number of gestural turns taken without assistance. Toward the end of the block of sessions with the robot, LS demonstrated an increased amount of independent participation as well as participation with support. For example, his clinician would begin the song segment and start singing a song. The clinician would then pause expectantly part way through, waiting for LS to complete the phrase. By the end of the robot sessions, LS would complete the song phrase as well as independently making the accompanying actions.

In the case of AH, the robot seemed effective for a short time, but this effect decreased after several sessions as AH appeared to tire of the robot. With the introduction of the robot, AH demonstrated an increase in the number of turns she took. Informally, the coders reported increases in shared affect and eye contact with her mother and the other clinicians. As her time with the robot wore on, however, AH began to show signs of disinterest, became more emotionally unregulated, and would rapidly lose interest in the activity with the robot. During the
song segments, she would frequently disengage and wander away from the interaction. This pattern of initial increase in interest followed by a decline in attention was observed with other activities and materials as well. It appeared that AH often lost interest once the novelty wore off. Clinically, this would suggest at least two possibilities. First, the robot could be removed from treatment at the point that AH’s attention waned and possibly reintroduced at a later time. A second possibility might be for the robot to produce a novel set of behaviors. This would require additional robot capabilities.

LR and KR showed highly variable behavior in the song segments with the robot. Although LR demonstrated some increases in gestural turns taken with assistance in some of the sessions, his behavior was too variable overall to indicate improved performance. KR’s participation was also highly variable. It may have been the case that neither LR nor KR responded well to singing activities. Because of the nature of their disabilities, however, it may also be the case that these children required a longer period of intervention to show gains.

The ratings of the level of engagement were highly variable for all four of the children as well. Perhaps more concerning, the ratings of engagement were not always related to increases in the various coded behaviors. That is, the measures of overall engagement did not always reflect the children’s participation in the singing activities. For example, there were instances in which a child displayed a high number of gestural turns taken with assistance. These behaviors were generally thought to be indicative of engagement. On occasion, however, a child would act out and the facilitating clinician would give hand-over-hand support to help the child refocus and participate. On paper, the child would be viewed as having a higher level of engagement because he/she had an increased number of turns taken with assistance. In actuality, these occasions
represented a lower level of engagement. With respect to these outcomes, the following considerations and limitations are reviewed.

**Considerations and Limitations**

Three of the four children studied demonstrated very little progress on the singing task studied. This performance must be considered in terms of the children’s general patterns of behavior and level of functioning. Each of the children studied demonstrated a severe impairment, and their response to intervention in general had been limited. The slow progress observed on the song task with the robot was indicative of their general response to treatment.

One of the children, LS, did show improvement during the song activities. This may have been related to the fact that he was the highest functioning child in the study and was thus more receptive to the intervention. It may also be the case that this child was more receptive to the singing activity.

Given level of severity, it was also possible that some of the children needed a longer period of therapy in order to benefit from the intervention involving the robot. This may have been the case for KR and LR. Both children performed in a highly variable manner. It is possible that with additional intervention sessions more positive patterns of performance would have emerged. This is speculative, however. A longer period of intervention may have also benefitted LS, who did appeared to be responsive to the intervention with the robot. It would have been interesting to see if he would have continued to make progress with additional intervention, or if his performance would have leveled off. AH was the only child who appeared to respond to and then tire of the robot.

In evaluating the children’s performance in the overall context of the intervention, it should be remembered that this project focused on a highly specific activity. In this particular
study, the children were only observed for a singing activity that lasted a few minutes. The children’s performance during the activity, both positive and negative, may not have been reflective of the children’s overall performance in intervention involving the robot.

The coding system used to analyze the data was complex and required a number of adjustments to make it possible for coders to achieve inter-examiner reliability. Although generally satisfactory, there were some potential issues that may have impacted coding validity. These issues primarily involved engagement. In addition to issues discussed previously, the system was not able to always capture engagement between episodes of disregulation. For example, when a child became regulated following disregulation, he/she would often become more engaged and would be in a state ready to learn. By convention, however, if the child acted out once, a rating of minimally engaged was assigned. Thus, the rating system was not able to fully describe the episodes of disregulation and subsequent regulation.

Another general limitation of the coding system that complicated interpretation was that each child had differing clinicians who provided somewhat differing levels of support during the singing activity. Efforts were made to achieve treatment fidelity across clinicians. Despite these efforts, there did appear to be some differences. For example, some clinicians appeared to provided a greater amount of gestural hand-over-hand support for their particular child, thus increasing the child’s number of gestural turns taken with assistance, whether the child was engaged or not. This increased support also increased the child’s rating of perceived level of engagement. Other clinicians seemed to give very little hand-over-hand support and would only demonstrate the gestures for the song in front of the child. This resulted in a smaller number of gestural turns with assistance. The results of the “gestural turns taken with assistance” category and the level of engagement rating may thus have been impacted by the varying level of support
from the different clinicians. This possibility could be further investigated by additional analysis. One way to accomplish this would be by modifying the coding system so that the definition of engagement took more behaviors into account than unassisted and assisted turns. It might also be possible to consider other aspects of engagement such as eye contact or shared affect.

**Suggestions for Future Research**

Additional research is needed to better understand the effects of a robot on the social engagement of children with autism. Based on the limitations noted above, the following recommendations are made. Because of the severity of impairment experienced by many individuals with autism, a longer duration of treatment sessions with the robot would provide a more appropriate assessment of the intervention involving the robot. In addition, the robot activities should be geared more specifically to the capabilities and interests of the child.

Clearly, the development and implementation of a reliable and valid coding system is a challenging task. This task is complicated by the highly variable performance of individuals with autism. With these issues in mind, it is recommended that the coding system used in future studies be adapted to account for additional acts of engagement and socialization such as eye contact or shared affect. It is recognized that over-coming these problems will require some highly innovative problem solving.

Finally, it will be important in future studies to examine how the children’s overall level of emotion regulation impacts participation in intervention during individual sessions. This could be achieved by asking parents to rate the child’s behavioral state prior to the intervention session. Such a rating would have potential to provide insight into the child’s performance on a particular day.
Conclusions

The purpose of this study was to examine the effects of a robot when incorporated into the treatment plan for four children with autism. An increase in turn taking was observed in one of the children. Another child showed a gain and then appeared to tire of the robot. The other children did not display any systematic patterns of increase or decrease of turn taking behaviors. The analysis of these results required the development of a coding system which included various levels of turn taking as well as overall level of engagement. There were limitations within the study and other components that need to be taken into consideration when interpreting the results. Additional research is needed in order to more reliably establish the effect of a robot on children with autism.
References


therapy to encourage children’s proactivity and initiative-taking. *Interaction Studies, 10*(3), 324-373. doi:10.1075/is.10.3.04fra


Appendix A

Annotated Bibliography


Purpose of the study:
To measure the effects of the inclusion of a robot into autism therapy on joint attention and social interaction.

Method:

Participants:
There were two male children involved in this pilot study, ages 3 and 9. Each of these participants displayed either a moderate or a severe language delay and exhibited severe deficits in social functioning and in joint attention.

Procedure:
Each subject participated in traditional therapy along with the inclusion of a robot for a short time in each session. Once the robot was introduced in each session, the clinician would continue to engage the child in reciprocal play in an interaction between the clinician, the robot, the child himself, and the child’s parent if available. An upper body, humanoid robot with the capability of producing simple arm movements and a few short phrases and songs, was used. Baseline and follow-up data on initiating and responding to social engagement were gathered. This data consisted of a child-parent play assessment, a child-clinician play assessment, an unfamiliar adult play session, and a triadic interaction assessment; however, only the child-parent play assessment and child-clinician play assessment were addressed in this thesis.

Results:
The results from the child-parent assessments showed a decrease in the initiation of language and eye contact, and no change in affect and imitation in the first participant. There was also a decrease in imitating language, but an increase in responding to affect and eye contact, as well as a decrease in instances of complete non-engagement. In the second child, however, the initiation of language, affect, imitation, and eye contact all increased. All of his responding behaviors increased as well, with a decrease in non-engagement behaviors.

The results from the child-clinician play assessments showed that the first child’s initiating behaviors of language and eye contact both increased, but affective behaviors decreased, with no change in imitation. His responding behaviors of affect and eye
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contact increased while his imitation decreased, with no change being observed in language use. The amount of non-engagement was shown to increase. The second child’s initiating engagement behaviors of language and eye contact increased, whereas affect and imitation remained constant. All of his responding behaviors increased, and the amount of his non-engagement instances decreased.

Conclusions:
One of the participants showed evident improvement throughout the course of treatment, whereas the other participant showed decline in most engagement behaviors. This may be explained by the different methods of interaction and engagement used by the different sets of parents, the age of the children and age level of the toys and activities used in therapy, the child’s temperament and personality, and the difference in the level of functioning at which each child started. Although there was a portrayal of decrease in functioning in one of the children, the clinician noted clinical observations that showed an increase in some positive behaviors.

