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The Effects of Intervention Involving a Robot on Compliance of Four Children with Autism to Requests Produced by their Mothers

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ABSTRACT

The Effects of Intervention Using a Robot on the Levels of Compliance of Four Children with Autism to Requests Given by Their Mothers

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The current study presents the use of a humanoid robot to facilitate compliant behaviors to two types of directives in four children with autism. The children participated in a three-month intervention program that incorporated core components of the SCERTS model in order to facilitate social communication (Prizant, Wetherby, Rubin, & Laurent, 2003). Treatment sessions were comprised of 40 minutes of traditional treatment and 10 minutes of interaction with a humanoid robot. Pre- and post-intervention assessment were conducted, each involving a 5 minute interaction with the child's mother, in which they were presented with directives in the form of physical manipulation and verbal requests accompanied by a gesture or model. These pre- and post-intervention sessions were recorded, analyzed, and coded for compliant and non-compliant behavior to the directives, as well as any eye contact, language, or reciprocal action that accompanied their behavior. The overall results were variable, revealing that two participants made notable gains, one child remained consistent, and another participant showed a decrease in compliant behavior in the post-intervention sessions. Further research should be conducted to include a longer period of baseline and intervention, more systematic identification of the most effective probes for the child, and documentation of the child's physical and emotional state.

Keywords: Autism, Robots, Parent Interaction

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DESCRIPTION OF STRUCTURE AND CONTENT

The body of this thesis is written as a manuscript suitable for submission to a peer-reviewed journal in speech-language pathology. An annotated bibliography, a coding manual, a coding checklist for data collection, and the raw data used in this study are presented in Appendices A, B, C, and D respectively.

Introduction

Autism Spectrum Disorder (ASD) is a collection of pervasive developmental disorders that affect social interaction skills such as joint attention and social engagement. Recent research has shown that joint interaction skills may improve in young children with autism through a combination of traditional intervention paired with exposure to a robot during short segments (low-dose) of the intervention sessions. It has also been demonstrated that the targeted joint attention behaviors may generalize to more naturalistic contexts (Goodrich et al., 2012). The purpose of this study was to further examine the use of robots to aid in the development of joint attention skills in four children with ASD.

Definition and Characteristics of Autism

Autistic disorder is a lifelong developmental disability that affects the way a person communicates with and relates to people around them (Robins, Dautenhahn, Boekhorst, & Billard, 2004). Current views of autism consider it to be of neurogenic origin. In almost all cases it has a dramatic impact on family members (Prizant, Wetherby, Rubin, & Laurent, 2003). The prevalence rate of autism has recently increased dramatically. In 2000 the U.S. Department of Education reported that the number of children diagnosed with autism increased by 244% between 1993 and 1998 (Levy, Kim, & Olive, 2006). Autism is typically recognized and diagnosed at approximately two to three years of age with onset following a period of seemingly normal neurological and behavioral development (Campolo et al., 2008).

Autism is a behaviorally specified disorder. “Diagnosis relies on a clinician's intuitive feel for the child's social skills including eye-to-eye gaze, facial expression, body postures, and gestures” (Scassellati, 2007, pg. 553). The most noticeable and prevalent observed characteristic of autism, however, is the significant deficits in the quality of reciprocal social interaction and joint attention skills (Rapin, 1991). Children with autism typically do not spontaneously seek to share enjoyment, interests, or achievements with other people (i.e., not showing, bringing, or pointing out objects they find interesting). Deficient social or emotional reciprocity, such as actively participating in simple social play or games may also be present. Children with autism tend to prefer solitary activities, only involving others in activities to perform as tools to meet wants and needs. "Often an individual's awareness of others is markedly impaired" (American Psychiatric Association, 2000, "Autistic Disorder," Diagnostic Features section, para. 2). Autistic children typically avoid eye contact, pay less attention to human faces than they do to everyday objects, and often seem not to react when called by their name (Campolo et al., 2008).

Existing evidence suggests that the level of joint attention and symbolic play skills in young children with autism are predictive of their language abilities (Kasari, Freeman, & Paparella, 2006). Language comprehension is often delayed in autism, and the child may be unable to understand simple questions or directions (American Psychiatric Association, 2000).

"Motor impairments in autism include deficits in postural reflexes, repetitive, stereotyped movements and awkward patterns of object manipulation, lack of purposeful exploratory movements, gaze abnormalities, unusual gait pattern, and alterations of movement planning and execution, which express themselves as 'hyper-dexterity'" (Campolo et al., 2008, pg. 4875). The restricted and repetitive behaviors secondary to autism create a major barrier to learning and social adaptation. However, they have been found to evolve over time. According to Leekham (2011), these deficient motor behaviors and patterns have been shown to decrease with age and cognitive and language ability.

In summary, the fundamental feature of autism is the breakdown of reciprocal social interaction. The severity and character of this disorder varies with the child's age and developmental level (Rapin, 1991).

Joint Attention

As noted, a failure to develop joint attention is a primary deficit in children with autism. "Joint attention refers to the ability to coordinate attention between a person and an object for the purpose of sharing" (Gulsrud, Kasari, Freeman, & Paparella, 2007, pg. 536). The development of joint attention skills in infancy are thought to be important to later abilities in social learning (Vaughan Van Hecke et al., 2007). A young child's ability to consider the attentional focus of another and to draw another's attention toward objects and events of mutual interest is a foundation for the later development of language, social-conversational skills, and social relationships (Prizant et al., 2003).

Before the development of language, a child's capacity for joint attention motivates the ability to communicate not only for need-based instrumental purposes such as requesting or protesting, but also for more social purposes such as commenting to share observations and experiences and using gestures (Prizant et al., 2003). In addition to promoting the development of cognition and language skills, joint attention in infancy is positively correlated to the emergence of social and behavioral competence in later childhood (Vaughan Van Hecke et al., 2007).

"Children, especially those in the first year of life, develop the capability for social communication through physical and social interactions with their caregivers (e.g., mothers) and artifacts such as toys" (Kozima & Nakagawa, 2006, pg. 270). At the prelinguistic stages of language acquisition, joint attentional capacities include to orienting to a social partner, coordinating and shifting attention between people and objects, sharing and interpreting affect or emotional states, and ultimately, using gestures and vocalizations paired with physical contact or gaze to purposely communicate with another person (Prizant et al., 2003).

In typical children, joint attention appears with the development of intentional communication. Infants understand early in development that another person can be a means for the achievement of the infant's goal and that the infant can send signals that effect that person's actions (Bruinsma, Koegel, & Koegel, 2004). The development of child-caregiver interaction during the first year of life establishes the basis of an understanding of each other's mental states. With this foundation, the child is able to begin learning various social skills such as language use and cultural norms (Kozima et al., 2006). Deficits in these joint attention behaviors are among the most prominent features of autism.

Speech and Language Treatment for Children with ASD

In providing treatment to children with autism, there are numerous possibilities of approaches with regard to treatment technique, target behaviors, and overall goals. One goal in behavioral intervention may be to reduce restricted and repetitive behaviors, thus loosening rigidity, facilitating more flexibility, and reducing pervasive behavior patterns (Leekham, Uljarevic, & Prior, 2011). Another goal may be to increase the duration of the child's interaction or attention. This may be achieved through child-specific interactions involving social initiations and responding to others' initiations (McConnell, 2002).

Research suggests that interventions providing a stimulating environment and encourage alternative adaptive behaviors are more effective than interventions that contain only one of these aspects (Leekham et al., 2011). Woods and Wetherby (2003) found that naturalistic developmental therapy with children with autism may be superior to discrete approaches, as therapy given in a natural context was more efficient in the child generalizing core social and communication goals such as gaining independence, taking initiative, showing joint attention, and developing social and symbolic play. These are goals imperative to an autistic child's social and cognitive development. Discrete behavior therapy, on the other hand, could be more efficient in reducing ritualistic and obsessive behaviors (Francois, Powell, & Dautenhahn, 2009). When creating target goals, it is important to keep in mind that due to the variable nature of autistic disorder children may differ in their intervention needs (Bruinsma et al., 2004). Not every child benefits from a single treatment approach (Prizant et al., 2003).

Early intervention is critical to success in treatment. Recent research has found that early interventions for autism that include (a) a focus on a variety of areas including language, behavior management, social skills, etc., (b) were intensive and delivered over a substantial period of time, and (c) involved the children's parents provided the most gains in the child's development (Levy et al., 2006).

One such intervention technique that incorporates these criteria for effective treatments is the SCERTS Model. The SCERTS Model for intervention for children with autism has been carefully developed and found to be an extremely influential treatment strategy focusing on joint attention (Prizant et al., 2003). This model is not only based on current research, but it is flexible in incorporating different treatment methods, can be administered in an individualized manner, and is family-centered, taking into account differences across family priorities (Prizant et al., 2003). The SCERTS Model targets joint attention by breaking into three aspects for intervention: social communication, emotion regulation, and transactional supports (Prizant et al., 2003). This intervention technique aids in establishing and generalizing joint attention behaviors and provides support for family members as they interact with their child.

The most effective and beneficial intervention strategies target joint attention behaviors. According to Chiang, Soong, Lin, and Rogers (2008), interventions should place an emphasis on teaching children to monitor a significant adult's attention within the context of requesting situations and focus on basic dyadic play like turn-taking routines. When the adult partner is able to understand the child's level of social and communicative competence and know what behaviors are most likely to engage the child successfully in interaction, they prove valuable in facilitating dyadic interaction involving joint attention (Seibert, Hogan, & Mundy, 1982).

One major difficulty in treatment is the generalization of joint attention behaviors (Gulsrud et al., 2007). One of the most important goals of any early intervention program for children with autism is the ability to learn new skills and generalize these skills to different situations. Since joint attention is a major deficit in children with autism, the ability to learn and generalize these skills is imperative (Gulsrud et al., 2007). Gulsrud, Kasari, Freeman, and Paparella found that by violating established routines, children with autism were able to spontaneously reference the interventionists more and engage in shared looks in contexts outside of treatment sessions. Generalization may also be facilitated by providing treatment using a multi-clinician team approach, as it has been shown to provide improvements in social interaction (Goodrich et al., 2012).

The Use of Humanoid Robots in Intervention for Children with ASD

Recently, several studies have been conducted observing the effects of a robot on the joint attention skills of children with autism. Using a robot in therapy with children with autism has many educational, therapeutic, and practical potential benefits that motivate research. Unique to other therapy materials, a robot can be programmed and thus potentially be able to fulfill a number of roles in the context of autism treatment and education (Robins et al., 2004). It has been found that robots, when compared to simple toys, elicit a range of behaviors in children with autism that are more desirable in facilitating social communication in children with autism (Francois et al., 2009).

A humanoid robot may be defined as one that has been given human characteristics such as emotion and movement and features (Kozima et al., 2006). A formulated theory states that as a child with autism comes to understand that a humanoid robot perceives and acts as humans do, this knowledge tends to work as the motivating basis for children to explore and communicate with it (Kozima et al., 2006). The child may learn joint attention skills through these interactions with the robot and may generalize those learned behaviors into more naturalistic contexts.

A study conducted by Robins, Dautenhahn, Boekhorst, and Billard (2005) used a robot with human-like characteristics to show that “the approach of repeated exposure of the children to the robot over a long period, in a stress free environment, with a high degree of freedom, allowed the children, as hoped, to have unconstrained interactions, which facilitated the emergence of spontaneous, proactive, and playful interactions” (2005, pg.116). Not only did the child interact with the robot, but the robot mediated joint attention interactions with an adult.

In 2010, a team of researchers at Brigham Young University conducted a pilot study to determine the efficacy of utilizing a robot in treatment sessions of two children diagnosed with autism (Acerson, 2011; Goodrich et al., 2012; Hansen, 2011). Comparing data collected from pre- and post-treatment sessions revealed dramatically increased social behaviors in one child and moderate gains in the other (Goodrich et al., 2012). This pilot study suggested further research was warranted to explore the use of robots to increase social engagement in other children with autism (Acerson, 2011; Hansen, 2011).

Summary

The current study is part of an expansion of the pilot investigation conducted by Acerson (2011) and Hansen (2011). Using the same treatment protocols and humanoid robot, this investigation observed the pre- and post-treatment sessions of 4 children with autism. The data collected was previously used to examine social behaviors in a triadic interaction (Blanchard, 2012), interactions with a familiar adult (Stabenow, 2012), and interactions with an unfamiliar adult (Dodge, 2012). The purpose of this study was to examine the compliance shown and accompanying social engagement behaviors that the children produced in response to two types of directives issued by their mother in a highly interactive environment. The two types of directives given by the mother included physical manipulation to request an action or obtain the child's attention and verbal requests of an object or action using gestures and/or models.

Method

The current project aimed to further the research concerning the use of a humanoid robot as a treatment tool for joint attention skills in children with autism. The following methods were formulated to answer the question: Can a humanoid robot, when presented in low-doses within play-based therapy with children with autism, increase levels of compliance to physical and verbal requests presented by their mothers?

Participants

Four children, two male and two female, previously diagnosed with autism were included in this study. Each child exhibited severe deficits in social communication, joint attention, and language development. Further assessment was completed by graduate clinicians at the Brigham Young University Speech and Language Clinic. Informed consent part was provided by each child's parents before participating in this study. The case histories and individual assessments for each child are summarized in the following sections.

Participant 1: LS. LS was a 9:1 (year: month) year-old-male at the commencement of the study. LS was born in Japan and lived there with his family until the age of 4:5 years. After moving to the United States, LS began school at a specialized preschool for children with autism and then later enrolled in a specialty kindergarten. He lived with both of his parents as well as his five siblings. His father was employed and his mother worked in the home. English was the primary language spoken in the home. The following information was obtained through a parent report questionnaire and assessment in the clinic using formal and informal assessment measures.

At the time of the initial study, LS was able to communicate using a vocabulary of approximately 150 words. He exhibited some intentional communication by only relying on basic word combinations (e.g., , “I want…” to request an item). LS frequently produced echolalic speech utterances that were unclear with regard to communicative intent. LS showed deficits in emotional regulation and often became disregulated by environmental stimuli. When disregulated, LS exhibited self-injurious behaviors and/or aggressive behaviors to others. At times, LS performed appropriate reciprocal action in social interactions and exhibited eye contact. However, during the majority of social interactions observed at the clinic, this social connection was absent.

Participant 2: LR. LR was a 5:5 year-old male. At the time of the study, he was attending a specialty preschool designed for children diagnosed with autism. He lived with both of his parents and his five siblings. His father was employed and his mother worked in the home. English was the primary language spoken in the home. The following information was obtained through a parent report questionnaire and observation in the clinic through formal and informal assessment measures.

LR was non-verbal at the commencement of the study, though he exhibited non-variegated sound play. He demonstrated high levels of restrictive repetitive behaviors such as flapping his arms and tapping objects together. He also tended to fixate on these objects. Occasionally, LR used gestures to communicate, though he would mainly initiate interactions through requesting aid in obtaining a toy or item. He did show moderate levels of eye contact with positive affect during social interactions. However, he showed very little engagement in social interactions and required maximal support in participating in simple reciprocal play activities.

Participant 3: KR. KR was an 8:1 year-old-female. She lived with both of her parents as well as five siblings. English was the primary language spoken at home. Her father was employed and her mother worked in the home. KR had previously attended a specialty preschool designed for children with autism and was currently enrolled in a self-contained classroom for children with autism at a local elementary school. The following information was obtained through a parent report questionnaire and observation in the clinic through formal and informal assessment measures.

KR demonstrated limited communication skills, both socially and linguistically. She babbled and verbalized using jargon, but had a lexicon of only approximately 4 or 5 words. She made few attempts to initiate engagement by establishing eye contact while exhibiting positive affect. KR demonstrated affect typically through vocalizations, though the source of her positive affect was inconsistent. She often laughed or smiled; however, those around her could not determine the cause of her affective behavior. KR demonstrated negative affect by yelling or throwing items when others misinterpreted her communicative intent. In these instances of frustration, KR would self-regulate through the use of sensory and sometimes self-injurious behaviors such as biting her hand or fixating on and manipulating specific toys or items. KR frequently seemed to require physical closeness to those around her, as she often attempted to sit on, lie on, or hug the clinicians.

Participant 4: AH. AH was a 4:11 year-old-female living with both her parents. AH did not have any siblings. Both of her parents were employed outside of the home and primarily spoke English. At the commencement of the study, AH was attending a specialty preschool for children with autism. The following information was obtained through a parent report questionnaire and observation in the clinic through formal and informal assessment measures.

