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Examining the relationship between social communication on the ADOS and real-world reciprocal social communication in children with ASD

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Abstract

Background—While many children with autism spectrum disorders (ASDs) communicate better with adults than peers, diagnostic measures are given by adult examiners. These measures may not accurately capture the deficits that children with ASD have in communicating with their peers.

Method—This study examined the ability of the Autism Diagnostic Observation Schedule (ADOS) Social Communication scale to predict reciprocal communication in children with ASD during natural play with peers using the Peer Interaction Paradigm (PIP). Thirty participants with ASD were given the ADOS and then participated in the PIP, after which their behavior was analyzed.

Results—Using linear regression, we found that Social Communication was the primary significant predictor for reciprocal communication during play, and that reciprocal communication was not predicted by Verbal IQ or the Restrictive and Repetitive Behaviors scale on the ADOS.

Conclusions—The findings suggest that the ADOS measures naturally-occurring social communication patterns with peers and can be used to inform treatment options for children with ASD based on an accurate measure of their level of impairment in social communication.

Keywords

ASD; ADOS; Social Communication; Play; Assessment

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Conflicts of Interest

The authors declared that they have no potential or competing conflicts of interest.

Introduction

Autism spectrum disorder (ASD) is a developmental disorder characterized by deficits in social communication and interaction, as well as by restricted interests and repetitive behaviors (APA, 2013). Among the earliest recognized and most pronounced symptoms of ASD are deficits in the formation of social communication skills (Charman & Stone, 2008). Due to these deficits, many children with ASD participate in fewer social interactions than typically developing (TD) children (Lord & MaGill-Evans, 1995), struggle more with participating when they do try to interact, and seem to be less aware of their social difficulties (Bauminger, Shulman, & Agam, 2003). These challenges often lead to difficulty forming friendships (e.g., Carrington, Templeton, & Papinczak, 2003; Fein, 2015; Orsmond, Krauss, & Seltzer, 2004) and greater stress in social situations (e.g., Corbett, Schupp, Simon, Ryan, & Mendoza, 2010; Corbett, Schupp, & Lanni, 2012). In contrast, children with ASD who do participate in reciprocal social interactions are more included in school, involved in more social and extra-curricular activities, and have greater independent living skills (Orsmond et al., 2004). Therefore, having a measure of social communication ability that accurately maps onto real-world social communication with peers is necessary to provide accurate recommendations to improve the lives of those affected by the disorder.

Social communication refers to the behavioral expression of emotional and cognitive information through gesture, facial expression, and speech prosody (Robertson, Tanguay, L'Ecuyer, Sims, & Waltrip, 1999). Development of social communication begins at an early age, when infants learn to socially reference the facial expressions and gaze direction of caregivers. For children later diagnosed with ASD, impairments in joint attention and deficits in the use of symbols to communicate meaning typically appear in the first twelve months, and these deficits often evolve into the inability to communicate with social purpose (Weatherby, 2006). Ozonoff, Dawson, and McPartland (2002) illustrate several examples of social communication deficits in ASD, which include difficulty with initiating interactions with others, responding to social overtures, using appropriate vocal tone and gesture, taking another's perspective, and participating in back and forth conversations. Children with ASD can also demonstrate unusual or repetitive language in the form of echolalia of other people, scripting from television or movies, and using neologisms (Ozonoff et al., 2002). Children with higher-functioning versus lower-functioning ASD often have more subtle differences in speech, such as unusual prosody or intonation and difficulty with the pragmatics of language (i.e., situational context; Landa, 2000; Peppe, McCann, Gibbon, O'Hare, & Rutherford, 2007; E. Rubin & Lennon, 2004). Deficits in social communication skills affect children with ASD in several areas, including their abilities to form friendships (Carrington, Templeton, & Papinczak, 2003; Fein, 2015), make social overtures (Lord & MaGill-Evans, 1995), and have stress-free interactions with peers (Corbett et al., 2010; Corbett et al., 2012; Schupp, Simon, & Corbett, 2013).