Relevance to the current work:
This was the pilot study to the current study. It shows that there may be a positive effect in the incorporation of a robot in autism therapy with children with autism. With more research needed, the path was paved for this study.


Purpose of work:
This article explains what autism is, and what the disorder involves. It describes what behaviors are evident in those diagnosed with autism.

Summary:
Autism falls under a broader category known as Pervasive developmental disorder, which contains several disorders such as autistic disorder, Rett’s Disorder, Childhood Disintegrative Disorder, Asperger’s Disorder, and Pervasive Developmental Disorder Not Otherwise Specified. In order for a child to be diagnosed with autism, he/she must portray at least six behaviors from a list including the broad categories of impairment in social interaction, impairment in communication, and portrayal of restricted repetitive and stereotyped patterns of behavior. Of the six behaviors that must be evident, two must come from the first category, and one from each of the other two categories. These delays must be evident before 3 years of age in order to be considered autistic disorder. People with autism are said to have impairment in social interaction because they have difficulty in regulating social interaction and social communication, in that they do not use eye
contact, facial expression, body postures, or gestures, and do not have an awareness of others when they interact. In fact, many do not even develop peer relationships at their appropriate developmental level. The communication impairment affects both verbal and nonverbal communication, as well as everything from comprehension to pragmatics; however, those with autism show a range of communicative ability. The stereotyped and restricted behaviors may consist of a restricted range of activities and interests and a lack of imagination. These may be abnormal in intensity and/or focus.

Relevance to the current work:
This article explains the behaviors and irregularities that are correlated with autism. This helps in the treatment of the disorder in knowing what the impairments are, and what needs to be addressed.


Purpose of the study:
To study the effects of the incorporation a humanoid robot in the therapy of children with autism on the children’s joint attention and social interaction with other people.

Method:
Participants:
Four children (two boys, two girls) with autism participated in this study. The children were between the age ranges of 4 and 9 years. Each child displayed minimal verbal language and little joint attention.

Procedures:
Each participant went through a series of treatment sessions, each lasting approximately 50 minutes. Ten of these minutes involved the incorporation of a robot. A triadic interaction was set up with the robot and turn taking games were played between the child, the child’s mother, the clinician, and the robot. Each child also participated in a series of baseline and follow-up sessions before and after treatment. These sessions included segments with a familiar adult, an unfamiliar adult, an interaction with the child’s mother, and a triadic interaction. Each session was recorded, and the baseline and follow-up sessions involving triadic interaction were analyzed for this paper.

Results:
Within the triadic interaction, the first participant showed increases in reciprocal action. He decreased in eye contact. The next participant showed a decrease in eye contact, improvements in reciprocal action, and no change in language or initiating engagement. The third participant portrayed an increase in eye contact and reciprocal action, and little
change in initiating engagement and language. The last participant had a decrease in eye contact and reciprocal action, and no change in language and initiating engagement.

Conclusions:
All but one of the participants showed gains in reciprocal interaction. This is because the therapy with the robot focused on turn taking and reciprocal games, and these interactions with the robot were always accompanied with other humans. All but one of the participants showed a decrease in eye contact, which may be accounted by the fact that the robot was not designed to elicit eye contact. The features of the robot were simple, and not motivating for the children to establish eye contact with. There were no improvements in language and initiating engagement. This may be because the focus of the therapy with the robot was turn taking games to elicit responses to engagement, not initiating engagement.

Relevance to the current work:
This paper is based off the same study as the current paper, only written on different aspects of the data.


Purpose of work:
To provide an overview of the core deficits of autism that need to be taken into account when considering components of developmental intervention approaches.

Summary:
Social communication does not come naturally to children with autism, and there has been found to be two main deficits within social communication, a deficit in joint attention and a deficit in symbol use. Other distinguishing features include lack of eye contact, poor initiations and responses to bids for interaction, poor shared attention, lack of shared affect, and no shared intentions, lack of use of gestures, and fewer communicative behaviors. Most children with autism have also been identified as portraying early signs and symptoms of the disorder before the age of 2 years. Current theories are suggesting an interaction between abnormal brain development, the child’s overall profile, and the learning environment found in autism. This means that the symptoms and core deficits in the disorder may further effect the disruption in brain development, creating a cumulative effect on the manifestations in social communication. Because of this, these core deficits need to be a main target in the early intervention of social communication to aid these children in their development. It has also been found
that social communication is best improved within intervention when the adult inserts themselves into the child’s current area of interest and following the child’s lead, rather than gaining the child’s attention by attempting to divert the interest to another object.

Treatment approaches range along a continuum from more traditional to contemporary, behavioral approaches. More contemporary discrete trials have shown to improve IQ as well as various broader communication domains, but they lack natural context, natural reinforcement, and thus generalization as well. Traditional developmental behavioral approaches incorporate a more natural setting in the therapy and have shown to improve speech, language, and communication. These developmental approaches use the developmental framework of what a child should be learning next as a guide to what is taught in therapy. This approach uses naturalized contexts by embedding intervention into the child’s everyday routines, which more naturally leads to generalization of the behaviors. In general, however, it has been shown that, in any approach taken toward intervention, an incidental language teaching method where more of the management is given over to the child is more likely increases generalization for even the most severely disabled children.

Conclusions:
Providing early intervention to children with autism shows great benefit and improvement on the child’s social communication. The developmental approach to intervention is one approach shown to be highly effective in this process as it has been proven through a number of studies to show improvements and generalization. Developmental and contemporary behavioral treatment have many differences, but they also portray commonalities as well, and features from both are often blended together in treatment; however, further research is needed to observe the relationships between characteristics of the child and the disorder, specific treatment procedures, and their outcomes.

Relevance to the current work:
A great deal of information is presented about the core deficits in autism as well as a possibly effective treatment approach. Aspects of intervention to treat these core deficits can be drawn from this, and can be applied in other aspects of treatment to increase efficacy in other therapy approaches.


Purpose of work:
To summarize the work completed in relation to robot based autism therapy, as well as to discuss newer ideas that involve the therapist directly in this therapy. In so doing, this paper talks about other therapy strategies that can be included with a robot for children with autism as well as those with specific language impairment (SLI).

Summary:
Children with SLI and autism have a tendency to demonstrate reticence, withdrawal, emotion regulation problems, and language impairment. Research has shown that robots can be helpful in the therapy for these children, especially in regards to that of social intervention. Robots have shown to prompt or elicit these lacking social behaviors found in those with autism. There has been no research, however, to prove if these elicited social behaviors would generalize to the child’s interactions with other people. In regards to children with SLI, who also present with deficits in social development, early intervention has shown to be helpful in this population in learning social skills and reaching a higher functioning level. The authors speculate that therapy with a robot would also be beneficial for this population as well.

Using a triadic interaction including the child and robot is thought to be effective in robotic therapy. In this way, the robot is used as a tool by the clinician, who then has more control to facilitate and shape social interactions from the child. Because of this more natural way of interaction with a robot, this triadic set-up is considered to potentially lead to better generalization. There are two different groups that have more promise than others in this triad. These consist of the child, the robot, and the child’s companion, or the robot, the child’s companion, and a third person directing the robot’s behavior and hidden from the child. These triadic therapies aim to decrease interaction with the robot, and to maximize interaction with the other people in triad. In conducting the therapy, imitating the child’s behavior has shown to have some positive outcomes when incorporated into the treatment. This type of imitation is currently being expanded into the realm of robotics so that the robot will be able to imitate the movements of the child. Further technological work needs to be accomplished before conclusions can be reached in this technique.

Conclusions:
Incorporating robotics in the therapy of children with autism and SLI may help improve their social interaction. Some techniques, however, are more successful than others, such as using a triad in the interaction to increase human to human exchanges, and to increase generalization. Further research is being done to determine how best to design a robot, how to use the technology involved in a robot, how to incorporate the robot into the therapy, etc.
Relevance to the current work:

This article provides a basic foundation for the current work. It explains why robots are useful in the therapy of children with autism, why a triadic interaction should be used, and how the robot could be designed to elicit good interactional skills.


Purpose:

To discuss the disorder of autism and how robots are considered to increase social interaction within the disorder.

Summary:

Persuasive robots, whose main purposes are to change humans’ attitudes, behaviors, and opinions, range from being used as tools, to being used in media and virtual environments, to supporting social interaction. Computers and virtual technology have been increasingly used in autism therapy over the years. Autism is known to have three main deficits. These consist of impairment in social interaction, impairment in communication, and repetitive, stereotyped behavioral patterns, all of which make it difficult for those with autism to understand social rules. The use of technology in interventions for autism helps create a more predictable and reliable atmosphere, making it easier for children with autism to learn more appropriate social interactions. One particular study, known as the Aurora project, was completed to assess the efficacy of the use of a robot in increasing social interaction in those with autism. In this study, the therapy was mostly conducted in an unstructured manner as the participating children with autism were allowed to interact in any manner desired. These children were placed into a room with a teacher and an experimenter, and were left to play with a robot of their own accord. Results of the study showed that the robot was successful in engaging the children in social, dynamic interactions through turn-taking games.