AH was non-verbal, though she produced minimal verbal vocalizations and approximations and inconsistent sound play. She was able to produce some signs but usually required a visual prompt or model to produce the signs that were appropriate. AH demonstrated restrictive repetitive behaviors such as flapping her hands. AH exhibited basic symbolic play skills with specific toys, such as feeding a baby doll with a bottle. AH did not, however, expand these actions into more complex symbolic play. She frequently became frustrated or dissatisfied and demonstrated negative emotional outbursts. AH had difficulty self-regulating and often cried and sought external, tactile regulation as an expression of her emotions. Such tactile regulatory needs included hugs from her mother or clinician and being squished in a bean-bag chair. AH showed limited initiation of social interaction. To express wants and needs, AH would either cry or physically manipulate others without eye contact. AH rarely established eye contact, share affect, or attempt to engage the clinicians in a shared experience.

Procedures

As previously discussed, this study is an expansion of a study previously conducted by Acerson and Hansen in 2011. This study is also part of a larger investigation utilizing a single subject multiple baseline design. Each child was assigned 3, 4, 5, or 6 baseline sessions. Following the baseline observations, each child participated in 20 50-minute treatment sessions, some comprising of 40 minutes of traditional treatment and 10 to 15 minute interactions with a humanoid robot. Within the 20 treatment sessions, the participants were each allotted different numbers of complete traditional treatment sessions and treatment sessions that included time interacting with the robot. Following the treatment sessions, each child participated in three follow-up sessions. A summary of the distribution of therapy sessions assigned to each participant is presented in Table 1. Each child was paired with a graduate clinician who provided therapy during portions of the baseline, follow-up, and treatment sessions. An assisting graduate clinician was also present to provide additional support during portions of the baseline, follow-up, and treatment sessions with the humanoid robot.

Table 1

Number of Each Session Types Assigned to Participants

	Participant			
Session Type	LS	LR	KR	AH
Baseline	4	6	5	3
Traditional Treatment	4	6	5	3
Treatment with Robot	16	14	15	17
Follow-Up	3	3	3	3

Baseline and follow-up sessions. Each participant was involved in a varying number of 50-minute baseline sessions. The baseline sessions aimed to establish the child's level of social engagement skills before beginning intervention. Baseline sessions involved various play activities targeting joint attention skills. Each baseline was structured as follows, in variable sequence: (a) a triadic interaction between the child, graduate clinician, and assisting graduate clinician, including four activities with a ball, a car, a musical toy, and a tambourine, (b) an interaction with a familiar adult with the graduate clinician assigned to that particular participant, including six activities with a baby doll and food, a baby doll and a blanket, a push-car, a ball, wind-up toys, and two songs, (c) an interaction with an unfamiliar adult with an adult the child had not met, including the six previously named activities, and (d) a parent interaction.

The current study focuses on the effects of the parent interaction baseline and follow-up segments only. To introduce the parent interaction, the graduate clinician set out various toys such as books, blocks, stuffed animals, a play house, a farm house, etc. The parent was introduced into the therapy room where the child was waiting. The graduate clinician then left the therapy room for approximately 5 minutes to allow the parent and child to interact naturally, as they would at home. After 5 minutes, the graduate clinician again entered the room, ending the parent interaction. After completing the allotted number of baseline sessions, and the 20 treatment sessions, each child participated in three follow-up sessions. The follow-up sessions were identically structured to the baseline sessions.

Traditional treatment. Each participant took part in various numbers of traditional treatment sessions, each lasting 50 minutes long. Traditional treatment sessions consisted of interactive, play-based therapy as outlined by the SCERTS Model (Prizant et al., 2003). Treatment goals focused on increasing expressive language, improving play skills through symbolic play, and improving social interaction skills such as frequency of eye contact, initiating activities, and turn-taking (Acerson, 2011; Hansen, 2011).

Treatment with a robot. After completing the set number of traditional treatment sessions, each child began their treatment sessions involving interaction with a humanoid robot. These sessions consisted of 40 minutes of traditional therapy and 10 to 15 minutes of robot interaction. The placement of the robot interaction within the session was systematically varied from the beginning, middle, and end of the session. When it came time for the robot interaction, the child and graduate clinician moved into a different therapy room where the robot was situated on the floor.

The humanoid robot used in the study was created by a team of graduate students in the Brigham Young University Mechanical Engineering and Computer Science departments. The robot, called Troy, was designed to be the same size as an average 4-year-old child. Troy was 63.5 centimeters tall with two arms 30.48 centimeters long (Acerson, 2011; Hansen, 2011). Each arm was able to raise and lower, and adduct and abduct. Troy’s arm movements also consisted of medial rotation of the forearms and flexion and extension of the elbows (Goodrich et al., 2012). Troy's face was a 17.78-centimeter computer screen that could be programmed with facial emotions such as happy, sad, and neutral (Acerson, 2011; Hansen, 2011). A speaker attached to the torso allowed Troy to produce previously recorded speech and songs. Troy was connected to a computer for programming and was controlled by clinicians using a Wii™ remote (Acerson, 2011; Hansen, 2011). Troy was designed to facilitate reciprocal interactions through promoting turn-taking and imitation behaviors (Goodrich et al., 2012).

Each therapeutic interaction with Troy consisted of a quadratic interaction with the participant, the participant's parent (mother), the graduate clinician, and Troy. The assisting graduate clinician was also present, providing support to the child with hand-over-hand manipulation and modeling. The participants were seated across from Troy with the graduate clinician and parent seated on opposite sides. The assisting graduate clinician sat behind the child. The interaction began with an exchange of greetings and waves between the graduate clinician, Troy, and the child. Further interaction with Troy focused on group activities targeting turn-taking procedures with an object such as a ball, push-car, or musical instrument, and singing songs with actions. At the end of the allotted interaction time, each person said good-bye to Troy while waving.

Videotaping procedures. Each session was recorded using two different cameras. One camera was a stationary, being mounted on the wall of the therapy room. An undergraduate and graduate clinical assistant were able to control this camera from a supervisory room. This camera allowed observation of the participant's gross motor movements around the room, as the camera swiveled to follow their position as well as the position of the interaction partner(s). The second camera was a hand-held camera held by a clinical assistant in order to capture close-up footage of the child’s face. The footage of the two cameras were synced together and viewed side-by-side using Final Cut Pro Express™ to be used to code the child’s exhibited social behaviors.

Data Analysis

Each child’s exhibited behaviors of social engagement were analyzed through careful viewing of the acquired baseline and follow-up video data synced together with Final Cut Pro Express™. The analysis consisted of coding the child’s behavior and determining reliability between coders. For the purposes of this study, only the data concerning the directives given by the mothers and the child’s compliance patterns in the baseline and follow-up sessions were used and compared.

Coding. Each baseline and follow-up session was analyzed by looking at each child’s responses to the directives given by their parent over the 5 minute interaction. Directives given by the parent that were included in this analysis consist of those given after the door completely closes to those given just before the initial sounds of the keypad to open the door.

Two types of directives were analyzed. First, physical manipulation was looked upon as a type of non-verbal directive. The probe was identified as the mother physically manipulating the child is some way to obtain their attention, direct their attention to some activity, do prevent them from doing an action, etc. A verbal cue was not necessary to count physical manipulation as a directive probe. The child may either comply or not comply with this type of directive. Behaviors accompanying these directives, such as eye contact, language, or reciprocal behavior, were noted during analysis.

The second type of directive coded in this analysis was a verbal request of an object or action with a gesture or model. The probe was identified as the mother gesturing while making a request to the child. The verbal directive by the mother had to have been given simultaneously with a gesture or model or it was deemed an invalid probe. The child again may either comply or not comply with this probe. Similar to the physical manipulation probe responses, careful observation of any accompanying behaviors consistent with joint attention were noted. Detailed guidelines for coding this data and analyzing responses are included in the Coding Manual in Appendix B.

Reliability. Three graduate clinicians were trained in the coding analysis system and inter-rater reliability was established for each observed probe and exhibited behavior. One clinician's analysis served as the standard with which the other clinicians established reliability. Before initiating data analysis, inter-rater agreement of 10% of the data collected per child was established between the standard coder and the two other coders. Therefore, a total of 3 randomized sessions were coded reliably before beginning data analysis. Table 2 provides information regarding the percentage of agreement of the two coders with the standard coder.

Table 2

Established Reliability Between Standard Coder and Others (1, 2)

	Coder 1	Coder 2
Session 1:	97%	95%
Session 2:	90%	97%
Session 3:	100%	98%

Results

The purpose of this study was to identify instances of compliance and non-compliance from children with autism in response to spontaneous directives given by their mothers before and after sessions of intervention involving low-dose exposure to a humanoid robot. Specifically analyzed were the child's level of compliance to physical manipulation and verbal requests involving a gesture or object, as well as any co-occurring behavior such as language, eye contact, and reciprocal actions. The frequency of the child's compliance behaviors was tallied in pre- and post-treatment sessions through video analysis. The following is a summary of each child's performance during the assessments.

Participant 1: LS

LS participated in four baseline and three follow-up sessions, with each session involving directives given by his mother in the form of either physical manipulation commands or verbal directives with a gesture or model. A summary of LS's compliance behaviors to each type of directive given by his mother are outlined in Figures 1 and 2.

In the baseline sessions, LS exhibited an average of 5 compliances and an average of 1.7 non-compliances to physical manipulations from his mother. LS did not display any instances of language or eye contact in either compliance or non-compliance to physical manipulation in these sessions. In the follow-up sessions, LS displayed an average of 11.3 compliances to physical manipulation, with an average of 4 instances of language. He did not display any instances of eye contact with his compliant behavior to physical manipulation. LS also exhibited an average of 2 non-compliances to physical manipulations from his mother in the follow-up sessions. He did not display any instances of language or eye contact accompanying his non-compliant behavior to physical manipulation in the follow-up assessments.

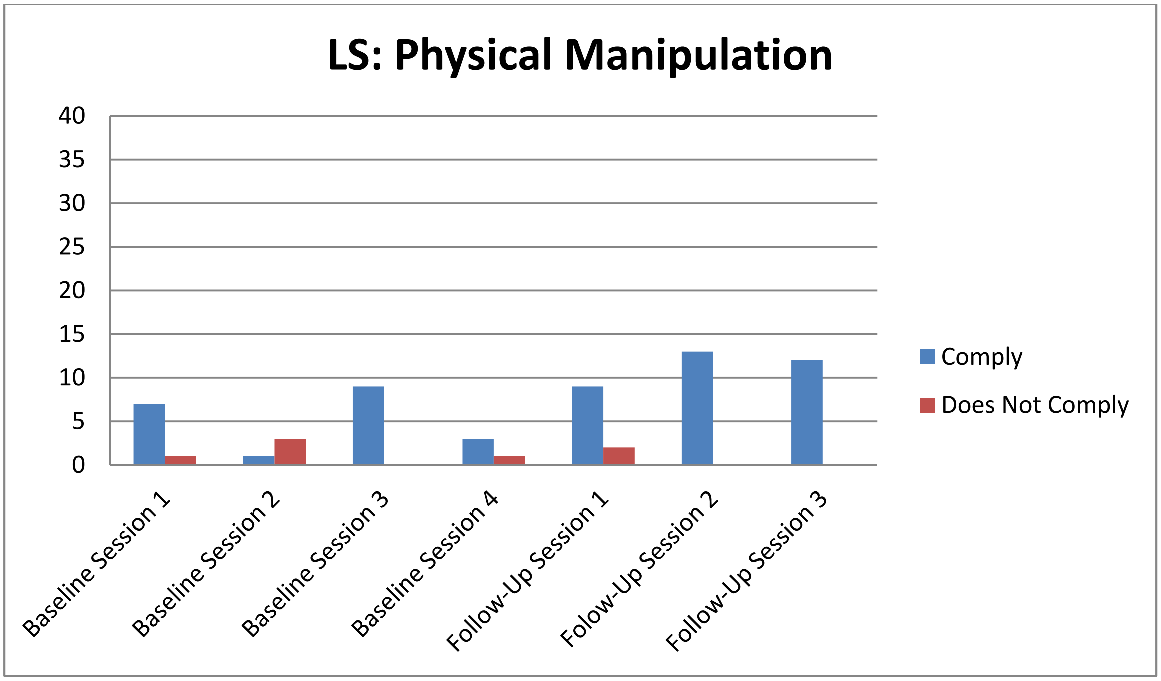

Figure 1 Participant 1, LS – Baseline and Follow-Up compliance behaviors in response to physical manipulation.

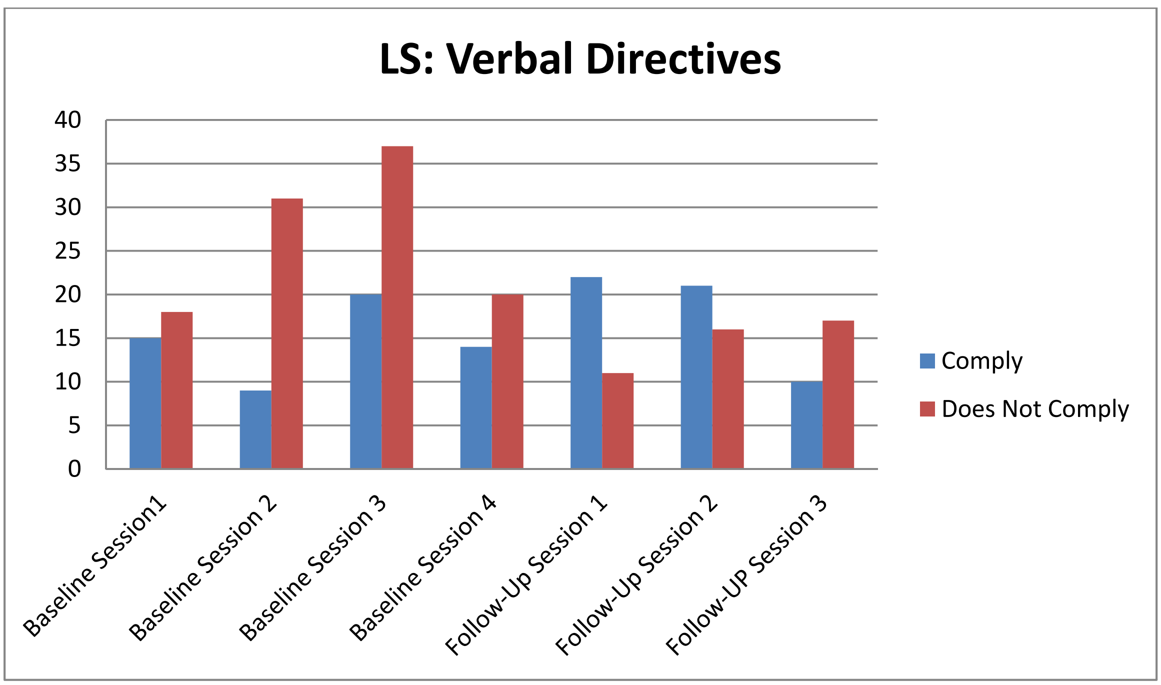

Figure 2 Participant 1, LS – Baseline and Follow-Up compliance behaviors in response to verbal directives with a gesture or model.

With regard to the verbal directives, in the baseline sessions LS exhibited an average of 14.5 compliances and an average of 26.5 non-compliances to verbal directives accompanied by a gesture or model from his mother. In complying to verbal directives, LS displayed an average of 4.3 instances of language and an average of 1 instance of eye contact. LS displayed an average of 2 instances of language and 1 instance of eye contact while exhibiting non-compliant behavior to his mother's verbal directives in the baseline sessions. In the follow-up sessions, LS exhibited an average of 17.7 compliances to verbal directives with a gesture or model from his mother, with an average of 6.7 instances of language. He also displayed an average 14.7 non-compliances, as well as an average of 1 instance of language, in response to verbal directives from his mother. He did not display any instances of eye contact in response to verbal directives given by his mother. LS exhibited no instances of reciprocal action over the course of his baseline or follow-up sessions.

Participant 2: LR

LR participated in six baseline sessions and five follow-up sessions. A summary of LR's performances in the physical manipulation and verbal directive categories are displayed in Figures 3 and 4 respectively.