The diagnosis of ASD is complicated by several factors in that there is no biomarker for ASD, diagnosis is based solely on observable traits, and the behavioral standards for ASD continue to change over time (Ozonoff, Rogers, & Hendren, 2003). Therefore, for an instrument to be able to effectively and accurately indicate a diagnosis, it must require subjects to demonstrate the same skills and deficits during the assessment as they exhibit in

daily life (Spooner & Pachana, 2006). The Autism Diagnostic Observation Schedule (ADOS-G and ADOS-2, collectively referred to as ADOS in this manuscript; Lord et al., 2000, 2012) utilizes direct observation via a collection of structured and unstructured activities designed to elicit behaviors that are coded based on their similarity to the characteristics of ASD. The ADOS-G and the ADOS-2 were developed from earlier versions of the ADOS (DiLavore, Lord, & Rutter, 1995; Lord et al., 1994) and revised to provide a standardized environment for the behavioral observation of a broad range of ages and developmental stages. The evidence from the ADOS is utilized in addition to parental interviews and clinical judgment to support a diagnosis of ASD (Lord et al., 2000, 2012).

The ADOS contains four modules, each aimed at a specific stage of verbal and chronological development. Module 1 is designed for use with children who are preverbal or who speak in single words and simple phrases. Module 2 assesses children with flexible phrase speech, but without the fluency required to merit using Module 3. Modules 3 and 4 are both used for individuals with fluent speech, but Module 4 has questions and activities more appropriate for older adolescents and adults. During the administration of the ADOS, specific social opportunities, or "presses," are created in order to elicit specific behaviors from the individual being assessed. For example, one of the "presses" given by the ADOS examiner is a statement designed to easily elicit a question from the participant (e.g., "I've been to a very fun place on vacation"). Such an open-ended prompt is not present in most natural conversation. These presses are part of the standardized environment created during the ADOS assessment. The activities, items, and questions used as a part of the ADOS administration are also kept consistent between assessments, though they differ between modules based on propriety for developmental age (Lord et al., 2000, 2012).

The ADOS performs well on several commonly used psychometrics including inter-rater agreement and test-retest reliability (see Method section). Importantly, demographic variables such as age and verbal ability level are not significantly correlated with algorithm items. This demonstrates that the ADOS scores reflect diagnostic classification independently of verbal, mental, and chronological age. In their standardization of the instrument, the ADOS-2 algorithm correctly classified nearly 95% of individuals with ASD and 92% of those that did not meet diagnostic criteria (Lord et al., 2012).

ADOS scores have also been shown to relate to parental report of child behavior. Pierucci and colleagues (2015) examined play in preschool-aged children by comparing clinician measures of play to parent reports of play and a measure of developmental skills. They compared a composite of the play scores from the ADOS (Module 1 and Toddler Module) and the Childhood Autism Rating Scales 2nd Edition, Standard Form (CARS2-ST; Schopler, Van Bourgondien, Wellman, & Love, 2010) to play scores from the parent-reported Communication and Symbolic Behavior Scales Developmental Profile, Infant-Toddler Checklist (CSBS DP-ITC; Wetherby & Prizant, 2002) and Adaptive Behavior Assessment System, 2nd Edition (ABAS-II; Harrison & Oakland, 2003). They did not find a significant agreement between clinicians' ratings on the ADOS and the CARS-2ST, and parents' ratings on the CSBS DP-ITC and the ABAS-II in relation to the level of play skills in children. However, ADOS play scores correlated with the developmental skills of children as

measured on the Mullen Scales of Early Learning (MSEL; Mullen, 1995) Expressive Language scale ($r = -.46$) and Fine Motor Skills scale ($r = -.51$; Pierucci et al., 2015).