Conclusions:

When robots are used as persuasive, social tools, they need to have the ability to engage people in social interactions. In order for this to be accomplished, they need to be inserted and socially embedded into the environment in order to be most effective. Robots have shown to be useful by being included in therapy for autism, but social robots have also been used for other purposes as well.

Relevance to the current work:

Social robots have shown a degree of usefulness in the therapy of those with autism as they have helped increase social interaction.

Purpose of work:
To discuss the use of robots and other technological environments in teaching children with autism. The article is based on the conclusions drawn from the autonomous robotic platform as a remedial tool for children with autism (Aurora) project, which studied the use and development of independent robots in the therapies of children with autism.

Summary:
Although people with autism have many varying symptoms, every case of autism presents with deficits in social interaction, social communication, and imagination. In addition to these three aspects of autism, repetitive behaviors and resistance to changes in routine are also usually seen in the disorder. Those with autism have great difficulty in making sense of the world, especially that of the social world. Because of the individualistic nature of this disorder, there are varying viewpoints on how to best treat autism and its deficits, one of which to teach the skills needed to interact and live in a typically developing population. The other viewpoint of treating those with autism consists of living separately from the typically developing population, and empowering those with the disorder to make their own choice as to whether to connect with the greater population or not.

The Aurora project was designed to investigate how a robot can be used as a tool in therapy for autism to support the children in engaging in different social interactions. The project aims to eventually have robots used in the schools and in homes with children with autism in the distant future. The interactions in this project were designed to be playful and unstructured in that the children were allowed to interact with the robot in any manner of their choosing.

The rationale behind this project is that a non-humanoid robot is a good starting place in treatment for children with autism because they tend to have difficulty interpreting facial expressions and other social cues, and they often avoid social interactions because people are unpredictable and confusing. Rather, they prefer a structured, predictable environment in which they are in control. The aim of the project was to slowly change the robot’s behavior and predictability toward a more complex, human-like interactional style as the child becomes comfortable with the robot.
Children with autism also imitate others’ actions, gestures, and speech less than typically developing children, which is a critical skill in learning intentional communication. Results from the Aurora project showed that conditions set up to elicit imitation resulted in the children manipulating objects more frequently and for a longer duration. This leads to an increase of social expectancies resulting in more attempts at initiating social interactions. Further results of this project showed that there was a significant increase in the interaction with the robot as seen by increasing amounts in eye gaze and amount of attention given to the robot.

One of the biggest problems found in interventions for autism is that of generalization. Although it is unknown how behaviors learned using a robot will generalize, it is thought that other virtual environments have the potential to lend themselves to better generalization since creating differing scenarios and environments is made possible. Realistic environments can be created through the virtual world, lending to the child’s feeling of presence in actually being a part of the world, and also to greater generalization.

Conclusions:
It is hoped that research on the affects of robotics in the therapy and education of children with autism will continue, and that they will eventually be used by teachers and parents, and tailored to the needs of those that use them. Because of the highly variable symptoms of those with autism, it is not likely that one robot will be successful for every person with autism. It is important to take into account the design and functions of different robots for this purpose. In addition to this area, further research also needs to be conducted to see how a child generalizes what they learn from a robot.

Relevance to the current work:
This article gives empirical support for the use of robots in the therapy for children with autism. It shows that more research needs to be done, but that there is great potential in this area.


Purpose of the study:
To assess the ability of children with autism to orient to both social and nonsocial stimuli in a naturalistic context.

Method:
Participants:
The participants were placed into three groups: 20 children with autism, 19 children with Down syndrome, and 20 typically developing children. The diagnosis of autism was established through a parent interview, a structured play assessment, and through the administration of the Childhood Autism Rating Scale. Thirteen of the children received the diagnosis of autistic disorder, and 7 were diagnosed with Pervasive Developmental Disorder Not Otherwise Specified. The three groups were matched according to each child’s receptive language mental age as derived from the Preschool Language Scale – 3 and the Vineland Adaptive Behavior Scales. The children with autism were additionally matched to the children with Down syndrome in chronological age and verbal IQ. The means of the ages of the three groups of children ranged from 30.9 months to 64.6 months.

Procedures:
Each child was tested by a familiar examiner. A second examiner was also present in the room and presented four orienting stimuli interspersed between different tasks. The stimuli included social stimuli, that of clapping of the hands three times and calling the child’s name three times, and nonsocial stimuli, that of playing a musical jack-in-the-box and shaking a rattle. Each of these stimuli was presented twice, once in front of the child in his/her view, and once behind the child, being presented for 6 seconds each time. For a shared attention task, the experimenter would wait until the child was losing interest in a present toy, and would then attempt to regain the child’s attention by holding the toy near the child’s face until he/she was looking at the experimenter’s face, at which time the experimenter would deliver one of four probes. These probes consisted of pointing to a cross strategically placed in front of the child, and pointing to a cross placed behind the child, or looking at one of the crosses behind, and one of the crosses in front of the child. Whether or not the child looked toward any given stimulus was coded along with any delay in response that the child gave. An error was coded if the child failed to look at the stimulus.

Results:
The children with autism produced more errors in shared attention and in orienting to both types of stimuli in comparison to the other two groups, and more specifically, showed most errors in social orientation. The children with autism also showed more delays in their responses to the social as well as nonsocial stimuli. Children with autism and those with Down syndrome showed a relation between shared attention and social orientation, but not with nonsocial orientation, language, or nonverbal ability; however, the typical group did show a relation between social orienting and receptive language, but not to shared attention.

Conclusions:
Children with autism show impairment in their ability to orient, particularly to that of a social stimulus. Those that do orient to social stimuli are more likely to portray a delayed response in such orientation. Children with autism also were impaired in their ability to share attention with others. It is hypothesized that this impairment in shared attention is caused by the impairment in attending to social stimuli (i.e. attending to another’s eyes or facial expression).

Relevance to the current work:
These findings add to the conclusions of previous researchers that children with autism display an inability to share attention and attend to social situations. It implies that it is important to target basic social attention skills as early as possible in intervention.


Purpose of the study:
To study the effects of the incorporation a humanoid robot in the therapy of children with autism on the children’s joint attention and social interaction with other people.

Method:
Participants:
Four children (two boys, two girls) with autism participated in this study. The children were between the age ranges of 4 and 9 years. Each child displayed minimal verbal language and little joint attention.

Procedures:
Each participant went through a series of treatment sessions, each lasting approximately 50 minutes. Ten minute segments of the intervention involved the incorporation of a robot. A triadic interaction was set up with the robot and turn taking games were played between the child, the child’s mother, the clinician, and the robot. Each child also participated in a series of baseline and follow-up sessions before and after treatment. These sessions included segments with a familiar adult, an unfamiliar adult, an interaction with the child’s mother, and a triadic interaction. Each session was recorded, and the baseline and follow-up sessions involving an unfamiliar adult were analyzed for this paper.

Results:
One of the participants showed an increase in initiating engagement and responding to joint attention in symbolic play, but showed a decrease in eye contact and in responding to joint engagement in turn-taking games and singing. Another participant showed an
increase in eye contact and in responding to joint engagement in turn-taking and singing activities, but a decrease in language and in responding to joint engagement in symbolic play. The third participant showed an increase in responding to joint engagement during turn-taking and singing activities, but decreases in eye contact, initiating engagement, and in responding to joint engagement for symbolic play. The last participant demonstrated an increase in responding to joint engagement during turn-taking and singing, but a decrease in responding to joint engagement for symbolic play, initiating engagement, and in eye contact.

Conclusions:
Eye contact decreased in three of the four participants from the start of the study to the end. This may be accounted by the fact that camera angles were frequently poor, making it so eye contact could not be coded. This decrease in eye contact may have also resulted from a decrease in the interest for the activities used in the baseline and follow-up sessions. Initiating engagement behaviors either decreased or remained stable in all four children. This may be because most of the probes used in the study were designed to elicit responses to engagement rather than initiating engagement. Responding to engagement during symbolic play decreased or remained the same in three of the four participants. One reason for this may be that all of the children demonstrated very little amounts of symbolic play to begin with, and improvement in symbolic play frequently takes more time than this study allotted. Responding to engagement in turn-taking games and song activities improved for three of the four children, which is considered clinically significant for these children because of their severity.

Relevance to the current work:
This paper is part of the same project as the current paper.


Purpose of work:
To evaluate and outline socially assistive robotics and its use in social interaction and assistive technology.