Over the six baseline sessions, LR exhibited an average of 16.2 compliances to physical manipulation directives from his mother. He displayed an average of 2.3 instances of eye contact accompanying his compliant behavior. LR did not comply to physical manipulations on an average of 1.3 instances, with an average of 1 instance of eye contact. He exhibited no instances of language in accordance to physical manipulations from his mother during his baseline

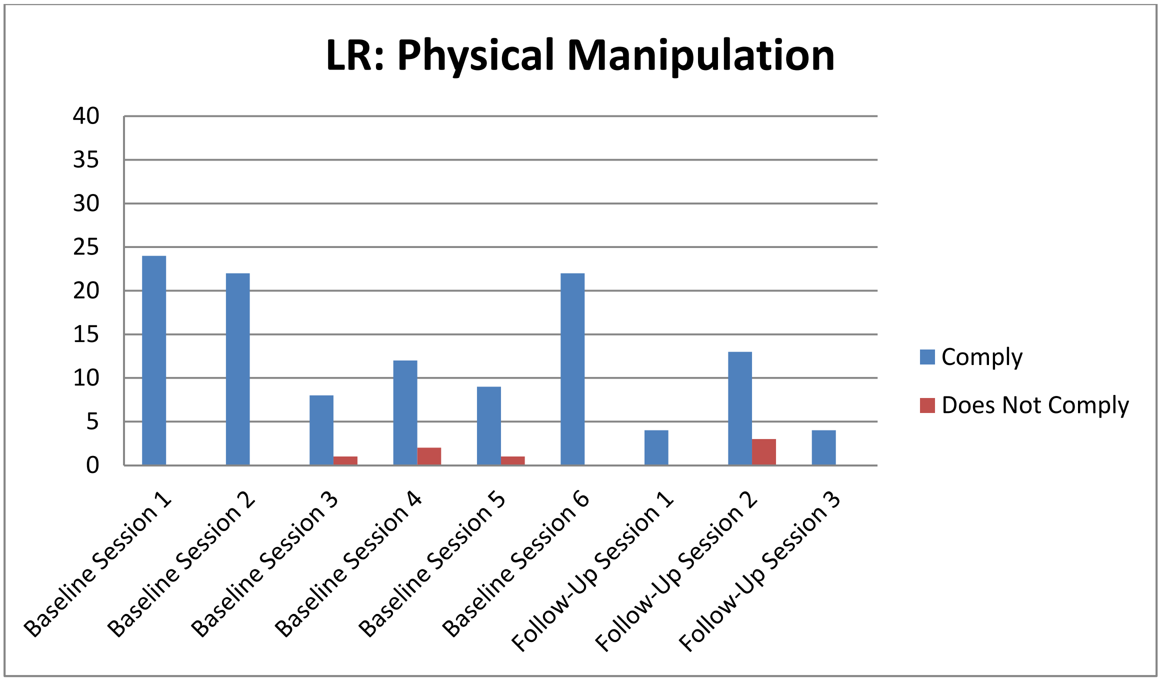

Figure 3 Participant 2, LR – Baseline and Follow-Up compliance behaviors in response to physical manipulation.

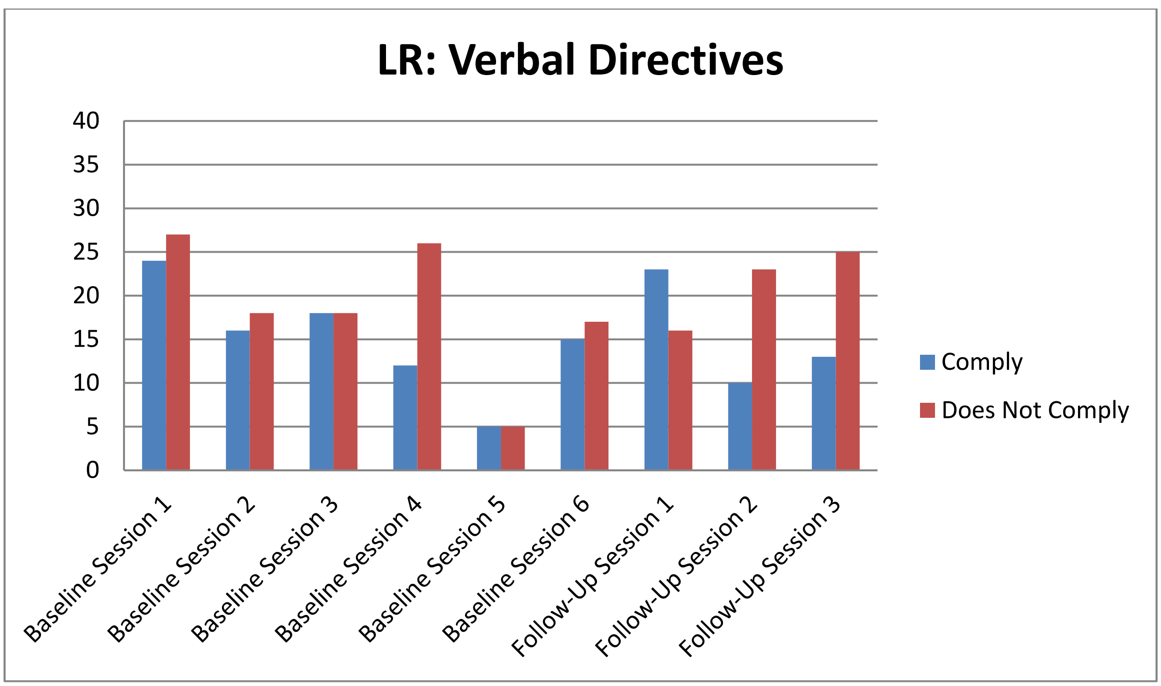

Figure 4 Participant 2, LR – Baseline and Follow-Up compliance behaviors in response to verbal directives with a gesture or model.

sessions. According to data collected from the follow-up sessions, LR demonstrated an average of 10.3 compliant responses to physical manipulation, as well as an average of 2 instances of eye contact. No language was observed in compliant behavior to physical manipulation. He also exhibited an average of 3 non-compliant responses to physical manipulation. No eye contact or language was observed in non-compliant behavior in response to physical manipulation from his mother in the follow-up sessions.

In compliance with verbal directives with a gesture or model, LR displayed an average of 15 compliant responses with an average of 2 instances of eye contact over the course of the baseline assessments. LR exhibited an average of 18.5 non-compliances with 1.7 instances of eye contact. Again, LR did not show any language accompanying his behavior following a verbal directive. Over the follow-up procedures, LR displayed an average of 15.3 compliant responses with an average of 2 instances of eye contact accompanying the response. LR did not comply on an average of 21.3 instances with an average of 1 instance of eye contact. Language was not observed in his compliant or non-compliant responses to verbal directives with a gesture or model. LR did not exhibit any instances of reciprocal action over the course of his baseline or follow-up sessions.

Participant 3: KR

KR participated in five baseline and three follow-up sessions. A summary of KR’s performance in the physical manipulation and verbal directive categories is displayed in Figures 5 and 6 respectively.

In the baseline sessions, KR showed compliant behavior to physical manipulation from her mother on an average of 6.2 directives, with an average of 1 instance of eye contact and an average of 1 instance of language. She did not comply to directives manifested in the form of physical manipulation on an average of 2.4 instances, with an average of 2 instances of language

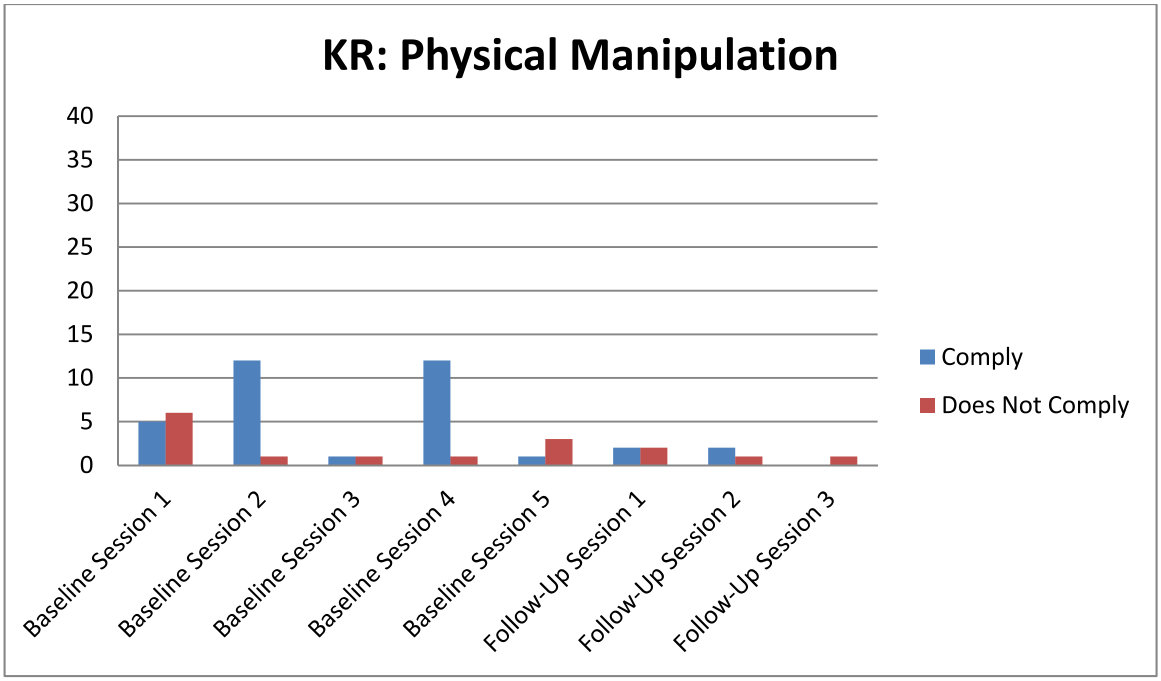

Figure 5 Participant 3, KR – Baseline and Follow-Up compliance behaviors in response to physical manipulation.

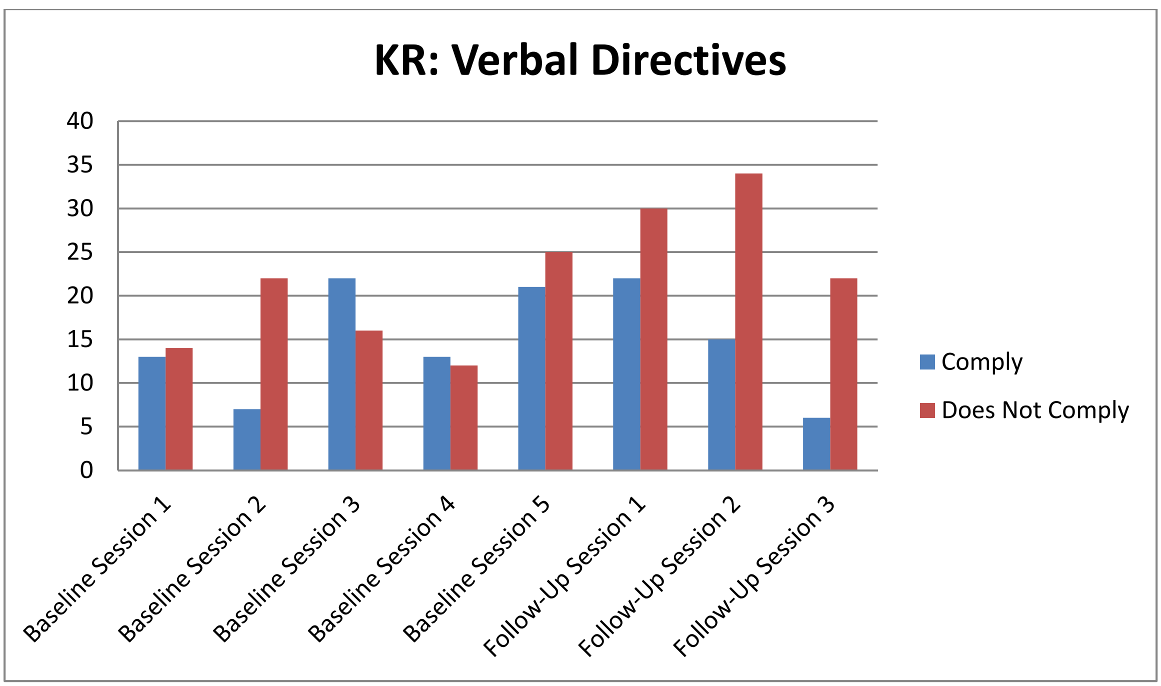

Figure 6 Participant 3, KR – Baseline and Follow-Up compliance behaviors in response to verbal directives with a gesture or model.

over the five baseline assessments in which she participated. KR did not show any instances of eye contact in non-compliant behavior to physical manipulation. Over her three follow-up sessions, KR displayed compliant behavior for physical manipulation from her mother on an average of 2 instances, and non-compliant behavior from physical manipulation on an average of 1.3 instances with an average of 1 instance of eye contact per session. Language was not observed in either compliant or non-compliant behavior in response to physical manipulation directives.

Baseline data showed that KR exhibited an average of 15.2 compliant responses to a verbal directive with a gesture or model presented by her mother, with an average of 5 instances of language and an average of 3 instances of eye contact. She did not comply to verbal directives in an average of 17.8 opportunities, with an average of 1 instance of language and an average of 1.3 instances of eye contact. When presented with a verbal directive with a gesture or model in the follow-up sessions, KR exhibited an average of 14.3 compliant responses with an average of 2 instances of language. She displayed an average of 28 non-compliant responses in response to verbal directives with a gesture or model from her mother, with an average of 1 instance of language. KR did not exhibit any instances of eye contact in response to verbal directives. She also did not exhibit any reciprocal action over the course of her baseline or follow-up procedures.

Participant 4: AH

AH participated in three baseline and three follow-up sessions. A summary of AH's performance in the physical manipulation and verbal directive categories is outlined in Figures 7 and 8 respectively.

Over the course of her three baseline assessments, AH showed an average of 5.3 compliant responses to physical manipulations from her mother. She did not demonstrate any instances of language or eye contact. Also, she did not show any non-compliant behavior to

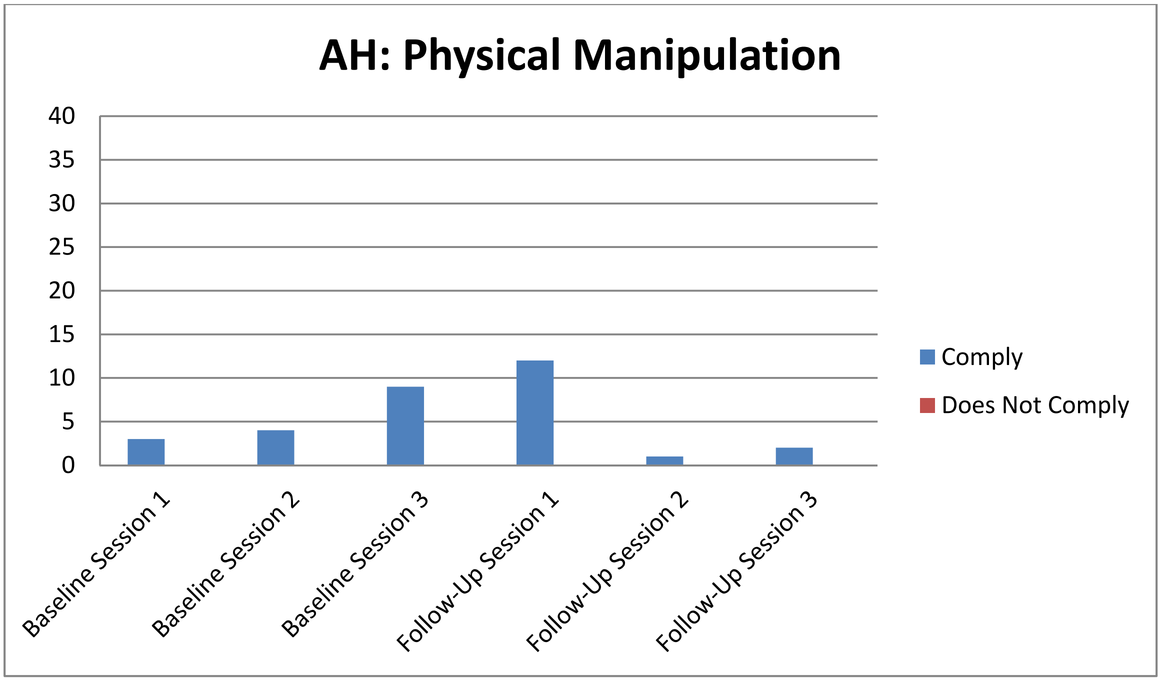

Figure 7 Participant 4, AH – Baseline and Follow-Up compliance behaviors in response to physical manipulation.