Summary:
Robots have been used for the elderly in order to help in their upkeep as well as in providing companionship. Rehabilitative robots have been used to provide encouragement and to track progress, as well as in physical therapy exercises. The use of robotics is also being explored in the diagnosis of autism, as it is hypothesized that their
use may facilitate an increase in socialization. Certain benchmarks should be used in robotics in order to assess the ethics, safety, scalability, adaptability, and social performance of their use. Other aspects that should be taken into consideration include the degree of autonomy, and the robot’s level of imitation of life-like behavior. Task-oriented benchmarks should also be taken into account, such as the level of the robot’s social success and the understanding of the social dynamics of the robot. Robotics have been used to replace a caregiver, or as an assistant to a caregiver; however, it is important to assess how effective and successful the robot is relative to the care of the user, or if the job of the caregiver improves.

Conclusions:  
Socially assistive robots can provide many benefits to those that are in need of services that a human caregiver is unable to provide; however, in order to determine efficacy, specific categories, or benchmarks, are needed in order to measure the success of the robot. These robots should not replace human interaction, however, but should aim to improve these interactions.

Relevance to the current work:  
This article shows several factors that should be taken into account when designing a robot in order to most effectively aid in social interaction.


Purpose of the study:  
To explore the effect that participation with a robot and examiner has on the play, reasoning, and affect of children with autism.

Method:  
**Participants:**  
Six children were selected to participate, all carrying the diagnosis of autism, and all between the ages of 7 and 10 years. Each of these children were selected from a school specifically for children with learning disabilities in the United Kingdom. Three of the children did not express themselves verbally, but used onomatopoeias and repetitive gestures, and were described as socially isolated. The other three children were verbally communicative, and were not described as being solitary children.  
**Procedures:**
Each subject participated in up to 10 sessions, the duration of which was dependent on the child’s willingness and desire to play and participate. The robot used in each session was that of a self-directed dog, and each child was invited to play and interact with the robotic dog during each session. The examiner followed the child’s lead, and the child was free to choose what to play and the pace of play. The experimenter was allowed to respond to the child when the child initiated some type of interaction; however, the experimenter was to direct and support the child in a couple of ways, so as to prevent or discourage a repetitive behavior, to help the child engage in play by drawing his/her attention to the robot, to give a better pace to the game if the game was in a standstill and the child had already participated in that particular game, to help the child reach a higher level of play, and to ask questions related to affect or reasoning. Each session was analyzed for play behaviors, reasoning, and affective behaviors. Each child’s play behaviors were coded according to a hierarchy of play, including social play, pretend play, exploration, and a chronology of play. Each act of reasoning was categorized as essence, mental state, social rapport, or moral standing. Affect was recorded if the child verbally expressed any likes or dislikes toward the robot, or if any assumptions were made about the robot liking him/her.

Results:
The first subject was afraid of the robot and did not interact with it for the first several sessions, and was thus not required to come to many of the sessions. The child proactively attended the final session, and interacted with the robot for a short time with the help of the examiner, but still showed signs of apprehension. The second participant was more distracted by the lap top in the room that ran the robot than he was of the robot itself. By the end of the group of sessions, however, the child was able to play with the robot for longer periods of time than in the beginning sessions, but the experimenter had to provide a great deal of support to help keep the child’s attention on the robot. Although this child did not show any differences in his reasoning capabilities, he did produce more gestures, which led to an increase in his exploration as well. The third child exhibited mainly exploratory play with the robot, but showed an increase in the complexity of his play as the sessions progressed, developed more social play, was able to develop new ways of expressing himself, and was then able to project these progressions in interactions with the experimenter. This child displayed reasoning in regard to mental states of the robot when probed, but did not display this knowledge on a proactive basis.. The fourth child displayed continual levels of play that grew in complexity. She was able to reason in the categories of essence, mental states, and social rapport. Affect played an important role in the interaction this child had with the robot as she would comment on how the dog and her liked each other. The fifth child also experienced growing levels of play complexity. He displayed reasoning portrayed through essence, mental states, moral standing, and social rapport. He displayed affect as well as he would also talk about how
the robot liked him. The last participant was engaged in social play most of the time, and progressively started to incorporate pretend play in his interactions. This child addressed all four components of reasoning—essence, mental states, social rapport, and moral statement. This child displayed affect using both verbal and nonverbal means.

Conclusions:
Each child progressed differently, but there found to be three general types of response among the children. The first group consists of the children that played in solitary with very little social play, if any at all. The second group consists of the children who only communicated nonverbally, but gradually came to produce some examples of verbal communication with very basic social play. The last group consists of the children who played socially, such as in a triad with the robot and the experimenter. Children in group one tend to participate in progressively longer periods of play and will eventually engage in basic imitation. Children in group two tend to progress to higher levels of play at a very basic stage, but children in group three tend to develop higher levels of play while acquiring more reasoning skills at the same time. It was concluded that nondirective play therapy encouraged more initiation and possibly symbolic play as well. Because the children were involved in an unrestrained environment, they were thus able to participate in a larger range of play behaviors, and were thus led to the use of causal and reaction play and symbolic play, which may be the case for other children outside of the study as well.

Relevance to the current work:
This is one of the first studies of its kind, and results have shown to be promising; however, more research needs to be accomplished in order to examine how to facilitate more developed play in those children who only portray solitary play. Generalization also needs to be assessed in order to know how the gains seen in robotic therapy transfer to other naturalized contexts and situations.


Purpose of the study:
To study the interaction between children with autism and a toy robot during free, spontaneous play, aiming to create a robotic tool to help autistic children better respond and interact socially.

Method:
Participants:
Three boys and one girl participated, ranging in chronological age from 7 years to 9 years old; however, their developmental ages fell between 2 and 4 years. Each child was formally diagnosed with autism.

Procedures:
A simplistic robot was used and was controlled by a remote control. Each child was individually brought into a room containing the robot, and the robot would carry out the same three movements at the start of each session. As soon as the child walked in, the robot would first move forward, then move backward, and then complete a 360 degree swivel. After this sequence of movements, if the child moved forward toward the robot, the robot would move back. If the child moved away, or ignored the robot, the robot would move toward the child or follow him/her to get his/her attention. If the child did not move and stayed still, then the robot would move toward the child, or would turn around in attempt to catch the child’s attention. Each of these sessions lasted a total of 5 minutes. At the complete of all the sessions, the data was analyzed and certain behaviors were coded. These behaviors included the length of time the child spent in eye contact with the robot, touching the robot, manipulating or operating the robot, and the child’s posture to the robot.

Results:
The first child spent 156 seconds playing with the robot, the second child spent 289 seconds, the third child spent 269 seconds, and the fourth child spent 241 seconds playing with the robot. The mean amount of time spent in interaction with the robot for all four children was 238.7 seconds, which is 79% of the children’s time. The amount of time spent in eye contact with the robot was relatively similar across all four participants; however, the duration of the touching, manipulating, and the posture categories were much more variable across subjects.

Conclusions:
It was concluded that the children were “quasi-constantly” in interaction with the robot in differing ways, and that a robot can indeed be used to successfully engage a child with autism. Because of the varying levels of time spent touching, manipulation, directing posture toward the robot, the participants not only visually looked at and explored the robot, but also demonstrated engagement with the robot in different types of play, thus, free game play, or other ecological scenarios, encourage children with autism to interact with a robot in a more spontaneous manner.

Relevance to the current work:
This shows that children with autism respond well to robots, and further study of using a robot to reduce the social and emotional impairment may show promising results.

Purpose of work:

To review different areas of technology that may temporarily be used instructionally with people with handicaps (i.e., autism). The article reviews the research and future research needs for each type of technology discussed.

Summary:

Technological auditory prompting and tactile prompting devices are sometimes used to give varying types of reminders on a timely routine. These types of devices are usually small and unobtrusive, allowing children using them to blend with their peers and not stand out. Generalization of such devices, however, is unknown, and further research needs to be conducted. How to fade these cues also needs more study.

Video technology, which is more widely used, is another tool being used. It is used mainly for modeling targeted behaviors, offering feedback, making discriminative situations for the child, and for providing a situation to teach basic skills that many find highly engaging. Yet another type of technology used in teaching and helping those with autism is that of computers. Computers have been used to help in many aspects, including predicting emotions, problem solving, expanding vocabulary, improving spelling, improving reading and communication, etc. The benefits of using computers include increased motivation, decreased inappropriate behavior, and increased attention in the children using the technology.

Stemming from the computer-based interventions comes virtual realities that have been created and potentially used in therapies for children with autism. This type of technology creates an environment in which a computer generated three-dimensional situation where actions and responses can be experienced. This area is not well researched, and although it shows great potential, more research needs to document its success.

Lastly, the area of robotics is currently being studied for use in autism therapy. Robots allow the social environment to be presented in a more simple way, and can thus be used to teach basic social skills and interactional competence. This can be done through turn-taking and imitation games to establish joint attention as the robot can be used as a social mediator between the child and interactional partner.

Conclusions:
The research that has included technology has shown success and great potential. The use of technology seems to appeal to children with autism. The next step in the research is to address the question of whether interventions using technology are more effective than traditional methods of intervention. The cost effectiveness of robots also needs to be considered. Through the growing research, however, multidisciplinary teams should be used including clinician researchers, programmers, and engineers so as needed expertise is available.

Relevance to the current work:
This study shows how technology, including robotics, has great potential in benefiting children with autism. It also indicates that further research is needed.


Purpose:
To measure the effects of the inclusion of a robot into autism therapy on joint attention and social interaction.

Methods:
Participants:
There were two male children involved in this pilot study, ages 3 and 9. Each of these participants displayed either a moderate or a severe language delay and exhibited severe deficits in social functioning and in joint attention.

Procedures:
Each subject participated in traditional therapy along with the inclusion of a robot for a short time in each session. Once the robot was introduced in each session, the clinician would continue to engage the child in reciprocal play in an interaction between the clinician, the robot, the child himself, and the child’s parent if available. An upper body, humanoid robot with the capability of producing simple arm movements and producing a few short phrases and songs, and the size of an average 3-year-old was used. Baseline and follow-up data on initiating and responding to social engagement were gathered. This data consisted of a child-parent play assessment, a child-clinician play assessment, an unfamiliar adult play session, and a triadic interaction assessment; however, only the unfamiliar adult play assessment and the triadic play assessment were addressed in this thesis.

Results:
In the triadic interaction, the first child’s language, affect, and imitation in regards to initiating engagement showed no change; however, eye contact greatly increased. All
areas of language, affect, imitation, and eye contact in regards to responding to engagement and interaction increased. The number of instances of non-engagement increased. In the unfamiliar adult pre and post assessments, this child demonstrated an increase in all categories of initiating and responding to engagement.

In the triadic interactions, the second child showed a decrease in initiating language, no change in imitation and affect, and an increase in eye contact. All categories showed an increase in regards to behaviors of responding to engagement, with the exception of imitation which remained the same. The number of instances of non-engagement greatly increased. In the unfamiliar adult play assessments, this child’s results showed an increase in all categories of initiating engagement, in addition to an increase in responding language, affect, and eye contact. There was, however, a decrease in this child’s imitation.

Conclusions:
The participants’ attention was sustained for a longer amount of time from the baseline data to the follow-data. Each child improved in overall initiating and engaging behaviors. Clinical observations made by the clinicians showed improvement in the children’s social interactions. The cause of the improvement seen in both children appeared linked to the robot’s ability to engage both of the participants. The increase of non-engagement in both of the children may be explained by the fact that they may have needed more time to become emotionally regulated before they could fully participate in the interaction.

Relevance to the current work:
This was the pilot study to the current study. It shows that there may be a positive effect in the incorporation of a robot in autism therapy with children with autism. With more research needed, the path was paved for this study.


Purpose of the study:
To examine the research completed regarding intervention for children with autism so as to establish valid and effective measures in developing such intervention programs.

Method:
Participants:
Studies that were included were found using searches in subject indexes, citation searches, browsing, and footnote chasing. A broad search locating any possible relevant study was conducted first, followed by a more limiting selection. In order to be included
in this synthesis of research, the study had to be an intervention study, had to have at least two thirds of the participants between ages 3 and 8 years, had to be published between 1975 and 2001, had to involve a treatment/comparison or single-group design, and had to have at least 50% of the participants identified as having autism. The selection process ended in the inclusion of 24 studies, all published journal articles.

Procedures:
A coding procedure was applied to each study to draw out and organize important information. The coding system included the recording publication, the coder’s information, the participants and setting, the purpose of the study, the research design, research methodologies, description of the intervention, the measures of the study, the observations found, and the findings and conclusions.

Results:
Parent involvement is one of many characteristics that showed positive effects in the therapy of children with autism. Those whose parents and family were involved in their therapeutic process had fewer autistic behaviors than those whose parents were not involved. Intensive behavioral treatment also produced improvements in various autistic behaviors. Multicomponent therapy had a positive effect on participants in that it improved play behaviors, increased development, and decreased autistic behaviors. Various studies have shown that including an individualized language remediation program in intervention will likely increase the amount of verbal and nonverbal language used by a child with autism. Including the use of typically developing children in the intervention of a child with autism has also shown to have an effect in the social behaviors of that child in that it increases and improves these behaviors. There has been evidence that the inclusion of touch therapy in an intervention program also helps increase the social skills and communicative ability of children with autism. There showed to be more improvement, however, with intervention programs of a longer duration. Lastly, one study examined the effects of the inclusion of a computer program in the intervention of children with autism and found that it increased their vocabulary, attention, and motivation.

Conclusions:
Intervention programs that have been found to be most beneficial to the progress of children with autism include the involvement of parents and family, use of intensive behavioral strategies, conduction of therapy over a longer period of time, and use of therapies that contain multicomponent attributes that target several behaviors at once. There are many different strategies used in reporting the child’s outcomes and progress from the intervention program, some of which are more reliable and accurate than others.

Relevance to the current work:
This paper highlights the type of interventions from which children with autism are most likely to benefit. Incorporating these ideas in any intervention program for these children is important.


Purpose of work:
To review previous studies and knowledge of the social interactions and social relationships of children with autism.

Summary:
Children with autism display deficits in social skills and social interactions. In fact, there are certain characteristic behaviors that prevent social interactions occurring more frequently and naturally (e.g., repetitive and nonfunctional movements, self-injury, and avoidance behaviors). To help remediate this problem there are several different types of social interaction interventions. These types of interventions are broken down into five categories; ecological variations, collateral skills intervention, child-specific intervention, peer behavior, and comprehensive intervention.

Interventions that take ecological variations into account manipulate the social and physical environment in such a way so as to increase stimulation for social interactions. These ecological variations have shown to be variable in their effect on children. It is frequently recommended that they be paired with other common and intensive intervention strategies. Collateral skills interventions are where the child’s social interactions are increased through, and generalized from the training of other skills such as academic responses and play skills. Through this method, it is thought that children become more competent in participating in social play, thus reinforcing social participation and improved social skills. Child-specific interventions include procedures aimed at improving the skill, frequency, and/or quality of the social behaviors in the child. This model is considered one of the more traditional and more commonly used techniques in therapy for children with autism. Best results are gained from this technique when therapy is also paired with generalization techniques. The peer behavior/peer-mediated intervention system consists of teaching the child’s peers various social skills regarding how to interact with the child in order to help improve the social skills of the child. An example of a skill that could be taught to the child’s peers includes giving the child praise and prompts in social settings to increase the child’s awareness and understanding of positive and appropriate behaviors in a very naturalistic context. Lastly,
comprehensive intervention combines two or more of any of the above categories for maximal progress.

Conclusions:
Children with autism can benefit from social interaction intervention, especially in areas of social initiation, responding, and general interaction. It is recommended that clinical educators assess the child with autism in naturalistic contexts. Therapy should be structured and manipulated to create proper prompts for better behavior, to teach social skills to the child’s peers, and to provide direct intervention to child himself. As the child learns and progresses, direct intervention should be faded, and the treatment should be extended to further naturalized contexts, such as settings outside of the therapy room and realistic activities the child participates in throughout the day. Effects of intervention should be monitored for an extended period of time for best results.

Relevance to the current work:
The review of this combination of research has provided direction in the clinical aspect of autism and has added a great deal to the knowledge and understanding of the social development in this population. Further work and study should be attributed to this aspect of autism to provide further knowledge, and research should also be started in other areas of the disorder as well to increase the span and the depth of our understanding.


Purpose of the study:
To examine if the social and joint attention deficits found in autism are specific to autism, or if they are universal to developmental delays in general.

Method:
**Participants:**
There were a total of 18 participants consisting of 14 boys and four girls, each with autism. Their ages ranged from 34-37 months. There was also a group of 18 cognitively impaired children who were matched with the children with autism according to chronological age, mental age, and the mother’s level of education. The mean age of the group with cognitive impairment was 50.2 months. Lastly, there was also a group of 18 children who were normally developing. They were also accordingly matched to the children with autism. The mean age of this group was 22.2 months.

**Procedures:**
Each child was individually assessed over three separate sessions. In the first session, each child was administered a non-verbal social-communication measure, and the Cattell
Scales of Infant Intelligence or the Stanford-Binet test. During the second session, the Reynell Language Scales and an unstructured play task were administered. In the third session, a structured play task was presented to each child. The children’s non-verbal communication skills were rated as a social interaction, an indicating behavior, or a requesting behavior. Within each of these three categories, the child’s actions were rated as either responding or initiating. The children’s play behaviors were assessed and categorized as either functional acts or symbolic acts.

Results:
There was a difference between the children with autism and the other two groups in their social interactional behaviors in that the children with autism showed a similar level of simple social interactional behaviors, but had a lower frequency of more complex behaviors of responding to social interaction. The children with autism also showed a lower frequency of initiating joint attention. They did not use pointing as a mode of communication within the initiating requests category as frequently, and also demonstrated less eye contact. These children did, however, reach for toys out of their reach more often than the cognitively impaired children. The results of the play assessments portrayed fewer acts of various types of play by the children with autism. There was individual variation, however, as a whole, the group with autism differed from the typically developing children and children with cognitive impairments within the symbolic play category in structured situations.