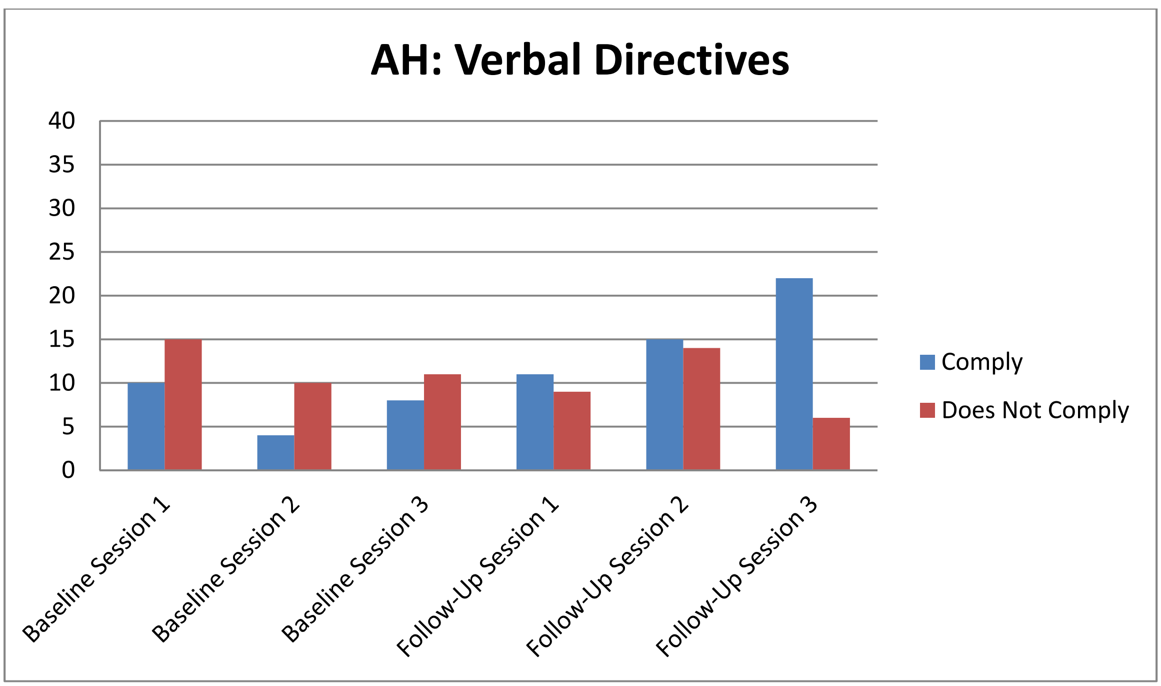

Figure 8 Participant 4, AH – Baseline and Follow-Up compliance behaviors in response to verbal directives with a gesture or model.

physical manipulation during her baseline sessions. In her three follow-up sessions, AH exhibited an average of 5 compliances to physical manipulation from her mother, and did not exhibit any non-compliant behavior in response to physical manipulation. She did not produce any language or instances of eye contact following this type of directive in these sessions.

AH complied on an average of 7.3 instances to verbal directives with a gesture or model but did not display any language or eye contact in her baseline assessments. She also exhibited an average of 12 non-compliant responses to verbal directives, again with no instances of eye contact or language. Throughout the follow-up procedures, AH produced an average of 16 compliant responses, with an average of 1.5 instances of language and an average of 1 instance of eye contact. AH displayed an average of 9.7 non-compliant responses to verbal directives from her mother, with no instances of eye contact or language. Again, over the course of her baseline and follow-up sessions, AH did not display any reciprocal action in response to either physical manipulation or a verbal directive with a gesture or model.

Discussion

This project was part of a larger investigation to examine the impact of intervention utilizing low doses of a humanoid robot on the social interactions of four children with autism. This particular study focused on compliance to physical and verbal directives issued by the mothers to their children. Each mother-child dyad participated in pre- and post-intervention sessions. These sessions were analyzed and coded for compliant and non-compliant responses from the children in response to directives involving either physical manipulation or verbal directives with either a gesture or a model. Instances of eye contact, language, and reciprocal action were also noted when accompanied the child’s response.

Evaluation of Results

Each of the four children in this study presented with severe deficits in social engagement and communication. The following discussion further evaluates the behaviors observed during the pre- and post-intervention sessions and the different effects that low-dose humanoid robot intervention had on the children regarding compliant behaviors in response to directives in the form of physical manipulation and verbal requests with a gesture or model.

Physical manipulation. Physical manipulation was probed when the children were engaged in a physical manner by their mothers. This physical engagement could have included tapping to gain attention, physically leading the child toward an activity, or manipulating their body in order to facilitate attention to a task. As expected, the results for each child were highly variable. Some children appeared to respond more favorably to the intervention than others in terms of complying to directives in the form of physical manipulation. Two out of the four children appeared to make gains in compliant behavior in response to physical manipulation from their mother. LS showed the greatest improvement in positive compliance to physical manipulation, and KR also showed relative improvement in exhibiting a decrease in non-compliant behavior. The other two participants appeared to make no gains, with one of the children showing a decrease in performance. AH was consistent in her compliant and non-compliant responses over the pre- and post-intervention sessions, and appeared to make neither positive nor negative gains in response to physical manipulation by her mother. LR's compliance in the post-intervention sessions appeared to decrease and with a corresponding increase in non-compliant behavior in response to physical manipulation directives. This decrease may have been in part due to the fact that in the post-intervention sessions he did not have as many opportunities to respond to physical manipulation, as his mother presented the probe fewer times than in the pre-intervention sessions. A possible reason for this decreased number of probes in these sessions was that LR appeared to show improved attention to the task at hand, and physical manipulation to get him to do so was unnecessary.

The instances of eye contact that accompanied either compliant or non-compliant behavior in response to physical manipulation appeared to remain consistent across all four of the children participating in this study. None of the children made notable gains or losses in achieving eye contact during a physical manipulation directive. However, it is important to note that the current study did not directly target eye contact abilities in intervention, as the focus was on improving the children's abilities to communicate socially and follow simple directives in a naturalistic play setting.

Results were variable in the area of language gains in response to physical manipulation. LR and AH did not display any instances of language over the course of the pre- and post-intervention sessions in response to physical manipulation. KR showed a decrease in language performance in the post-intervention sessions accompanying her responsive behavior to physical manipulation. LS, however, showed significant gains in instances of language in response to physical manipulation as observed in the follow-up sessions.

It is not possible to make definitive statements as to whether the use of the robot in the intervention produced the gains or decreases observed. It is interesting, however, to note the associated effects, such as changes in language and eye contact, that took place during the intervention.

Verbal directives with a gesture or model. In both the pre- and post-intervention sessions, each of the children was exposed to many verbal directives from their mothers. Many of these directives were accompanied by either a gesture or a model. Again, each child responded differently to treatment, and the results varied between the children. Two of the four children, LS and AH, showed positive gains in compliant behavior and decreased non-compliant behavior towards verbal directives with a gesture or model. LR, while showing relatively consistent compliant behavior in both the pre- and post-intervention assessments, showed a slight increase in non-compliant behavior in response to verbal directives in the post-intervention sessions. KR was the only one out of the four children who showed a general decrease in compliant behavior and an increase in non-compliant behavior in the post-intervention assessments.

Instances of eye contact were also noted while observing compliant or non-compliant behavior in response to verbal directives accompanied by a gesture or model. Two out of the four children showed decreased instances in eye contact in the post-intervention sessions, and one child showed no change. AH demonstrated a slight increase in instances of eye contact, going from no instances of eye contact in baseline to one occurrence in the follow-up sessions. In her baseline observations, AH did not exhibit any instances of eye contact. She did demonstrate one instance of eye contact over the course of her follow-up sessions. It is difficult to attribute this difference in joint attention behavior to the effects of the intervention. Considering AH's emotionality and aversion to socially engaging others, however, even one instance of eye contact was of note.

Instances of language were also observed as they accompanied responses to verbal directives with a gesture or model. One child, KR, showed decreased language use in her post-intervention sessions. LR remained consistent in his language abilities, making neither gains nor setbacks. She began treatment showing no signs of verbal language and continued on without the use of words throughout the sessions. Two participants, LS and AH showed improvement in their language skills in response verbal directives. While LS's gains proved only slight, AH's improvement was more notable because of her increased use of sign language in response to verbal directives with a gesture or model. In the baseline sessions, AH did not use any language, while in the follow-up sessions she produced two instances of sign language. Her use of sign language was appropriate in context of the request and appeared to greatly facilitate the naturalistic play interaction with her mother. Again, the goals of the intervention presented in the current study were less directed at language per se and more focused on responsiveness to directives. However, it is interesting to note the improvements observed in related behaviors such as language and eye contact.

Suggestions for Further Research

Several limitations and complexities observed in this study spurned a few suggestions for future research.

First, it would be beneficial if the intervention could begin with a longer baseline period. Rather than a few more sessions, however, a notably longer period of traditional intervention would be ideal. This would allow a more thorough understanding of the child's behavior and a more complete understanding of the child's specific needs. It would also allow the children and clinicians more time to adjust to one another and to the intervention context. As observed in this study, it took considerable time for the children to become comfortable with the intervention and to adjust to their clinicians. This may have limited potential gains.

In accord with the previous suggestion, a second recommendation for future research would be to conduct low-dose robot exposure in intervention with children with autism over a longer period of time. According to Levy, Kim, and Olive (2006), children with autism appear to be more likely to benefit from interventions that are intensive and last at least a year. The intervention in this study was carried out over the course of a few months. Longer duration of this type of therapy would allow more confidence in the observed outcomes, whether they were positive or negative. Taken together with the first suggestion, it may be the case that more time to adjust to the clinician and the intervention, and a longer period of intervention, would produce better outcomes across a range of targeted behaviors. At the same time, a failure to produce gains would be a stronger indication that the intervention was not likely to produce meaningful changes.

A third suggestion to increase would be to determine the type and frequency of probes that are most effective for a child, and then train the mother to specifically produce those probes. This would be likely to increase the efficiency of interaction with the child in general. It would also be likely to make the probes easier to code. In the current study, at times it was difficult to identify appropriate probes produced by the mother. There were also questions as to what constituted a request in the form of physical manipulation as opposed to simple touches. Additionally, it was difficult to differentiate between probes for verbal requests involving gestures or models and simple gestures such as holding out a toy. Providing more structure for the mother as to what types of directives to give the child would make identification of these specific types of request probes more accurate and would make the number of compliant or non-compliant responses more accurate.

Finally, by documenting the child's physical and emotional states on each day of intervention, it will be possible to get a better indication of how these factors affect the participant's performance in therapy. For example, in the current study, LR was at times ill or exhausted from a long day at his school. This impacted therapy progress in many ways, as he was lethargic and unwilling to participate in many of the activities. Thus, physical/emotional status almost certainly impacted performance on a range of measures, including compliance to his mother's requests. Another example of how documentation of physical/emotional state could be beneficial was observed in interactions with AH. AH, as previously mentioned, had difficulty with emotional regulation, and spent many of the initial sessions crying and not participating in therapy activities. Again, this likely hindered gains she may have shown had she been more regulated on those days. It is important to see how these behaviors impact the child's performance in therapy. If these physical and emotional states could be documented, a better picture of the child's performance throughout the course of low-dose exposure to a humanoid robot might have been obtained.

Summary and Conclusion

The focus of the current study was to measure the effects of utilizing a humanoid robot in autism therapy on compliance behaviors to two categories of directives. During pre- and post-intervention sessions, four children with low-functioning autism were given opportunities to comply with directives in the form of physical manipulation and verbal directives accompanied by a gesture or model. The overall results showed that two participants made notable gains, one child remained consistent, and another participant showed a decrease in compliant behavior in the post-intervention sessions. Further research should be conducted to include a longer period of baseline and intervention, more systematic identification of the most effective probes for the child, and documentation of the child's physical and emotional state.

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Appendix A

Annotated Bibliography

Acerson, A. (2011). ***The effects of the use of a robot during intervention on joint attention in children with Autism*** **(Unpublished master's thesis). Brigham Young University, Provo, Utah.**

Purpose of the study: This study examined the use of a humanoid robot in therapy with children with autism. The investigators examined whether or not two children with autism displayed generalization through increased social engagement with a human communication partner after the use of the robot in therapy.

Method:
Participants: Two male children identified with autism were selected to participate in this study. Both children were currently receiving services at the Brigham Young University Speech and Language Clinic and were identified with moderate to severe language delay, severe deficits in social and communicating function, and limited joint attention behaviors.

Procedures: Incorporated into the two children's regular treatment sessions was a 10-15 minute interaction with a humanoid robot named Troy. The robot was introduced to each child and the clinician then engaged the child in a series of reciprocal games and activities involving the robot, the clinician, the child, and a parent whenever available. Assessments for this study included a child-parent play assessment, a child-clinician play assessment, an unfamiliar adult play assessment, and a triadic interaction assessment. The researchers collected pre- and post-treatment data. This investigation only focused on the child-parent play assessment and the child-clinician play assessment.

Results: Participant 1 demonstrated a decrease of all target behaviors in the child-parent post-treatment assessment except eye contact in responding to engagement. Eye contact increased for this child in the post-treatment child-parent interaction assessment. In the child-clinician post treatment assessment, participant 1 demonstrated a decrease in emotional affect in initiating engagement and in imitation in responding to engagement.

Participant 2 showed dramatic increases in frequency and duration of behaviors in initiating engagement and responding to engagement during post-treatment assessments. He also showed a marked decrease in the frequency and duration of behaviors of non-engagement during post-treatment assessments.

Conclusions: Both subjects benefited from the use of a humanoid robot during treatment, as they demonstrated clinically relevant changes in behaviors. This investigation suggests that a low-dose treatment that emphasizes interaction involving the robot as well as other human communicative partners may be beneficial to some children with autism.

Relevance to the current work: The current work is an expansion of this study using four participants instead of two. This research provided information as to the design and methodologies of the treatments implemented in the current study.

American Psychiatric Association. (2000). ***Diagnostic and statistical manual of mental disorders – Fourth edition – Text revision (4th test rev. ed.*** **). Washington, D.C.: American Psychiatric Association. Retrieved from http://dsm.psychiatryonline.org/content.aspx? bookid=22&sectionid=1888402#7549**

Purpose of work: The American Psychiatric Association provides the diagnostic framework for Autistic Disorder. It is according to these DSM IV standards that individuals are given the diagnosis of Autistic Disorder.

Summary: A person receiving a diagnosis of Autistic Disorder must have a qualitative impairment in social interaction, as observed by at least two of the following: impairment in the use of various nonverbal behavior such as eye gaze, facial expression, body postures, and gestures for regulating social interaction; lack of development of peer relationships; failure to spontaneously seek to share enjoyment, interests, or achievements with others; a lack of social or emotional reciprocity. The individual must also have impairments in at least one of the following: delay in/lack of the development of spoken language; if verbal, a marked impairment in the ability to initiate and sustain a conversation with others; repetitive use of language or idiosyncratic language; no varied, spontaneous make-believe or social imitative play. Finally, to make the diagnosis of Autistic Disorder, the individual must present with restricted repetitive and stereotyped patterns of behavior, interests, and activities, as seen by at least one of the following: consuming preoccupation with one or more stereotyped and restricted patterns of interest that is abnormal in either intensity or focus; inflexible adherence to specific, nonfunctional routines or rituals; repetitive motor mannerisms; persistent preoccupations with parts of objects.

The individual receiving the diagnosis must also have delays or abnormal functioning in at least one of the following areas before the age of 3 years: social interaction; social language; symbolic or imaginative play. The pervasive disorders, if not already accounted for by Rett's Disorder or Childhood Disintegrative Disorder, may then be classified as secondary to Autistic Disorder.

Conclusions: The primary characteristic of Autistic Disorder is the presence of impaired development in social interaction and communication.

Relevance to the current work: As the subjects of the current work have all received clinical diagnoses of Autistic Disorder, this article is useful in understanding the characteristics and criteria of the disorder.

Bakeman, R., & Adamson, L. B. (1984). Coordinating attention to people and objects in mother-infant and peer-infant interaction. *Child Development, 55*(4), 1278-1289. doi: 10.2307/1129997

Purpose of the study: The authors hoped to observe the sequence and timing of normative changes in the patterning of infant attention in potentially social situations as well as the uniqueness of the role that adults, particularly the caregiver, may play in fostering simple forms of joint attention.

Method:
Participants: 28 infants were divided in two groups of 14, based on their age at the first of four recording sessions. The first group included infants observed when they were 6, 9, 12, and 15 months old. The infants in the second group were observed at ages 9, 12, 15, and 18 months of age. The children were all typically developing. The mothers of the infants were involved and each recruited another familiar infant peer to their child as a playmate for this study.

Procedure: The recording sessions took place in the infants' homes. First, the infant and mother were observed while they played on the floor with a set of toys provided by the researchers. Second, the infant and familiar peer were placed in the center of the room near various toys while their mothers were asked to sit to the side of the room and talk, paying minimal attention to their children. Finally, the infant was placed on the floor in the center of a room near a group of toys and the mother sat to the side on a chair. The video data were coded for six categories of engagement: unengaged, onlooking, persons, objects, passive joint attention, coordinated joint attention.

Results: At each age, most infants were observed at least one time to be unengaged, onlooking, and engaged in objects. Only about two-thirds were observed to be at least once engaged with persons. All infants were observed at least once in the passive joint attention state while interacting with their mothers, but only about two-thirds were passive in joint attention while with their peer. The percentage of instances of infant engagement occurring at least one time in coordinated joint activity increased exponentially when with the mother than with the peer.

Conclusions: Skilled adults, such as the caregiver of a child, are more likely able to elicit passive joint attention events in an infant than a familiar peer play partner. This is due in part to the fact that adults are more willing to tailor their actions to suit their infant's constant changing attention abilities and provide scaffolding to the infant's development of more complex joint attention skills.

Relevance to the current work: The current work focuses on mother-child interactions of children with autism and how joint attention skills may further develop through not only robotic interaction during therapy, but also through the mother's scaffolding abilities while giving directives.

Blanchard, K. A. (2012). *The effects of utilizing a robot on the social engagement behaviors of children with autism* (Unpublished master's thesis). Brigham Young University, Provo, Utah.

Purpose of the study: This study examined gains in social engagement behaviors in children with autism while in a triadic interaction following treatment sessions involving low-dose exposures to a humanoid robot. The social behaviors analyzed were eye contact, reciprocal action, language use, and initiating interaction.

Method:
Participants: Four children, two male and two female, identified with autism were selected to participate in this study. Each child had severe deficits in social communication including minimal amounts of joint attention and severe language impairments.

Procedures: Each child was assigned a staggered number of 3, 4, 5, or 6 baseline sessions, each 50 minutes long, targeting social engagement skills. Following the baseline sessions, the children each participated in 20 treatment session that comprised of both 50 minute traditional treatment sessions and 40 minute traditional treatment sessions accompanied by a 10 minute interaction with a humanoid robot. Upon completion of the treatment sessions, the children each participated in 3 follow-up sessions, structured identically to the baseline sessions. Each baseline and follow up session involved a parent interaction, a familiar adult interaction, an unfamiliar adult interaction, and a triadic interaction. Traditional treatment sessions were patterned after components from the SCERTS Model. The segments of treatment involving the robot consisted of group activities such as games and songs and focusing on increasing joint attention and social engagement skills.

Results: The following results were taken from the observation of the children's social behaviors during the triadic interaction. All children showed improvements in reciprocal action except for one participant. Gains in eye contact varied considerably in all the participants, with three of the children showing a decrease and one child producing an increase. None of the children experienced a notable change in language or initiating engagement in the triadic interactions.

Conclusions: Treatment involving low-dose exposure to a humanoid robot in addition to traditional therapy for children with autism had variable results. Some children made gains in some areas of social behavior while other children made gains in others. Future research should expand on using the robot to increase reciprocal action.

Relevance to the current work: This thesis provided information regarding the participants' background information as well as the methodology of this project. The current study focuses on the same collected data, but focuses on the parent interaction pre- and post-treatment segments.

Bruinsma, Y., Koegel, R. L., & Koegel, L. K. (2004). Joint attention and children with autism: A review of the literature. *Mental Retardation and Developmental Disabilities Research Reviews, 10*(3), 169-175. doi:10.1002/mrdd.20036

Purpose of work: This article is a review of current literature published with regard to the development of joint attention in typically developing children and children with autism. Studies examining forms and functions such as eye gaze alternation, the use of protodeclaratives and protoimperatives, and how joint attention may be a predictor of language acquisition were reviewed in this article.

Summary: The authors of this systematic review first discussed the importance of intentional communication and how it related to the development of initiated joint attention behaviors in both typically developing children and children with autism. Second, they provided an overview of child development of the initiation of joint attention bids. Results from the examined studies showed that children with autism do not tend to use communication for social purposes, as do typical children. Instead, communicative acts produced by children with autism tend to use communication as a means to meet wants and needs. Finally, the authors examined how initiation of joint attention may be viewed as a prognostic indicator as to how the child will succeed in acquiring language. At this time, few empirical studies have been published that predict language outcomes based on joint attention behaviors in prelinguistic children with autism.

Conclusions: Through an extensive review of literature, the authors have concluded that though intentional communication in typically developing children has been widely studied, additional research is warranted on prelinguistic children with autism. Controlled studies comparing the onset of communication and other social behaviors between children with autism who are taught joint attention skills and those who are taught first words may be helpful in guiding the development of intervention programs.

Relevance to the current work: In the current work, we measure the amounts of joint attention displayed by four children with autism when presented with directives given by their mothers.

We hope to further the research on joint attention by comparing joint attention behaviors before and after treatment sessions involving a humanoid robot.

Campolo, D., Taffoni, F., Schiavone, G., Laschi, C., Keller, F., & Guglielmelli, E. (2008, September). A novel technological approach towards the early diagnosis of neurodevelopmental disorders. ***30th Annual International Conference of the IEEE Engineering in Medicine and Biology Society*** **[1557-170X] (pg:4875 -4878). doi:10.1109/IEMBS.2008.4650306**

Purpose of work: The purpose of this study was to compare three different types of instruments used to assess both the perceptual and motor behavior of infants. The authors attempt to develop technological platforms and non-obtrusive, ecological assessment methods to determine more information regarding perceptual and intersubjective capacities of infants suspected of having an Autism Spectrum Disorder.

Summary: An instrumented ball, the MAG3 device, consisting of a kinematics sensing unit, a force sensing unit, a pre-processing and acquisition unit, a data transmission and storage unit, and a power unit was presented. The force sensors were found to be in the outer part of the device, and the final prototype was approximately 5 centimeters in diameter, weighing less than 100 grams. This allows the device to be suitable for grasping with a single hand for children as young as 6 months old. The second device, wrist and ankle movement sensors (WAMS) provided insight to the development of the central nervous system of the infant, which proves useful in the evaluation of motor abilities in infancy. The authors developed this device, weighing less than 10 grams and suitable for infants as young as 2 weeks old, to contain a MAG3 sensor and an analog-to-digital converter embedded in a soft silicon structure for comfort. A WAMS device is to be attached to each wrist and ankle of the infant to detect movement patterns. The final device to be presented was an Audio-Visuo-Vestibular Cap (AVVC), created by the authors, used to measure the amount of eye contact, joint attention, responsiveness to simple requests in children with autism. This wearable device assesses how humans coordinate vision, hearing, and orienting behavior during social situations in response to stimuli. It is composed of magneto/inertial sensors for monitoring head orientation, a mini camera to detect gaze direction, and a pair of microphones for sound localization.

Conclusions: The investigated technologies presented in this article are designed to be used in minimally structured environments, as either lone devices or in conjunction with other technology. The authors believe that early diagnosis of neurodevelopmental disorders such as autism will be accomplished through the use of multimodal assessment of different perceptual and motor domains. A current limitation is that, low cost technology is necessary for devices to be widely used in early diagnosis. Mass screenings are not possible with expensive technology.

Relevance to the current work: It is imperative, in measuring behaviors in children with autism, that one uses adequate technology systems to provide complete insight to the child's initiations and responses to visual and auditory stimuli. In the current work, cameras in the clinic room provide information as to the general interaction between the child and their parent. Additionally, video cameras trained on the child's face provide clarity as to the child's eye contact and emotional affect.

Chiang, C. H., Soong, W. T., Lin, T. L., & Rogers, S. J. (2008). Nonverbal communication skills in young children with autism. *Journal of Autism and Developmental Disorders, 38*(10), 1898-1906. doi: 10.1007/s10803-008-0586-*2*

Purpose of the study: This study was done to examine nonverbal communication skills in very young children with autism.

Method:
Participants: A group of 23 young children with autism approximately 32 months of age, a group of 23 children with developmental delay matched in age with the autism group, 22 18-20 month old infants who were typically developing, as well as 22 13-15 month old infants, also typically developing, were studied.

Procedures: The researchers used an abbreviated version of the Early Social Communication Scales (ESCS) for measuring nonverbal communication. The observed behaviors were categorized into high and low levels for scoring the child's development of nonverbal communication. Low level responses included eye contact while holding a toy and alternating eye gaze between the examiner's face and an active toy. High level responses involved pointing to toys within reach and showing toys or extending toys toward the examiner's face.

Results: The results revealed that 2 to 3-year-old children with autism lacked of skill in joint attention ability, particularly high-level skills. The insufficiency in terms of frequency of communication was similar to typically developing infants with a younger mental age. Young children with autism had different nonverbal communication patterns compared with the three other groups.

Conclusions: The authors concluded that 2 and 3-year-olds with autism displayed deficits mainly in initiating joint attention, especially in high level skills compared to both typically developing and delayed comparison groups. Interventions may need to include teaching children to monitor an adult's attention within the context of requesting situations.

Relevance to the current work: This article provides information regarding how adults should be incorporated into therapy sessions. Through this focus on basic social sequences such as turn-taking routines, the child may make more improvements. The current work involves parents in treatment with a humanoid robot to help children make these improvements.

Dautenhahn, K., & Werry, I. (2004). Towards interactive robots in autism therapy: Background, motivation, and challenges. *Pragmatics and Cognition, 12*(1), 1-35.

Purpose of the study: This article addresses the potential use of interactive environments as learning and teaching tools in a clinical setting for therapy of children with autism. The authors discuss experiences gained in the Aurora project, which was initiated to study ways to develop mobile robots as therapeutic tools for children with autism. It is expected that with new generations of children, novel technologically interactive systems will greatly impact methods of therapy and rehabilitation.

Methods:
Participants: The Aurora project consisted of 18 children between 8 and 12 years of age, and included non-verbal children clinically diagnosed with autism.

Procedures: A purely reactive robot tried to engage the subjects in simple, imitative, interaction games based on elements of turn-taking. The robot's behavior was guided by a set of rules, making it more predictable and less complex than human behavior. However, the same child-interaction procedures were not repeated, but rather were performed in variations. This was done to avoid influencing the stereotypical and repetitive behavior characteristic of autism. The subjects were to interact with the robot in a social play routine. Additionally, the authors observed the subjects play with inanimate toys to compare behaviors such as eye gaze, physical contact, and attention to the toy versus the robot.

Results: The results of this comparative study showed that most children responded well and with interest in the autonomous robot. The authors quantitatively evaluated video data of robot-child interaction, and noted eye gaze, physical contact, and attention towards and with the robot or an inanimate toy. Statistical results showed a significant increase in the interaction levels of the children with the robot when considering the amount of eye gaze and attention toward the robot. However, results also showed a significant increase in children's contact time when exposed to the inanimate toy.

Conclusions: The authors conclude that further study of the use of robotic technology in therapy treatments for children with autism would prove most beneficial. Based on their experience, only a certain range of robotic designs would be appropriate in the clinical setting. Different types of robotic tools might serve for different therapy goals. A challenge to their study was the development of appropriate design methodologies and evaluation methods to effectively compare and assess their impact on autism therapy. Future robot developments and trials with children with autism would tell whether the goal of the facilitation of social interaction skills can be reached.

Relevance to the current work: In our current work, we use a humanoid robot as a therapy tool for children diagnosed with autism. Similar to the Aurora project, we have the child interact with the robot by engaging them in socially interactive games and routines to measure the amount of generalization of those skills in their regular play settings.

Dodge, S. S. (2012). ***The effect of intervention using a robot on the social engagement behaviors of four children with autism in interaction with an unfamiliar adult*** **(Unpublished master's thesis). Brigham Young University, Provo, Utah.**

Purpose of the study: This study aimed to observe any gains in social engagement behaviors in children with autism while in an interaction involving an unfamiliar adult following treatment sessions involving low-dose exposures to a humanoid robot. The social behaviors analyzed were eye contact, reciprocal action, language use, and initiating interaction.

Method:
Participants: Four children, two male and two female, identified with autism were selected to participate in this study. Each child had severe deficits in social communication including minimal amounts of joint attention and severe language impairments.

Procedures: Each child was assigned a staggered number of 3, 4, 5, or 6 baseline sessions, each 50 minutes long targeting social engagement skills. Following the baseline sessions, the children each individually participated in 20 treatment session that comprised of both 50 minute traditional treatment sessions and 40 minute traditional treatment sessions accompanied by a 10 minute interaction with a humanoid robot. Upon completion of the treatment sessions, the children each participated in 3 follow-up sessions, identically structured to the baseline sessions. Each baseline and follow up session involved a parent interaction, a familiar adult interaction, an unfamiliar adult interaction, and a triadic interaction. Traditional treatment sessions were patterned after components from the SCERTS Model. The segments of treatment involving the robot consisted of group activities such as games and songs and focusing on increasing joint attention and social engagement skills.

Results: The following results were taken from the observation of the children's social behaviors during the interaction involving an unfamiliar adult. All children showed improvements in responding to bids for turn-taking except for one participant. Gains in eye contact varied considerably in all the participants, with three of the children showing a decrease and one child producing an increase. The language produced by the participants remained fairly stable across the study, with little change. Initiating engagement behaviors also either decreased or remained relatively stable in three of the four participants.

Conclusions: Treatment involving low-dose exposure to a humanoid robot in addition to traditional therapy for children with autism has variable results. Some children may make gains in some areas of social behavior while other children may make gains in others. Future research should expand on using the robot to increase reciprocal action.

Relevance to the current work: This thesis provided information regarding the participants' background information as well as the methodology of this project. The current study focuses on the same collected data, but focuses on the parent interaction pre- and post-treatment segments.

Duquette, A., Michaud, F., & Mercier, H. (2008). Exploring the use of a mobile robot as an imitation agent with children with low-functioning autism. ***Autonomous Robots, 24*****(2), 147-157. doi: 10.1007/s10514-007-9056-5**

Purpose of the study: This study aimed to verify the research hypothesis that an animated object that is more predictable and less complex than humans can help a child with autism establish reciprocal communication. The authors hoped to observe the reduction of avoidance behaviors such as repetitive and stereotyped play with inanimate objects, an increase in shared attention and shared conventions, and the appearance of symbolic communication such as verbal language.

Method:

Participants: 4 children (3 boys and 1 girl, around age 5) previously diagnosed with low-functioning autism participated in this research experiment. Two of these children were paired with a human mediator and the two other children were paired with the robot mediator.

Procedures: The child entered the room and their favorite toy was placed at their feet. The child was probed to interact either by their human or robot mediator. The activity sessions were comprised of imitative play patterns, in all of which the child was asked by the mediator to imitate them. Each child was exposed to a total of 22 sessions with their paired mediator at a rate of three times per week over seven weeks. All sessions were video recorded.

Results: Shared conventions such as imitation of body movements and familiar actions were higher with two children paired with a human mediator, as compared to two children paired with a robot mediator. However, the two children paired with the robot mediator demonstrated increased shared attention through visual contact and physical proximity as well as an increased ability to imitate facial expressions, such as smiling, more than the children paired with a human mediator.

Conclusions: When paired with a robot mediator, children with autism were able to improve shared attention skills in all types of imitation play patterns such as facial epressions. However, with an adult mediator, children with autism were more apt to improve shared attention sequences such as imitation of body movements and familiar actions. This may have been due to the low-functioning children having difficulty in understanding communicative intent from the limited movements of the robot.

Relevance to the current work: The current study also works to further research of robotic therapy in low-functioning children diagnosed with autism. This article provides useful information in describing the benefits of human interaction with the children and robotic interaction and how the children might improve their joint attention skills through both.