Conclusions:
Children with autism portray some differences from normally developing children and children with cognitive impairments in that they have poorer nonverbal indicating skills, demonstrate briefer turn taking engagement, respond less frequently to invitations to interact, and make less eye contact. These children also tend to show fewer acts of symbolic play. In general, children with autism mainly show deficits in initiating and indicating, which may lead one to believe that one of the possible problems in autism lies within allowing one’s focus to be shared with another partner. Children with autism do portray behaviors that are similar to that of children with cognitive impairments as well, such as that of following simple commands, and combining eye contact with and a gesture in order to obtain a wanted object.

Relevance to the current work:
This work established that non-verbal indicating skills are a significant deficit in the social skills in such children.

Purpose of the study:
To record early signs of autism in infants who were later diagnosed with the disorder compared to the behaviors of typically developing infants. Four questions were addressed in regards to this purpose: Are differences in autistic and normal children’s behavior apparent at 1 year of age, can we identify specific behaviors that distinguish autism, does the early development of children with autism differ between those with and without later documented cognitive delay, and is there empirical support for the existence of late onset autism.

Method:
Participants:
Eleven children with autism and 11 typically developing children were included, each group containing 10 boys and one girl. Seven of these children were diagnosed with autism and one was diagnosed with pervasive developmental disorder not otherwise specified. Two of the children in this group were suspected of having late-onset autism as reported by the parents; however, the other nine were reported to portray autistic symptoms before age 1. Four of the children with autism had cognitive delay.

Procedures:
Recordings were gathered from each child’s first birthday, and the presence or absence of social, affective, joint attention, and communicative behaviors were coded. Looking at another person’s face, smiling at another person, seeking contact with another person, and imitating another person were coded as social behaviors. Distress and tantrums were coded as affective behaviors. Pointing, reaching for something in a communicative way, showing an object to another, and alternating gaze between an object and another person were coded as joint attention. Babbling, saying a word, using a conventional gesture, and following directions were coded under communicative behaviors. Specific autistic behaviors were also assessed, such as self-stimulatory behaviors, covering the ears, failing to orient to name, staring blankly, and diminished affect. A developmental pediatrician also viewed the recordings and made her best judgment as to whether or not each child had autism.

Results:
A significant difference between the two groups was found within the categories of social behaviors, joint attention, and portrayal of autistic behaviors, but not in communicative behaviors. More specifically, there were four main behaviors found to have a significant difference between the two groups. These consisted of orienting to the child’s own name,
showing an object to another person, looking at the face of another person, and pointing. The typically developing group did these four behaviors more than the group with autism. The behavior of those with autism did not differ in whether the child would later have cognitive delay when the group was analyzed alone. Lastly, the developmental pediatrician was able to identify and label 82% of the participants correctly, and was able to identify all but one of the autistic children correctly.

Conclusions:
The differences between children with autism and typically developing children can be seen by the first year of age. There were three main categories in which differences were observed. These categories consisted of social behaviors, joint attention, and various behaviors specifically characteristic of autism. It was concluded that the child’s ability to look at others, to participate in joint attention, and to orient to speech were the best screening predictors of a later autistic diagnosis.

Relevance to the current work:
The results show that autism may be manifested at an early age of one, much earlier than was originally suspected. Because of this, screening infants at risk for autism and applying early intervention may have benefit.


Purpose of work
To discuss how script therapy is effectively used in the intervention of children.

Summary
Script therapy is a way of teaching children in a tightly structured, predictable framework. Because of its repetitive nature, script therapy reduces the cognitive load on the children, and embeds the teaching moments into a familiar routine. It can help teach joint attention, language forms, semantic forms, syntactic forms, etc. Script therapy can be incorporated into things such as events, book reading, songs and rhymes, etc.

Relevance to the current work
This chapter gives a rational for script training, which was incorporated into the song activities that are used in the current study, which is the main focus of this paper.

**Purpose of the study:**
To show that robot interaction can stimulate imitation behaviors in children with autism.

**Method:**

**Participants:**
There were 24 children that participated in this study—6 boys and 6 girls diagnosed with autism, and 6 boys and 6 girls who were typically developing that were used as a control group. The control group was sex, age, and IQ matched with the autism group; however, they showed no neurological or academic problems. All children were between the ages of 10 and 13 years, and none knew the purpose of the study while they were participating.

**Procedures:**
Subjects participated in a group of trials in four different conditions, the first being a human-human condition. In this section, a human model performed an action in which he reached out his hand and grasped a target disc stimulus. Once the action was completed, a bell sounded and the participant repeated the action him/herself. There was also a robot-human condition in which the above procedure was copied, only with a robot model performing the action instead of a human model. In the human control and robot control conditions, the subjects performed the same action again, only with the human or the robot being static.

**Results:**
The movement of each participant was analyzed by calculating the time between the start of the reaching movement and when his/her fingers closed on the object. Eye movement was also recorded and analyzed, and trials where the subjects’ gaze moved away from the model performing the action were discarded and repeated. The results of the study found that facilitation was evident in the human model condition for the typically developing group, and in the robot model condition for the group with autism. Those with autism had a shorter movement duration and earlier peak velocity and maximum grip aperture times for the robot model than for the human model. There were no statistical differences in the eye gaze of the two groups of children, and gazes were not found to avert more from one type of model than the other.

**Conclusions:**
The main, more unique result found in this study is that visuomotor priming progresses normally in children with autism when it is modeled by a robot rather than a human, showing that robotics or other computer types may elicit normal levels in those with
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autism. This may be explained by the fact that those with autism have trouble connecting and following human behavior because of the variability of human actions. People with autism tend to be hyper attentive to small details, and thus respond better to repetitive and predictable patterns of stimulus, such as found in a robot. This inability to attend to variability of action may be caused by difficulty building motor representations that is found in autism, leading to a lack of understanding of another’s behavior and actions. Robots and their more rudimentary movements, therefore, may be able to trigger automatic imitative movements that humans do not.

Relevance to the current work:
This study shows that robots may be more efficient than humans at teaching children with autism certain behaviors, such as imitation.


Purpose of work:
To discuss the use of a robot in autism therapy and to explore possible directions that could be taken in the future.

Summary:
Autism is a behavioral disorder in which the individual presents with deficits in social interaction, communication, and play patterns. There is a growing push for early identification of autism leading to early intervention to increase higher functionality earlier in the lives of those with the disorder. The use of robots in this process is currently being studied to help with this early diagnosis. Machines and technology are being used to potentially aid in the diagnosis. For example, some of these machines aim to track eye gaze of infants, infants’ moving patterns of their arms and legs, and to track how a child handles and plays with a ball.

Robots are also being increasingly used in the treatment of children with autism. One way in which this is being done is by using robots to increase these children’s ability to self initiate an interaction as the children engage the robots proactively. Robots are also being used to facilitate turn taking and imitation. Since robots are more repeatable and less complex than humans, some robots have been designed specifically for helping those with autism recognize emotion. Joint attention is also frequently targeted when using a robot. To help these behaviors generalize from a robot to other humans, the inclusion of triadic interactions between the child, the robot, and another companion can be included in the therapy. In this situation, the robot acts only as a mediator in eliciting the interaction between the child and the other companion.
The design of the robot plays a part in the success of the intervention. It has been found that the less human-like a robot appears, the more interest the children portray. These children will frequently withdraw from something that has a human appearance, and robots that are nonhuman (i.e. animals, toys, nonhuman forms) are more engaging. These simple robots may be more appealing; however, because of their lack of human-like appearance, they have a low impact in generalization. It has been found that humanoid robots contribute most to generalization, and the children are more likely to carry over the behaviors that are elicited from a humanoid robot to other humans.

Conclusions:
From the research that was reviewed in this article, robot based therapies have potential to improve the behavior in children with autism, with potential in the early diagnosis of infants with autism as well. Triadic interactions have the most promising potential.

Relevance to the current work:
This article gives promising results to the incorporation of triadic interactions with a robot, which the current study included. It also shows how a robot has the potential to improve the joint attention, turn taking, and self initiating interactional skills which were targeted in the current study as well.


Purpose of the study:
To determine the influence of repeated exposures to a robot over an extended period of time impacts the basic social interactional skills in children with autism.

Method:
Participants:
Four children with autism participated in this study, ages 4, 5, and 10 years old. All of the children had limited expressive language with the exception of one who had the ability to speak, but chose not to. Each child demonstrated problems in sustaining attention and staying engaged in an activity.