Francois, D., Powell, S., & Dautenhahn, K. (2009). A long-term study of children with autism playing with a robotic pet: Taking inspirations from non-directive play therapy to encourage children's proactivity and initiative-taking. *Interaction Studies, 10*(3), 324-373. doi:DOI 10.1075/is.10.3.04fra

Purpose of the study: This study, as a branch of the ongoing Aurora Project, investigated the potential use of robotic technology as a part of therapy for children with autism. Deficits in social communication may be addressed through non-directive play therapy as instigated by the clinician, involving an autonomous robot. The authors believed in the value of investigating new approaches in how to design and conduct robot-assisted play for children with autism.

Method:
Participants: Six children (five boys and one girl, between the ages of 4 and 11 years) from a school for children with a clinical diagnosis of autism were involved in this study. Each child was classified as having a moderate learning disability. These children collectively displayed a wide range of abilities, from being able to participate in verbal communication to being described as solitary and nonverbal.

Procedures: Ten approximately 40 minute-long treatment sessions were conducted once a week. Each session included the subject, the clinician, and sometimes another adult involved in the Aurora project with whom the child was familiar. Each session was filmed. The robot was programmed differently for each child, according to the child's needs, abilities, and demands. The clinician controlled the robot through a wireless connection with a laptop. During the session, the child was invited to play with the robot. The approach utilized in this session was mainly child-centered. Upon reviewing the videos of the session, the authors made note of the child's social play patterns, cognitive reasoning, and emotional affect. Inter-rater reliability testing was carried out for each of the three measures.

Results: A qualitative approach was utilized for the analysis of the three measures: play, reasoning, and affect. Results showed that each child progressed differently across the treatment sessions. Child B engaged in basic imitation during the final sessions, children C, E, and F tended to experience higher levels of play gradually over the sessions and constructed more reasoning about the robot as well as reasoning about real life situations. Child D experienced higher levels of play progressively, and may have learned reasoning about social rapport.

Conclusions: This long-term study showed interesting results in support of the approach of robot-assisted play for children with autism. The results were found to be in agreement with previous findings, that non-directive play therapy, particularly when paired with robotic interaction, encouraged the child's initiative-taking and symbolic play.

Relevance to the current work: We work to further this research in exploring how a child with autism may increase in directive responsiveness through multiple treatment sessions involving a humanoid robot. Similar to these methods, we videotaped our sessions and qualitatively analyzed the videos to establish inter-rater reliability and measure the children's behaviors.

Goodrich, M. A., Colton, M. B., Brinton, B., Fujiki, M., Atherton, J. A., Robinson, L., Ricks, D., Maxfield, M. H., & Acerson, A. (2011). Incorporating a robot into an autism therapy team. *IEEE Intelligent Systems, 27*(2), 52-59.

Purpose of the study: This article provides a case study to describe the cooperative professional environment necessary to provide treatment to children with autism, identify the role a robot can perform on this team, and describe the robot design and technologies that allow the robot perform this role within treatment sessions.

Method:
Participants: Two children, a 3-year-old and an 8-year-old both previously diagnosed with autism, were presented in the case study. The therapy team included the primary clinician, a secondary clinician, the therapy supervisor, and the child's primary caregiver.

Procedures: Each child attended 16 treatment sessions over a 3 month period. Each session involved 40 minutes of treatment followed by 10 minutes of interaction with the robot. Pre- and post-treatment assessments were conducted in four contexts: child-parent interaction, clinician-child interaction, triadic interaction involving both clinicians, and child interaction with an unfamiliar adult. In each context, various toys and routines were introduced and the child was prompted to participate in joint attention with the adult. The pre- and post-treatment assessments used the same individuals, time frames, toys, and routines. Treatment sessions were video recorded and analyzed behavior content such as the use of language or gesture, eye contact, affective display, and imitation.

Results: The 3 year old child showed a significant increase in the number of behaviors of social engagement. The 8-year-old child's gains were not as significant, but were still moderate. Data analysis showed social behaviors in the post-treatment sessions not previously observed, such as greeting clinicians by waving, symbolic pretend play, sharing toys, and decreased restricted and repetitive behaviors.

Conclusions: Low-dose robot therapy proved beneficial to the improvement of the social behaviors of two children with autism. When used as a team approach to autism therapy, robotic technology may prove to be valuable in future treatment of autism spectrum disorders.

Relevance to the current work: This article provides the framework for the treatment methods of the current study. The current study focuses specifically on the parent-child interaction pre- and post-treatment data, and how the children have been able to generalize learned therapy behaviors to their caregivers.

Gulsrud, A. C., Kasari, C., Freeman, S., & Paparella, T. (2007). Children with autism's response to novel stimuli while participating in interventions targeting joint attention or symbolic play skills. *Autism, 11*(6), 535-546. doi: 10.1177/1362361307083255

Purpose of the study: This research article further reports on generalization findings of the joint attention and symbolic play intervention method reported by Kasari et al. (2006).

Method:
Participants: 35 children from an existing intervention study diagnosed with autism spectrum disorder (ASD) were included in this study. 28 children were male and 7 were female, their ages ranging from 33 to 54 months.

Procedure: The children were randomly assigned into one of two treatment groups, either a targeted intervention for joint attention skills or one for symbolic play. In joint attention intervention, the children were taught to engage in joint attention acts such as pointing and showing, and encouraged to share attention between people and objects through the use of eye contact. In symbolic play, the children were taught to engage with toys in a developmentally appropriate manner through the use of functional and pretend play acts. A treatment protocol was developed and followed by the interventionists. Data were collected during the treatment sessions through videotaping. The data were later coded by the following categories: eye gaze, affect, non-verbal gestures, and verbalization. These procedures were previously instigated by Kasari et al. (2006).

Results: Results revealed that children in the joint attention intervention group were more likely to acknowledge the probe and engage in shared interactions with the interventionist. Also, the joint attention group improved in the proportion of time spend sharing coordinated joint looks with the interventionist.

Conclusions: Coordinated joint looks were successfully generalized to a novel situation that included the activation of an auditory-visual probe never before seen or heard by the child.

Relevance to the current work: In the current work, we look at the play interactions between mothers and their child with autism. We believe joint attention skills may be learned through treatment sessions involving a humanoid robot and be generalized to play interactions with their caregiver.

Hansen, M. (2011). *The effect of a treatment program utilizing a humanoid robot on the social engagement of two children with Autism Spectrum Disorder* (Unpublished master's thesis). Brigham Young University, Provo, Utah.

Purpose of the study: This study extended the research on the use of a humanoid robot in therapy with children with autism. The investigators examined whether or not two children with autism displayed generalization through increased social engagement with a human communication partner after the use of the robot in therapy.

Method:
Participants: Two male children identified with autism were selected to participate in this study. Both children were currently receiving services at the Brigham Young University Speech and Language Clinic and were identified with moderate to severe language delay, severe deficits in social and communicating function, and limited joint attention behaviors.

Procedures: Incorporated into the two children's regular treatment sessions was a 10-15 minute interaction with a humanoid robot named Troy. The robot was introduced to each child and the clinician then engaged the child in a series of reciprocal games and activities involving the robot, the clinician, the child, and a parent whenever available. Assessments for this study included a child-parent play assessment, a child-clinician play assessment, an unfamiliar adult play assessment, and a triadic interaction assessment. The researchers collected pre- and post-treatment data. This investigation only focused on the triadic interaction with student clinicians and a dyadic interaction with an unfamiliar adult.

Results: Changes were noted in the both participants' levels of engagement during a triadic interaction with two clinicians, as well as an interaction with an unfamiliar adult. Each child exhibited longer durations of sustained attention to activities in the post-treatment sessions. Conversational partners were also more successful in regaining both children's attention after periods of non-engagement.

Each participant demonstrated an increase in all behaviors of engagement during both triadic interaction and interaction with an unfamiliar adult. Though initiating engagement merely showed modest gains, significant improvements were shown in the category of responding to engagement.

Conclusions: Clinical observation concluded that both subjects benefited from the use of a humanoid robot during treatment, as they demonstrated clinically relevant changes in behaviors. This investigation suggests that a low-dose treatment that emphasizes interaction involving the robot as well as other human communicative partners may be beneficial to some children with autism.

Relevance to the current work: The current work is an expansion of this study using four participants instead of two. This research provided information as to the design and methodologies of the treatments implemented in the current study.

Kasari, C., Freeman, S., & Paparella, T. (2006). Joint attention and symbolic play in young children with autism: a randomized controlled intervention study. *Journal of Child Psychology Psychiatry, 47*(6), 611-620. doi:10.1111/j.1469-7610.2005.01567.x

Purpose of the study: The authors of this investigation utilized a randomized control design to compare and contrast two different intervention groups with a control group. They hypothesized that joint attention and symbolic play skills would improve in the experimental groups and not in the control group. They further sought how the subjects would improve in coordinated joint looking and greater functional play resulting from the employed interventions.

Method:
Participants: 58 children with autism were randomly organized into two treatment groups, targeting either joint attention or symbolic play, or a control group. 20 children consisted of the joint attention group, 21 children were in the symbolic play group, and 17 children were in the control group.

Procedures: Children were first assessed through the ADOS and the ADI-R to confirm their diagnosis of autism. The authors also observed the child playing with their mother with a standard set of toys for 15 minutes. These assessment procedures were repeated following intervention sessions. Each treatment session was approximately 30 minutes long. The approach involved applied behavior analysis and developmental procedures of interactive and facilitative methods. After 5-8 minutes of table time, the child worked on the same goal on the floor in a minimally structured session with the clinician that was similar to milieu teaching. Targeted goals were considered mastered if the child spontaneously demonstrated the behavior at least 3 times both at the table and on the floor.

Results: The results indicated that both intervention groups improved significantly over the control group on their prospective behaviors. Children in the joint attention group initiated significantly more responsiveness to joint attention on the post-treatment measures. The children in the symbolic play group showed more diverse types of symbolic play and more sophisticated play in the interactions with their mothers.

Conclusions: This study suggested that joint attention and symbolic play skills could indeed be taught to children with autism. Second, these children are able to generalize their newly learned skills from the individualized treatment sessions with the clinician to playing with their caregiver. Finally, the child-centered nature of the treatment approach yielded positive effects of joint engagement with others.

Relevance to the current work: In our current work, we used a multiple baseline design to look at the play interactions between mothers and their children with autism. Our hope is that joint attention skills may be learned through multiple treatment sessions involving a humanoid robot and be generalized to play interactions with their caregiver.

Kozima, H., & Nakagawa, C. (2006). Interactive Robots as Facilitators of Children's Social Development. *National Institute of Information and Communications Technology, Japan,* 269- 286.

Purpose of the study: The authors described design principles of interactive robots for the study of human social intelligence and how this knowledge can be implemented in therapeutic environments. They discuss how robots are capable of embodied interactions with children with autism, and provide many observations of how the children interact with the robots and improvements these children have made.

Method:
Participants: The authors observed 25 typically-developing children in a class of 3 year-olds longitudinally for a year. Also included in this study were 30 children from their own research-driven therapeutic day-care preschool children with developmental disorders. Most of these children in the therapeutic day-care facility had been diagnosed with an Autism Spectrum Disorder.

Procedure: First observed were the typically-developing children interacting with a humanoid robot. The robot alternated between eye contact and joint attention tasks with pointing. The child was first alone with the robot, and then after 3-4 minutes a caregiver came in and sat next to the child. The interaction continued for approximately 30 minutes. At their therapeutic day-care facility, the authors observed how the children expressed themselves to the robot. These children were longitudinally studied over a 3 year period.

Results: The authors found that the typically-developing children showed a wide range on spontaneous actions toward the robot, not only dyadic interaction but in larger groups of peers in which the robot was the focus. They often spoke to the robot as if it had a "mind." They interpreted the robot's responses as having communicative meaning. In observing the children with autism, the authors began to see the emergence of both spontaneous and interpersonal dyadic interactions, the emergence of triadic interactions involving their mother or therapist, and a change in affective behavior toward the robot from hostile to gentile and protective.

Conclusions: The authors conclude the following from their study: children were able to approach the robot with curiosity and security due to it's technologic nature; some children were able to extend their dyadic interactions with the robot into triadic interpersonal ones, where they share affective behavior with others, such as their caregivers; each child exhibited a different style of interaction that changed over time, displaying an evolution of a relationship with the robot.

Relevance to the current work: In observing interactions between children with autism and a humanoid robot, we hope to see our subjects evolve from simple dyadic interactions to interpersonal triadic interactions with their caregiver.

Leekham, S. R., Uljarevic, M., & Prior, M. R. (2011). Restricted and repetitive behaviors in autism spectrum disorders: A review of research in the last decade. *Psychological Bulletin, 137*(4), 562-593. doi: 10.1037/a0023341

Purpose of work: This review article brought together compiled research over the last decade concerning restricted and repetitive behaviors (RRBs) from the fields of developmental psychology, cognitive psychology, neurobiology, and psychiatry. The goal was to draw out the evidence from these areas and to structure particular themes to enable the development of a framework that would allow a set of predictions to be tested.

Summary: The authors structured their review around three main themes: definition, cause, and change. Concerning definition, evidence suggests that RRBs form a structure that resemble diagnostic categories which divide them into lower and higher level RRBs. These classes are seen in various clinical groups, and though RRBs in autism spectrum disorder (ASD), there is no distinctive RRB marker for ASD. Whether or not RRBs are good indicators of ASD early in live compared with social and communication features, there is evidence that RRBs provide a good indication of ASD as children get older. Further work is necessary on other factors that may influence the association between RRBs and social communication impairment.

In reviewing cause, the authors focus on answering why RRBs happen in children with ASD by looking at perspectives from neurobiology, neuropsychology, and developmental psychology. Some research claims that RRBs arise from gene-environment neuroadaptations, though these studies focus on animal models and repetitive sensory and motor behaviors rather than sameness behaviors. Neuropsychology accounts attempt to address both lower level repetitive sensory and motor behaviors and higher level sameness behaviors, though the claims made for problems in the executive processes have not been sustained by further evidence. Research done in the area of developmental psychology claims that RRBs in children with ASD are immature behavioral responses that are a normal part of early development but have been maintained beyond the typical period of development. This approach enables predictions to be made concerning developmental effects, triggers for RRBs, functions of RRBs, and intervention predictions. Future research on the causes of RRBs is very important in order for clinical interventions based on functional analysis to proceed.

Finally, the authors ask whether RRBs have the ability to spontaneously change across time and to the extent to which pharmacological and behavioral interventions lead to their improvement. According to the research, changes are indeed observed in RRBs, although this potential is influenced by age and cognitive and language ability. Behavioral approaches to intervention that involve careful identification of triggers and functions are backed with encouraging support. Comprehensive interventions in particular are most promising for children with ASD if implemented in the early years of development. Pharmacological treatment may be effective for treating irritability, inattention, and aggression in some cases. In such cases, medication can be used to complement behavioral treatment since these behaviors can present serious obstacles for the delivery of behavioral interventions. The goals of behavioral intervention are to increase the use of social and behavioral skills beyond RRBs and reduce rigidity and, thus, repetitive behavior patterns in children with ASD.

Conclusions: The authors conclude this article by acknowledging the advances made in the last decade of research regarding RRBs in ASD. There has been greater consistency of measurement and increasing use of subscales and factor analysis to interpret research findings, and a growing awareness of how various factors impact the severity of RRBs and their potential to change. The article further goes on to state four key points regarding current research and future research possibilities. First, there are several dimensions of RRBs that emerge in children with ASD such as repetitive sensory and motor behaviors. Second, the forms of RRBs observed in ASD are also found in other neurodevelopmental and genetic conditions. Third, RRBs are affected by age and developmental level in ASD. Fourth, explanations are advancing as to why RRBs happen. Future research can be directed to RRBs and other core social communication impairments, as well as the developmental aspects and possible causes of these behaviors.

Relevance to the current work: By providing an engaging companion (robot) in therapy sessions we hope to observe less RRBs displayed by the children and more meaningful interactions with their caregiver.

Levy, S., Kim, A.-H., & Olive, M. L. (2006). Interventions for young children with autism: A synthesis of the literature. ***Focus on Autism and Other Developmental Disabilities, 21*****(1), 55-62.**

Purpose of the study: The purpose of this study was to examine different intervention studies that have been conducted with young children with autism. The authors set out to compare these intervention studies in order to conclude the most effective procedures and components of the different strategies and to therefore identify guidelines for development of future autism intervention programs.

Summary: Procedures included searching in subject indexes, citations, and further browsing and footnote chasing through a two-step procedure. It began as a broad search with the intent of locating all relevant research articles and dissertations, and then became more restrictive as predetermined selection criteria were applied. The criteria were as follows: it was an intervention study, at least 2/3 of the participants were between the ages of 3 and 8 years, it was published between 1975 and 2001, it involved a treatment/comparison or single-group design, and 50% or more of the participants were identified as having autism. Coding was conducted in order to organize the different publication and coder information, participants and setting, purpose of the study, research design and methodologies, description of the intervention, measures and observations, and findings.

The findings for the 23 studies that met the criteria were divided into six categories: parent involvement, intensive behavioral intervention, multicomponent intervention, speech-language treatment, setting, and other interventions. Interventions involving parent involvement, intensive behavior intervention, multicomponent early intervention, language training, and included typically developing children in the treatment sessions. Some interventions were shown to be influential in increasing levels of cognitive and social skills development. Other interventions involving touch therapy, computer programs, and imitative interactions also gave positive outcomes.

Conclusions: When examined closely, 4 aspects of interventions show consistent positive effects across all contexts. They were: parental involvement, intensive behavioral therapy, multicomponent interventions, and duration of interventions. Children with autism appear to be more likely to benefit from interventions that are instigated at an early age, are intensive and last at least a year, target developmental areas, and involve the child's parents.

Relevance to the current work: The current work employs an intervention program to target social communication in children with autism. We strive to create the most appropriate intervention strategy involving a humanoid robot to bring about positive behaviors in the subjects. Our approach involves parent interaction and targets proximal developmental areas.

McConnell, S. R. (2002). Interventions to facilitate social interaction for young children with autism: Review of available research and recommendations for educational intervention and future research. *Journal of Autism Developmental Disorders, 32*(5), 351-372.

Purpose of work: This review of literature aimed to provide a critical, scholarly review of research through the year 2000 on interventions to facilitate the social interactions of children with autism, considering adult-child interactions as well as child-child interactions.

Summary: The studies included in this synthesis of literature all met the following criteria: repeated, continuous assessment of the dependent variable within and across experimental phases, minimum of baseline and treatment contrast with additional contrast/control phases typically included, direct replication of treatment effects across three or more subjects/settings/behaviors, and evidence of experimental control of independent variables and other relevant features within and across settings. The authors analyze data from studies researching social interaction outcomes, behaviors that may compete with social participation, and different intervention strategies that focused on teaching, training, or providing therapy for social function. The latter category was divided into five categories: ecological variations, collateral skills interventions, child-specific interventions, peer behavior, and comprehensive interventions.

Conclusions: According to recent research, some conditions characteristic of autism are able to improve through social interaction skill interventions. Investigators have shown positive outcomes in the following areas: social initiations, responses, and interaction bouts, "Pivotal responses," and collateral behaviors such as play, language, and problem solving skills. Three limitations are identified from the literature reviewed. First, there are few examples available of evaluations of intact, well-described interventions. Second, some of the intervention procedures have little or no peer-reviewed empirical support. Finally, most studies were conducted using teachers or other professionals as interventionists rather than family members.

Relevance to the current work: The current research works to provide intervention that involves the child's primary caregiver, so as to facilitate generalization of the targeted behaviors.

Pioggia, G., Igliozzi, R., Ferro, M., Ahluwalia, A., Muratori, F., & De Rossi, D. (2005). An android for enhancing social skills and emotion recognition in people with autism. *IEEE Transactions on Neural Systems and Rehabilitation Engineering, 13*(4), 507-515. doi: 10.1109/TNSRE.2005.856076

Purpose of the study: The primary goal of this article was to create an interactive life-like facial display and a supporting therapy protocol that would enable researchers to determine if the system can help children with autism to learn, identify, interpret, and use emotional information and generalize it into a socially appropriate, flexible, and adaptive context.

Method:
Participants: Two children, one typically developing (8 years 7 months of age) and the other with high-functioning autism (7 years 8 months of age), were monitored and compared.

Procedures: The robot FACE was created to be able to both express and recognize basic emotions. Initial treatment sessions were dedicated to familiarization of the children to the robot. The therapist's role was to probe the subject's emotional reaction to the robot and mediate the interactions between them. A series of behavioral observations were noted as the researchers examined eye gaze, orientation, smiling, and vocalizing. Interrater reliability was established in analyzing imitation, facial expression association such as facial matching and emotion labeling, and emotion contextualization.

Results: The child with autism attended to the robot only when prompted by the clinician. When probed, the child attributed the robot with an expression, saying it was "sad." The typically developing child spontaneously observed the robot and also attributed the robot as being "sad." The typically developing child became uncomfortable when the robot's facial movements were increased.

Conclusions: Children with autism can be led to interact proactively with an android and their interest in interaction with nonhuman objects can be positively utilized through the use of a robot and the designed protocol. Further study of the robot FACE involving 20 children will further examine how it may diminish social impairment in children with autism.

Relevance to the current work: This article gives further support to the research regarding robotic technology in the treatment for children with autism. This population is readily engaged with an object that assimilates human behavior rather than a human being.

Prizant, B. M., Wetherby, A. M., Rubin, E., & Laurent, A. C. (2003). The SCERTS model: A transactional, family-centered approach to enhancing communication and socioemotional abilities of children with autism spectrum disorder. *Infants and Young Children, 16*(4). 296-316. doi: 10.1097/00001163-200310000-00004

Purpose of work: This article describes the SCERTS model, a treatment plan prioritizing social communication, emotional regulation, and transactional support as the primary developmental aspects that must be addressed in a comprehensive program created to support the development of young children with autism spectrum disorder (ASD) and their families.

Summary: The authors provided a detailed discussion on the three core components of the SCERTS model: Social Communication, Emotional Regulation, and Transactional Support.

The social communication component of the model directly addresses the core challenges in social communication experienced by children with ASD. These challenges fall into two main categories: the capacity for joint attention, which underlies a child's ability to coordinate and share attention, share emotions, express intentions, and engage in reciprocal situations; and the capacity for symbol use, which underlies a child's understanding of meaning expressed through conventional gestures, words, and more advanced linguistic forms, and the ability to engage in appropriate use of objects leading to imaginative play. Through naturalistic contexts and communicative partners, children with ASD may improve their development of social communication.

Emotional regulation is difficult for children with ASD due to neurophysiological factors. These difficulties may result in a low threshold for physiological and emotional reactivity and cause hyper-reactivity behaviors such as anxiety, agitation, and a limited ability to attend in a learning and interactional environment. The SCERTS model addresses emotional regulation by targeting goals for the development of self-regulatory and mutual-regulatory abilities.

Transactional support in the SCERTS model emphasizes that supports must be flexible and responsive to different social contexts and learning environments, and to the changing needs of children and families. These supports are needed to maximize learning abilities and to improve the participation in daily living activities and events. Transactional supports are divided into three major components in the SCERTS model: interpersonal support in interacting with others, educational support in learning environments, and family support for the caregivers.

Conclusions: As it is based on current empirical research and has been extensively studied, the SCERTS model offers a framework that addresses the key challenges of ASD as it focuses on building the child's capacity to initiate comunication and to develop regulatory capacities.

Relevance to the current work: The current study incorporates aspects of the SCERTS model in treatment sessions for children with ASD.

Rapin, I. (1991). Autistic children: Diagnosis and clinical features. *Pediatrics, 87*(5), 751-760.

Purpose of work: The purpose of this study is to inform the public about the diagnostic criteria, the characteristics, the prognosis, and the management of autism. The author provides much information so as to adequately report the characteristic behaviors of the disorder.

Summary: Autism is a behaviorally defined developmental disorder. Although there may be a variety of possible etiologies, the majority of cases of autism has no known cause. Boys are typically more diagnosed with autism than girls. Autism presents itself during the preschool years and affects sociability, communication, and limits the child's interest in activities. There is a broad range of severity in autism, and thus makes it a spectral disorder. Such dysfunctions may include motor signs, abnormal responses to sensory stimuli, and disorders of affect and attention. Many autistic children experience seizures and abnormal brain development. The level of intelligence may range from profound mental deficiency to gifted intellect. In preschool years, all autistic children present with a language disorder, as verbal expression may be either completely lacking or echolalic and comprehension and language use are consistently impaired. There are no pharmacologic remedies to autism; however, medication may be taken to moderate seizures or attention deficits. Children with autism tend to change in character as they mature and undergo intervention. Communication skills and sociability, though they remain deficient, are able to improve in all but those profoundly affected. Outcomes of intervention depend on the child's innate cognitive competence and the effectiveness of the intervention focused on developing appropriate social skills and meaningful communication. Intelligent autistic adults may complete their education, may obtain a job, and may be able to live independently. However, more severely handicapped autistic individuals may require a long-term protected environment.

Conclusions: The most limiting handicap in all persons with autism is their social deficit. This can be aided through vigorous and appropriate intervention from teachers, family members, and typically developing peers.

Relevance to the current work: In the current study, it is imperative we understand the characteristics of autism and develop appropriate target goals for intervention. Our intervention strategy enables children with autism to improve their social skills with their respective caregivers, so they might more adequately communicate with individuals closest to them.

Robins, B., Dickerson, P., Stribling, P., & Dautenhahn, K. (2004). Robot-mediated joint attention in children with autism: A case study in robot-human interaction. *Interaction Studies, 5*(2), 161-198.

Purpose of the study: As a part of the Aurora study, this article further examines how robots can potentially be used as a therapy intervention tool to improve joint attention skills in children with autism. The authors focus their analysis on joint attention, which plays a fundamental role in human development and social understanding.

Method:
Participants: This study involved four children, aged 5 to 10 years, each having been previously diagnosed with autism. Each child participated in as many therapy trials as possible during a 12 week period. On average, each child participated in 9 trials, lasting an average of 3 minutes per trial.

Procedures: The child was brought into the therapy room by their caregiver, the robot placed on a table and ready to begin with a click of a button from it's operant laptop. The clinician sat next to the table to operate the laptop, and thus the robot, when necessary. The therapy trial ended when the child was no longer comfortable with staying inside the therapy room. During the trial session, the clinician did not initiate communication or interaction with the child, but did respond when addressed by the child.

Results: The researchers obtained their results through recorded video observations taken during the trial sessions. Their observations focused on the children's body movements and vocal expressions. In looking at conspicuous noticing, it was discovered that one child displayed intentional orientation through eye gaze and gesture. In organization of vocalizations and gaze, a child produced a vocalizaiton after establishing eye contact with the clinician, labeling the clinician as the intended recipient of his vocalization. In establishing mutual orientation to and through gesture, a child was observed directing the clinician's gaze to a referent. The researchers also analyzed how the children followed the gaze of others and found instances in which the children appropriately followed the adult's gaze and pointed towards the robot.

Conclusions: The analysis of the researchers indicated that the subjects displayed skillful actions in orienting themselves to their adult clinician. The children's vocal and non-vocal actions including body movement, gaze, and gestures demonstrated their patterns of orientation to others in the clinic room. The results of this study highlight that a robot can serve as a social mediator, or an object for focus of attention and joint attention, that children with autism may use to communicate with other people.

Relevance to the current work: The current work aims to improve the joint attention skills in children with autism through therapeutic interactions with a humaniod robot. Measures of the current work involve how four children respond to directives given by their mothers before and after undergoing several treatment sessions involving the robot.

Robins, B., Dautenhahn, K., Boekhorst, R. T., & Billard, A. (2005). Robotic assistants in therapy and education of children with autism: Can a small humanoid robot help encourage social interaction skills? ***Universal Access in the Information Society, 4*****(2), 105-120. doi:10.1007/s10209-005-0116-3**

Purpose of the study: This longitudinal study aimed to encourage imitation and social interaction skills in four children diagnosed with autism. These children were repeatedly exposed to a humanoid robot over a period of several months, using basic imitative and turn-taking games. Different criteria including eye gaze, touch, proximity, and imitation were evaluated.

Method:
Participants: Four children diagnosed with autism, ages from 5 to 10 years from the Enhanced Provision unit at Bentfield primary school were selected by their teacher to participate in the trials. Each child participated in as many trials as was possible in the 12 week period, with an average of 9 trials each. The children displayed a spectrum of abilities.

Procedures: Before each trial, the robot and its equipment was placed on a table in the therapy room. The cameras, operated by a remote control, were placed to record. The children were individually brought into the room by their caregiver. The trials stopped when the child was no longer comfortable in the therapy room. The average duration of the trials was approximately 3 minutes. The therapy trials were set up to move from very simple exposure to the robot to more complex opportunities for interaction.

Results: Based on the video data collected throughout the robot treatment sessions, a quantitative and qualitative analysis was conducted. Four behavior criteria were defined in the evaluations and were observed in the video data. They were eye gaze toward the robot, touching the robot, imitation of the robot's actions, and proximity to the robot. The quantitative analysis showed an increase in duration of pre-defined imitation behaviors towards the later trials. A qualitative analysis of the video data presented the children's activities and revealed further higher levels of social interaction skills such as imitation, turn-taking, and role-switching as well as communicative competence. Children displayed straightforward imitation of various body parts' movements, self correction, interaction initiation as part of the imitation and turn-taking game without any pre-determined cue, thus causing a role-switch, and interaction initiation using a newmovement.

Conclusions: Supporting evidence was found for the researcher's hypothesis, namely that repeated exposure to an interactive small humanoid robot will increase basic social interaction skills in children with autism. In some cases the children began using the robot as an object of shared attention for their interaction with the teachers, carers, and the clinician.

Relevance to the current work: In the current study, it is hypothesized that four children with autism will generalize joint attention behaviors learned in treatment sessions involving an interactive humanoid robot to social interactions with their caregivers.

Scassellati, B. (2007). How social robots will help us to diagnose, treat, and understand autism. *Springer Tracts in Advanced Robotics, 28*, 552-563. doi: 10.1007/978-3-540-48113-3_47

Purpose of work: This research article discussed how scial robots will make an impact on the ways in which autism is diagnosed, treated, and understood.

Summary: Recent studies have shown that robots enerate a high degree of motivation and engagement in children with ASD who are unlikely or unwilling to interact socially with human therapists. However, the criteria for what makes autistic children likely to respond to these robots are not yet understood. The authors hypothesized that one reason children would respond so positively to robots is that the robots offer simple, contingent, predictable responses to the child's actions. They instigated a small pilot study analyzing the behaviors of typically developing children and children with autism with regards to interacting with a contingent and non-contingent robot. Typical children were found to be engaged with the contingent robot but quickly lost interest in the non-contingent. Children with autism were engaged the duration of the observation, regardless of whether the robot was contingent or not. These preliminary results demonstrate that further detailed study of design variables are necessary to determine factors that cause desired responses from children with autism.

The authors further argue that diagnostic problems with autism may be diminished through passive observation of the child at play or in interactions with caregivers and clinicians, as well as through structured interactions with robots that are able to create standardized social cues designed to elicit particular social responses. The authors provide examples of experimental treatments they have conducted using this technique to observe gaze direction, vocal prosody, and position tracking.

Conclusions: Through the analysis of social capabilities of children with autism that result from work on therapeutic and diagnostic applications, the authors claim that clinicians have the opportunity to enhance their understanding of autistic disorders.

Relevance to the current work: The current study aims to provide a robot in therapy sessions with children with autism. We use a contingent robot to engage these children and to help them improve their development of joint attention skills.

Seibert, J. M., Hogan, A. E., & Mundy, P. C. (1982). Assessing interactional competencies: The early social communication scales. *Infant Mental Health Journal 3*(4), 244-245. doi:10.1002/1097-0355(198224)3:4<244::AID-IMHJ2280030406>3.0.CO;2-R

Purpose of work: This article presents an overview of the behavioral content of the Early Social-Communication Scales (ESCS), as organized according to the cognitive developmental model.

Summary: The ESCS is organized into five levels, similar to Piaget's five sensorimotor stages. Each level characterizes the development of skills for adapting to the social and physical environment. The levels increase in complexity, enabling the child to acquire more skills for interaction. Three primary functions including social interaction, joint attention, and behavior regulation are identified as core foci to the ESCS. Children are observed in semi-structured interactions with familiar adults. Depending on the child's behavior, they are categorized into the appropriate level. Level 0: Reflexive or Responsive; Level 1: Siple, Voluntary Interactions; Level 2: Complex, Differential Interactions; Level 3: Immediate Modification of Interactions to Feedback; Level 4: Anticipatory Regulation of Interactions. The ESCS may also be given as a questionnaire. Adequate supprotive research has been done in evaluating this assessment procedure.