Procedures:
The children were brought into the room containing the robot one at a time. Each trial only lasted for as long as the child was comfortable staying in the room. In the first step, the robot was placed in an open faced box where it danced in place while the child was in
the room. The investigator did not initiate any responses or actions from the child, but was allowed to respond if the child initiated anything. In the next stage of the trials, the robot was taken out of the box, and the investigator controlled the robot from a hidden laptop. In these trials, the child was actively encouraged, and the caretaker of the child was allowed to try to initiate interaction of some kind. In the last stage of trials, the children were once again given no encouragement or instruction to interact with the robot, and were left to interact and play their own games with the robot on their own. Eye gaze, touch, imitation, and proximity were assessed from these trials.

Results:
The behaviors of eye gaze, touch, imitation, and nearness were counted and recorded over the course of the trials. Although each child showed different results, the general trend showed that touch, imitation, and nearness all increased as the trials progressed. There were also several instances noted in which the children interacted with the adults in the room as well. Many of the more detailed results of the children’s interactions are discussed in a different paper.

Conclusions:
Overall, once the children had become familiar with the robot, they all increased their interaction with their experimenter and their caregiver, and each child initiated interaction with the adults in order to share the experience of the robot with them. The children were able to use the robot as a mediator in interaction, using it as an object of joint attention with the adults in the room. The experimenters were unsure, however, if these behaviors would be consistent without the robot, and if they would generalize to other aspects of the children’s lives.

Relevance to the current work:
This shows positive potential for the incorporation of robotics in autism therapy to increase social interaction.


Purpose of the study:
To study the impact of the use of a robot on interactions with children with autism.

Method:
Participants:
Four children diagnosed with autism were selected for this study, ages 5, 6, and 10. All children had limited verbal language, with the exception of one of the participants who had the ability to express his needs, but chose not use language.

Procedures:
The four children with autism were exposed to both a small, doll-like robot, and a professional pantomime acting as a human, life-sized robot. The children were exposed to the pantomime dressed as a human, as well as dressed as a typical robot. In all scenarios, the same sequence of actions and movements were performed by the pantomime. Each trial lasted a couple of minutes, and data was taken on the observed behaviors of the children.

Results:
Quantitative data was gathered as certain behaviors conducted by the participants were counted in each session. The general behavior of each child was described in the presence of each robot as well. All four of the children interacted with the robots that looked like a typical robot, and ignored the pantomime that had humanlike appearances. This was consistent with these children’s behaviors toward a stranger. The children made more eye contact with the pantomime that looked like a robot, and made no eye contact with the pantomimed that looked like a human.

Conclusions:
When using robotics with children with autism, the more human-like a robot appears, the less social interaction the children are likely to show. On the other hand, the less human like the robot appears, the more social behavior is likely to be elicited from a child.

Relevance to the current work:
This study shows how the appearance of a robot affects a child with autism, and what type of robot is likely to elicit the greatest amount of interaction.


Purpose of the study:
To see if the use of robotics could be effective in therapeutic or educational settings.

Method:
Participants:
This study included four children between the ages of 5 and 10 years. Each child had been diagnosed with autism. They ranged from having limited language to no verbal language.

Procedures:
Each child participated in an average of nine sessions with a robot, each session lasting approximately three minutes each. Each trial, however, lasted only as long as the child was comfortable. In each trial, the experimenter responded to the child only if the child initiated an interaction. The robot had two appearances that were each presented to the child—a robot that looked like a small human doll, and a robot that had a plain, robotic look. The robot was operated from a laptop.

Results:
Each child showed signs of enjoyment when with the robot. In fact, one of the children took notice and became concerned when the robot experienced a temporarily static leg, which could be interpreted as a cognitive concern. The robot also elicited vocalizations from some of the children that were thought to be directed toward the examiner in the room. This was established based on eye gaze, which the children would use to establish joint attention with the examiner. The children were also able to orient and respond to the pointing and gaze of the experimenter with the help of the robot.

Conclusions:
It was concluded that a robot can act as a social mediator in order to elicit joint attention, which can help children with autism better communicate with other people. From this study alone, it cannot be assumed that the robot caused this behavior in the children completely, rather, it may also be attributed to any given toy used. Because of past conclusions of other studies, however, and because of the fact that the children’s interactions occurred in response to the robot’s behaviors, the experimenters felt this would be a likely conclusion.

Relevance to the current work:
The use of robotics in autism therapy show potential in increasing joint attention and interaction, but more information needs to be explored.


Purpose of the study:
To study the effects of the incorporation a humanoid robot in the therapy of children with autism on the children’s joint attention and social interaction with other people.
Method:

Participants:
Four children (two boys, two girls) with autism participated in this study. The children were between the age ranges of 4 and 9 years. Each child displayed minimal verbal language and little joint attention.

Procedures:
Each participant went through a series of treatment sessions, each lasting approximately 50 minutes. Ten of these minutes involved the incorporation of a robot. A triadic interaction was set up with the robot and turn taking games were played between the child, the child’s mother, the clinician, and the robot. Each child also participated in a series of baseline and follow-up sessions before and after treatment. These sessions included segments with a familiar adult, an unfamiliar adult, an interaction with the child’s mother, and a triadic interaction. Each session was recorded, and the baseline and follow-up sessions involving an interaction with a familiar adult were analyzed for this paper.

Results:
The first participant increased in symbolic play as well as reciprocal action, but demonstrated little change in eye contact, initiating engagement, or language. The next participant increased in eye contact as well as reciprocal interaction, but displayed very little change in language, initiating engagement, and symbolic play. Another participant increased in eye contact and reciprocal action as well, but had no change in symbolic play, initiating engagement, or language. The last participant showed small increases in symbolic play, but no changes in initiating engagement, language, or reciprocal action.

Conclusions:
Three of the four participants showed improvements in reciprocal action. This may be because the activities carried out with the robot mainly focused on reciprocal action and turn taking. Two of the participants showed improvements in eye contact, one showed no change, and one showed a decrease in eye contact. One explanation for the decrease may be a lack of interest in the toys and activities on the child’s part. None of the participants changed in their language behaviors; however, because of the severity of the disorder in these children and the focus of intervention, change was not to be expected. Three of the four participants improved slightly in symbolic play. This may be because many of the activities incorporated with the robot involved symbolic play.

Relevance to the current work:
This paper is from the same project as the current paper, only written on different aspects of the data.

Purpose of work:
To review various studies that observe language and communication in those with autism in order to acquire a possible developmental model of language and communication in autism, and establish the resulting implications this model would have on intervention.

Summary:
Despite traditional thought, children with autism may not be as noncommunicative as might have originally been thought. It has been found that the seemingly irrelevant utterances spoken by these children can be associated and identified with a specific source or personal experience of the child, and often carry a possible message. These attempts may lack conventionality, social acceptability, awareness, and intentionality, however. In this regard, these utterances may carry an attempt at communication, but come across as ineffective as the listener cannot decode meaning. The attempted communication of children with autism changes and develops as the child develops. In a typically developing child, communication does not progress from one communicative function to another, but develops synchronously. This is not the case for children with autism. In this population, communicative functions are learned linearly, one at a time, and there is evidence of an order of emergence consistent across these children.

Among the first functions to appear is using intentional communication to achieve an environmental end, such as using a person as an object to achieve another desired object. Using language to achieve a social end appears to emerge later in this developmental model, along with focusing one’s own attention on a specific referent. These functions, however, appear first among ritualized performatives and after the function of self regulation. There also seems to be a development to the contextualization and generalization in each of the communicative function as they emerge. Each function emerges in only contextually restricted forms at first, and then grows to be more conventional and creatively used in varying contexts as the function further develops.

Conclusions:
These findings carry many clinical implications and should be applied to the intervention of these children. Because of these many findings, it is concluded that the main focus of intervention for children with autism should be intentionality. In fact, communicative intent and vocal imitation, whether it be verbal or nonverbal, are prerequisite to referential speech, and ought to be supported in development through therapy. The intervention program should follow the developmental model laid out by the author in that early developing functions should be taught before later developing functions. The
context in which therapy is carried out is also important. Language in this population should be taught as naturalistically as possible, incorporating the natural consequences of communication. Joint action between the adult and the child is what forms the natural communicative context needed for normal language acquisition, but children with autism frequently struggle in establishing the needed joint attention, thus the child needs to be taught his/her reciprocal role in an interaction. This can be supported by incorporating turn taking games in social interaction that require joint participation. Also, as a therapist works with a child with autism, new functions that the child is learning should be taught through basic, simple means, and already existing and developing functions should be paired with conventional and general means. Also, the idiosyncratic behaviors so frequently assumed to be noncommunicative in these children should always be assessed for possible communicative intent.

Relevance to the current work:
Much of the research accomplished up to this point had not addressed the development of language and communication in those with autism. The conclusions drawn in this text were able to develop a possible model of development, which leads to many implications for treatment that this population of children need. As this is one of the first conclusions drawn of its kind, more research is needed in this regard.