Conclusions: The results of these scales are consistant with predictions made by the theoretical model. However, longitudinal studies would provide useful to this research and these claims. The behavioral content of the scales of the ESCS should not be approached as a diagnosis, but rather as a suggestions as to what might be going on and what one might expect at that level. These scales may also be helpful in modifying adult-child interaction by informing the adult of the child's level of competence.

Relevance to the current work: This article provided valuable information concerning the developmental process of social interaction and joint attention, and improving adult-child interactions.

Stabenow, A. (2012). *The effect of utilizing a humanoid robot on social engagement behaviors in children with autism during interaction with a familiar adult* (Unpublished master's thesis). Brigham Young University, Provo, Utah.

Purpose of the study: This study aimed to observe any gains in social engagement behaviors in children with autism while in an interaction involving a familiar adult following treatment sessions involving low-dose exposures to a humanoid robot. The social behaviors analyzed were eye contact, reciprocal action, language use, and initiating interaction.

Method:
Participants: Four children, two male and two female, identified with autism were selected to participate in this study. Each child had severe deficits in social communication including minimal amounts of joint attention and severe language impairments.

Procedures: Each child was assigned a staggered number of 3, 4, 5, or 6 baseline sessions, each 50 minutes long targeting social engagement skills. Following the baseline sessions, the children each individually participated in 20 treatment session that comprised of both 50 minute traditional treatment sessions and 40 minute traditional treatment sessions accompanied by a 10 minute interaction with a humanoid robot. Upon completion of the treatment sessions, the children each participated in 3 follow-up sessions, identically structured to the baseline sessions. Each baseline and follow up session involved a parent interaction, a familiar adult interaction, an unfamiliar adult interaction, and a triadic interaction. Traditional treatment sessions were patterned after components from the SCERTS Model. The segments of treatment involving the robot consisted of group activities such as games and songs and focusing on increasing joint attention and social engagement skills.

Results: The following results were taken from the observation of the children's social behaviors during the interaction involving a familiar adult. All children showed improvements in reciprocal action except for one participant. Two participants showed improvement in eye contact, one showed no change, and one showed a decrease in this behavior. None of the children experienced a notable change in language or initiating engagement in the triadic interactions.

Conclusions: Treatment involving low-dose exposure to a humanoid robot in addition to traditional therapy for children with autism has variable results. Some children may make gains in some areas of social behavior while other children may make gains in others. Future research should expand on using the robot to increase reciprocal action.

Relevance to the current work: This thesis provided information regarding the participants' background information as well as the methodology of this project. The current study focuses on the same collected data, but focuses on the parent interaction pre- and post-treatment segments.

Vaughan Van Hecke, A., Mundy, P. C., Acra, C. F., Block, J. J., Delgado, C. E., Parlade, M. V., et al. (2007). Infant joint attention, temperament, and social competence in

preschool children. ***Child Development, 78*****(1), 53-69. doi:10.1111/j.1467-8624.2007.00985.x**

Purpose of the study: The aims of this research were to examine the relations between individual differences in the development of infant joint attention and behavior outcomes in a sample of typically developing children. The authors also hoped to examine the degree to which different dimensions of joint attention and different types of joint attention measures may have associations with social outcomes in these children. The final goal of this study was to examine the possibility that variance shared with several other domains may contribute to, or even explain, the associations between infant joint attention and individual differences in social outcomes.

Method:
Participants: 52 infants were drawn from a sample of families enrolled in a 9 to 36 month longitudinal study of social development. Each child was considered typically developing according to a health and developmental status report.

Procedures: This study focused on language status at 9 months of age, joint attention development at 12 months of age, infant temperament at 15 moths of age, cognitive/language data at 24 months of age, and social-emotional outcomes at 30 months. When the infants were 9 months old, their parents reported the child's Language Status and Maternal Education. At 12 months, joint attention was assessed using the Early Social Communication Scales (ESCS). At 15 months, child temperament was assessed with a version of the Toddler Behavior Assessment Questionnaire—Revised (TBAQ-R). Cognitive status at 24 months was examined through the Bayley Scales of Infant Development—Second Edition. Socio-emotional outcome data at 30 months were observed through parents' endorsements in the Infant-Toddler Social and Emotional Assessment questionnaire.

Results: The authors found that 12 month old initiating and responding to joint attention were related to 30 month old social competence and externalizing behavior, even when accounting for 15 month old temperament ratings, 24 month old cognition and language levels, and demographic variables.

Conclusions: The results of this study suggest that infants display a range of individual differences in the development of joint attention skills, and that these differences are associated with variability in preschool social competence as well as cognitive and language outcomes. Observations also indicated that social competence at 30 months of age was positively predicted by 12 month old pointing and showing joint attention behavior and by 15 month old inhibitory control. Further research is necessary to better understand the processes of the development of different dimensions of infant joint attention and how they are related to social, cognitive, and language outcomes in later childhood.

Relevance to the current work: In the current work, researchers must be familiar with key indicators of the emergence of joint attention.

Woods, J. J. & Wetherby, A. M. (2003). Early identification of and intervention for infants and toddlers who are at risk for autism spectrum disorder. *Language, Speech, and Hearing Services in Schools, 34*(3), 180-193. doi: 10.1044/0161-1461

Purpose of work: The purpose of this study was to review the early indicators of autism in very young children (social and communicative impairments) as important implications for early identification. A second purpose of this research was to review evidence-based intervention practices for children with autism to develop a set of guidelines for providing intervention for at-risk infants and toddlers.

Summary: Through the analysis of current empirically supported intervention strategies for children with autism, the authors identified four major findings: (a) there is support demonstrating the effectiveness of a range of treatment approaches from behavioral to developmental to improve the communication skills for children with autism, (b) research is not yet available to predict which intervention approaches or strategies work best for children with autism, (c) there is a need to go beyond traditional outcome measures to include contextually compelling child characteristics, and (d) there is mounting evidence indicating that the age at the time of intervention is predictive of the treatment outcomes for children with autism.

In intervention for infants and toddlers at risk for autism, therapists are counseled to provide the following: early intervention strategies involving family members, intervention in natural environments so as to support generalization, support for the family members in the early intervention process, and strategies to embed intervention in daily routines.

Conclusions: Further study is necessary for determining the efficacy of such factors such as frequency of treatment, the exact appropriate age for intervention, and the use of parent-implemented interventions. Future research should also work to document meaningful changes for children that reflect the core social communication deficits associated with autism.

Relevance to the current work: This article provided information concerning joint attention and different treatment approaches with children with autism. This information contributed to the research and review of literature concerning these subjects.

Appendix B

Coding Manual

Probes introduced by the mother

I. Physical manipulation

a. Definition: mother physically manipulates the child in some way including (doesn't need a verbal directive):
    i. Hand over hand to perform an action
    ii. Pushing onto a beanbag, etc.
    iii. Taking arm to guide child's action
    iv. Physical directive of some kind (finger under child's chin for eye contact) accompanied by a verbal direction of some kind such as
        1. Look at this
        2. Eat the pizza
        3. Lie down
        4. Look at mommy

b. Response possibilities

    i. Comply
        1. Child permits manipulation without protest—code with yes
        2. Code other behaviors that might accompany a "yes"
            a. Eye contact
            b. Language
            c. Reciprocal behavior (hands an object back, continues a sequence, etc.)
    ii. Does not comply
        1. Child pulls away from or protests the manipulation
        2. Theoretically, there could be other engaged behaviors
            a. Eye contact made during protestation
            b. Language ("No" "I don't want to!")
            c. Reciprocal behavior (though unlikely)

II. Verbal Request of an Object or Action while Handing an Object, Gesturing, or Modeling

a. Definition: mother gestures, hands the child an object, or puts an object directly in front of the child while making a verbal request including:
    i. Look at this
    ii. Here's a blue one
    iii. Take this
    iv. Look at this book
    v. Take the yellow one

vi. Mother models an action and hands an object to the child—"eat the pizza"
vii. "Say…."
viii. An outstretched hand saying, "Can I have the…?" or "Give me…"
ix. Pointing to a container and saying, "Put it in."
x. Requesting to knock down a tower while pointing. "Knock it down."
xi. After modeling the sequence, requesting, "Show Mommy how you build."

b. Response possibilities
   i. Comply
      1. Child takes the object or performs the action as directed—score yes
      2. If the child's action does not match the verbal direction, do not score as comply—e.g., child puts the pizza on the tray in response to "eat the pizza"
      3. Other behaviors that might accompany a yes
         a. Eye contact
         b. Language
         c. Reciprocal behavior (hands an object back, continues a sequence, etc.)

   ii. Does not comply
      1. Child does not take object or perform action
      2. Child takes object and does something unrelated to request or direction
      3. Child takes object and throws it away

IV. Some general considerations

a. If we can't see what a child or mother is doing, we can't code the action
b. There can be more than one request for a single *action*
c. If there are several requests and the child complies to each, count them as separate (e.g., put his one in the bag [child does it] put this one in [child does it]
d. If there are several requests close together, count as a single request ("Turn the page, turn the page, turn the page" right in a row)
e. Start when you hear the door close, End when you hear the keypad

Appendix C

Coding Checklist for Parent Interaction

Physical Manipulation
Probe: The mother physically manipulates the child in some way. No verbal cue is necessary.

Comply: Child permits manipulation without protest ☐☐☐☐☐☐ ☐☐☐☐☐☐

Eye Contact ☐ ☐ ☐ ☐ ☐ ☐

Language ☐ ☐ ☐ ☐ ☐ ☐

Reciprocal Behavior ☐ ☐ ☐ ☐ ☐ ☐
(Hands an object back, continues a sequence, etc.)

Does not comply: Child pulls away from, or protests manipulation

☐☐☐☐☐☐☐☐☐☐☐

Eye Contact ☐ ☐ ☐ ☐ ☐ ☐

Language ☐ ☐ ☐ ☐ ☐ ☐

Reciprocal Behavior ☐ ☐ ☐ ☐ ☐ ☐

Verbal request of an object or action with a gesture or model
Probe: Mother gestures and makes a request to the child. Probes include handing the child an object or puts an object directly in front the child and makes a request. Count as one probe if there are multiple requests made in 2 seconds or less. Start the probe from the last request given.

Comply: Child takes the object or performs the action as directed
If the child's action does not match the verbal direction, do not score as comply

☐☐☐☐☐☐☐☐☐☐☐
☐☐☐☐☐☐☐☐☐☐☐

Eye Contact ☐ ☐ ☐ ☐ ☐ ☐

Language ☐ ☐ ☐ ☐ ☐ ☐

Reciprocal Behavior ☐ ☐ ☐ ☐ ☐ ☐
(Hands an object back, continues a sequence, etc.)

Does not comply: Child does not take an object or perform action
Child takes object and does something unrelated to the request or direction.

☐	☐	☐	☐	☐	☐	☐	☐
☐	☐	☐	☐	☐	☐	☐	☐

Eye Contact	☐	☐	☐	☐	☐	☐
Language	☐	☐	☐	☐	☐	☐
Reciprocal Behavior	☐	☐	☐	☐	☐	☐

Appendix D

Raw Data

LS

Pre-Treatment Sessions

		Number of Observances				
		Session 1	Session 2	Session 3	Session 4	**Avg**
Physical Manipulation						
Comply		7	1	9	3	**5**
	Language					
	Eye Contact					
	Reciprocal Action					
Does Not Comply		1	3		1	**1.7**
	Language					
	Eye Contact					
	Reciprocal Action					
Verbal Directive with a gesture or model						
Comply		15	9	20	14	**14.5**
	Language	2	5	7	3	**4.3**
	Eye Contact			1	1	**1**
	Reciprocal Action					
Does Not Comply		18	31	37	20	**26.5**
	Language			2		**2**
	Eye Contact	1		1		**1**
	Reciprocal Action					

LS

Post-Treatment Sessions

		Number of Observances			
		Session 1	Session 2	Session 3	**Avg**
Physical Manipulation					
Comply		9	13	12	**11.3**
	Language	2	6		**4**
	Eye Contact				
	Reciprocal Action				
Does Not Comply		2			**2**
	Language				
	Eye Contact				
	Reciprocal Action				
Verbal Directive with a gesture or model					
Comply		22	21	10	**17.7**
	Language	9	5	6	**6.7**
	Eye Contact				
	Reciprocal Action				
Does Not Comply		11	16	17	**14.7**
	Language		1	1	**1**
	Eye Contact				
	Reciprocal Action				

LR

Pre-Treatment Sessions

	Number of Observances						
	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6	**Avg**
Physical Manipulation							
Comply	24	22	8	12	9	22	**16.2**
Language							
Eye Contact	4		1	3	1		**2.3**
Reciprocal Action							
Does Not Comply			1	2	1		**1.3**
Language							
Eye Contact			1	1	1		**1**
Reciprocal Action							
Verbal Directive with a gesture or model							
Comply	24	16	18	12	5	15	**15**
Language							
Eye Contact	4			1	1		**2**
Reciprocal Action							
Does Not Comply	27	18	18	26	5	17	**18.5**
Language							
Eye Contact	3			1	1		**1.7**
Reciprocal Action							

LR

Post-Treatment Sessions

	Number of Observances			
	Session 1	Session 2	Session 3	**Avg**
Physical Manipulation				
Comply	4	13	14	**10.3**
Language				
Eye Contact			2	**2**
Reciprocal Action				
Does Not Comply		3		**3**
Language				
Eye Contact				
Reciprocal Action				
Verbal Directive with a gesture or model				
Comply	23	10	13	**15.3**
Language				
Eye Contact	2	1	3	**2**
Reciprocal Action				
Does Not Comply	16	23	25	**21.3**
Language				
Eye Contact		1	1	**1**
Reciprocal Action				

KR

Pre-Treatment Sessions

		Number of Observances				
	Session 1	Session 2	Session 3	Session 4	Session 5	**Avg**
Physical Manipulation						
Comply	5	12	1	12	1	**6.2**
Language		1				**1**
Eye Contact			1			**1**
Reciprocal Action						
Does Not Comply	6	1	1	1	3	**2.4**
Language	2					**2**
Eye Contact						
Reciprocal Action						
Verbal Directive with a gesture or model						
Comply	13	7	22	13	21	**15.2**
Language			2		10	**6**
Eye Contact	1				5	**3**
Reciprocal Action						
Does Not Comply	14	22	16	12	25	**17.8**
Language	1		1			**1**
Eye Contact		1	2		1	**1.3**
Reciprocal Action						

KR

Post-Treatment Sessions

		Number of Observances			
		Session 1	Session 2	Session 3	**Avg**
Physical Manipulation					
Comply		2	2		**2**
	Language				
	Eye Contact				
	Reciprocal Action				
Does Not Comply		2	1	1	**1.3**
	Language				
	Eye Contact			1	**1**
	Reciprocal Action				
Verbal Directive with a gesture or model					
Comply		22	15	6	**14.3**
	Language	1	3		**2**
	Eye Contact				
	Reciprocal Action				
Does Not Comply		30	34	22	**28**
	Language	1		1	**1**
	Eye Contact				
	Reciprocal Action				

AH

Pre-Treatment Sessions

	Session 1	Number of Observances Session 2	Session 3	**Avg**
Physical Manipulation				
Comply	3	4	9	**5.3**
Language				
Eye Contact				
Reciprocal Action				
Does Not Comply				
Language				
Eye Contact				
Reciprocal Action				
Verbal Directive with a gesture or model				
Comply	10	4	8	**7.3**
Language				
Eye Contact				
Reciprocal Action				
Does Not Comply	15	10	11	**12**
Language				
Eye Contact				
Reciprocal Action				

AH

Post-Treatment Sessions

		Number of Observances		
	Session 1	Session 2	Session 3	**Avg**
Physical Manipulation				
Comply	12	1	2	**5**
Language				
Eye Contact				
Reciprocal Action				
Does Not Comply				
Language				
Eye Contact				
Reciprocal Action				
Verbal Directive with a gesture or model				
Comply	11	15	22	**16**
Language	2	1		**1.5**
Eye Contact			1	**1**
Reciprocal Action				
Does Not Comply	9	14	6	**9.7**
Language				
Eye Contact				
Reciprocal Action				