Purpose of the study:
The first purpose was to study the communicative and cognitive-social abilities during the prelinguistic and early linguistic stages in children with autism in order to better understand these children’s development. The second purpose was to compare self-initiated communicative acts of children with autism to children with typical development to see if there were only quantitative differences between the two, or if there were qualitative differences as well.

Method:
Participants:
Four children with autism and four typically developing children participated in this study, and those with autism were chosen based on three criteria. These criteria were that the children had to have some language in the prelinguistic stage and be in the early stages of language development, they had to be between the ages of 6 and 12, and they had to have lived with their natural parents since birth. The typical subjects were selected to match the developmental language level of the children with autism. There were two
boys and two girls in each group. The typically developing subjects had an unremarkable medical history and were typical functioning in all areas of development.

Procedures:
Each participant was videotaped on two separate occasions. Each was recorded during a free play scenario as well as a structured communication setting during each of these two sessions. During the free play setting, five common toys and objects were placed in front of the child for 2 minutes (or longer if they showed interest in playing). During the structured communicative setting, the participants were presented with eight different communicative situations, and the examiner responded to the child in these situations in natural ways. During the second recording session, the children participated in an elicited play scenario where the examiner attempted to elicit appropriate play through modeling and support if the child did not demonstrate such play. Communicative intent, imitation, combinatorial and symbolic play, and language comprehension were also assessed. The data was transcribed and analyzed.

Results:
Subjects with autism had a lower developmental level of combinatorial play and tool use, whereas all of the typically developing subjects produced results that were typical for their chronological age. Within the language comprehension assessment, the preverbal children with autism displayed immature level of language comprehension for their age. The verbal subjects with autism displayed a higher level, but were still developmentally behind. The typical subjects, although displaying variation, were all within a typical developmental pattern when it came to comprehension. Surprisingly, the results also showed that the children with autism used significantly more interactive acts than the typical participants. More specifically, this meant that the subjects with autism used more interactive acts that resulted in an environmental response rather than a social response than the subjects that were typically developing. The children with autism, however, showed very few social interactive acts.

Conclusions:
Children with autism demonstrated varying levels of development in the areas of communicative intent, tool use, imitation, play, and language comprehension. These children also produced communicative functions that were behind that of typical development. Children with autism were found to regulate another’s behavior in order to obtain an environmental end; however, they were not able to direct the attention of the adult to him/herself. These children also demonstrated a lack of self communicative function in identifying and focusing his/her attention to prominent features of a referent. They have strengths in learning through trial and error by using tools and combinatorial play, but weaknesses in learning through observation.
Relevance to the current work:

The conclusions drawn add to the pre-existing knowledge of autism, and help deeper establish the characteristics of the disorder.


Purpose of the study:

To further the knowledge of possible social impairments in infants with autism by identifying aspects that distinguish infants with autism from infants of the same age and developmental level without autism.

Method:

**Participants:**
The researchers examined a group of 10 children with autism, and 10 children without autism but with developmental delays. This extra group was established as a control to differentiate if the characteristics found were specific to autism, or attributed to developmental delay in general. All participants were under the age of 48 months. The group with autism included eight boys and two girls. The control group consisted of five boys and five girls. Half of the group of children with autism was considered preverbal, and the other half used only one word utterances. The children with autism all met the standard autism criteria according to the DSM-IV, were each given the Childhood Autism Rating Scale (CARS), each went through a play-based assessment, and each went through the Performance Scale of the Griffiths Mental Development Scales to assess intellectual functioning to confirm the autistic diagnoses. The control group was matched with their ages and performance quotients from the Griffiths Mental Development Scales. Within this control group, two had significant communicative delays, one child was preverbal, six used one word utterances, two used two word utterances, one used phrases, and only two of the children had existing etiologies, which was Down syndrome for both of the children.

**Procedures:**
Parents of each of the participants underwent a Detection of Autism by Infant Sociability Interview (DAISI). These interviews, however, were conducted before the diagnostic procedures discussed above were administered. These interviews were given on the basis of a referral expressing that the child had a social-communicative disorder. CARS, the play-based assessment, the mental developmental scales, and the DSM-IV criteria for autism were then used in the diagnostic procedure after the interviews were conducted.

Results:
The two groups of participants were found to have highly significant differences in their mean scores for sociability within the DAISI. The mean for the group with autism was 3.6 out of a possible 19, and the mean for the developmentally delayed group was 15.7. There was no significant difference in the autistic group in the correlation between the CARS scores and the scores derived from the DAISI, but there was a significant negative correlation between the two scores for the control group. The items that showed differences between the two groups were categorized into 2 different classes: that of person-to-person communication, and interactions involving person-person-object (triadic interaction).

Conclusions:
The authors concluded that infants with autism manifest abnormal behaviors that are indicative of social engagement limitations. These behaviors were found to be distinctive in the group with autism, and were not found to be characteristic of general developmental delay. These behaviors of children with autism were found to be existent in both triadic and interpersonal interactions, and they were found to be present in both interactions containing positive and negative engagement. It was also reported that infants with autism produced less imitation, less desire to be comforted by parents, less interest in others, less joint attention, less eye contact, as well as less pointing and referencing.

Relevance to the current work:
This study has described specific deficits in engagement between a person-to-person interaction, as well as a person-person-object interaction, which are found to be in existence in children with autism before the age of 24 months. This study also adds to the notion of the importance to screen and diagnose autism at an early age, as there are behaviors that are manifested at early ages to do so.
Appendix B

Coding Manual

Definitions

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

Rules

1. Read the directions before coding.
2. When in doubt, don’t code.

Songs Coding Manual

- The start of a song activity begins when the clinician states that it is time to sing a song.
- The end of a song activity ends when there is a verbal bid to end the interaction
  - “We’re all done”
  - “Let’s play with a toy”
  - “Let’s do something else”
- Each time a child participates in a song activity, the behavior is coded. A child may:
  - Take a turn with assistance
    - A clinician uses hand-over-hand to help the child perform the appropriate action to a song (i.e. clapping to *If You’re Happy and You Know it Clap Your Hands*).
    - The child grabs the hands of the clinician as the clinician performs the appropriate action to a song.
  - Takes a turn without assistance
    - The child verbally sings along with the song
    - The child participates in the actions and gestures of the song by him/herself.
- Within the whole song segment, the child’s level of engagement should be coded. The child may demonstrate the following levels of engagement:
  - 1 – Fully Engaged:
    - The child is compliant
    - Child is on task
    - Child takes every turn unassisted and without prompt each time
  - 2 – Mostly Engaged:
    - The child demonstrates 5 or more instances of engagement
      - Taking a turn, assisted or unassisted
      - Eye contact with another human
    - Child may anticipate a turn
- Child is not off task for more than 2 seconds at a time
- Child does not act out

  3 – Moderately Engaged:
  - Child displays less than 5 instances of engagement
    - Taking a turn, assisted or unassisted
    - Eye contact with another human
  - Child may be passive in their turn-taking
  - Child has some indication of awareness
    - Clapping
    - Repetition
    - Echolalia
  - Child is compliant with assisted turns

  4 – Minimally Engaged:
  - Child is often off task
  - Child may be disruptive
  - Child may still demonstrate unassisted turns

  5 – Not Engaged:
  - Child is non-compliant
  - Routine could not be finished
  - The interaction is aborted

Some General Considerations for Songs
- If the child participates in a song with continuous actions, count as one turn.
- If the child intermittently participates in the actions of a song, code each point of participation as a separate turn
- If the child demonstrates an action in the song, but is delayed in doing so, it still counts as a turn.
- Count as a separate turn of assisted action each time the clinician takes her hands off the child and puts them back on for hand-over-hand assistance.
Songs Coding Manual

Amount of Time Song Segment Lasts: ______________________________________

The child participates either verbally or through gestures in a song activity.

** Takes a turn without assistance:** the child does an action on their own

Verbal: the child exhibits language during the song or greeting

Gestural: the child performs a gesture during the song or greeting

** Takes a gestural turn with assistance:** the child requires hand-over-hand support to complete the action

Level of engagement:

☐ 1 - Fully Engaged:
   Child is compliant, on task, takes every turn unassisted each time

☐ 2 - Mostly Engaged:
   Child takes a turn with, or without assistance, child may demonstrate anticipation for a turn, child is not off task for longer than 2 seconds, child does not act out, must display 5 or more instances of engagement (i.e. takes a turn assisted or unassisted, eye contact)

☐ 3 – Moderately Engaged:
   Child will have less than 5 instances of engagement (i.e. taking a turn with or without assistance, eye contact), child demonstrates some indication of awareness (i.e. clapping, echolalia, repetition, etc.)

☐ 4 – Minimally Engaged:
   Child is often off task, may be disruptive, but the child may or may not take an independent turn.

☐ 5 – Not Engaged:
   The child is non-compliant and the interaction had to be aborted
## Appendix C

### Raw Data

**LS’ Raw Data**

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### Table 5

**KR’s Raw Data**

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