Although psychological assessments and measures such as the ADOS (Lord et al., 2000, 2012), are the most widely-used medium to measure social communication behavior, some researchers, such as Stone and Caro-Martinez (1990), argue that observing interactions in natural environments, such as during informal play, is best. Play is extremely important for all types of development, including cognitive, motor, and especially social, which is most impaired in children with ASD (Boucher, 1999; Jordan & Libby, 1997; Pellegrini & Smith, 1998; K. H. Rubin, Fein, & Vandenberg, 1983; Vygotsky, 1978). Play can assist developmentally in a variety of ways. Boucher (1999) suggests that play allows children to develop new skills through trial and error in non-critical, supportive environments. Such supportive environments are critical for skill development, especially for the development of social skills (Corbett, Qualls, et al., 2014). Social play also enables children to learn about culture and gain insight into the minds of others that is needed to form friendships (Jordan, 2003). Previous studies (Rodman et al., 2010) have looked at ADOS-G scores in relation to play in younger children. Their findings suggest that preschool-aged children with ASD who had a greater diversity of play, more object exploration, and more turn-taking in their play had lower scores on the ADOS-G, indicating less ASD symptomology. While studies like this one have related ADOS scores to play, they have not compared Social Communication on the ADOS to peer social communication in a natural environment.

The Peer Interaction Paradigm (PIP) was developed by researchers to address difficulties in natural play observation (Corbett et al., 2010). As described in detail in the Method section of this manuscript, the PIP uses remotely-operated cameras and battery-operated microphones concealed in a waist pack to make audio and 360° video recordings of natural play behavior on the playground. Additionally, the PIP provides structure to the interaction by having a trained confederate invite participants to play in order to provide a more robust opportunity for children with ASD to display social behavior, especially social communication with peers. The video recordings from the PIP are coded in the Noldus: The Observer Program (Noldus Information Technology Inc., 2008), which allows for the coding of behaviors from multiple subjects simultaneously with temporal accuracy down to the hundredth of a second.

The most recent study using the PIP examined the differences in play behavior between children with ASD and typically developing (TD) children. Corbett, Swain, Newsom, and colleagues (2014) found that behavior during periods of independent play did not differ between children with ASD and TD children. However, during solicited play by a confederate, the participants with ASD more often refused the confederate's offer of play, engaged in less verbal interaction, and continued to play by themselves. As found in previous studies (Corbett et al., 2010; Schupp et al., 2012), children with ASD showed a higher cortisol stress response to social play and those children with the highest stress levels communicated less (Corbett, Swain, Newsom et al., 2014).

These findings demonstrate that the PIP is an effective way to measure the natural social behavior of children with ASD. While the ADOS simulates play and social communication,

the scenarios involve interaction between the child and an adult examiner. As many children with ASD have more problems initiating social interactions with peers their own age than adults (Hauck et al., 1995; Ingram et al., 2007), the play and social communication seen during the ADOS may not accurately represent natural interaction with peers. In this study, we examined the degree to which the two subscales of the ADOS predict reciprocal social behavior in children with ASD during natural play with peers using the Peer Interaction Paradigm. We predicted that higher scores on the Social Communication subscale of the ADOS (more severe ASD symptomology) would be associated with less reciprocal communication with peers on the playground, but that scores on the Restricted and Repetitive Behavior subscale would not predict reciprocal communication with peers.

Method

Participants

Thirty un-medicated children with ASD (27 males) between the ages of 8 and 12 years comprised the study sample (see Table 1). ASD diagnosis was established by a previous diagnosis by a psychologist, psychiatrist, or behavioral pediatrician with ASD experience and confirmed by the Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003) and the Autism Diagnostic Observation Schedule (ADOS-G, Lord et al., 2000 or ADOS-2; Lord et al., 2012). The ADOS was administered by research-reliable personnel, and participants were required to have a total score at or above the ASD threshold for Module 3 (see below). While the ADOS-G was used for earlier participants and the ADOS-2 for later participants, scores from the ADOS-G were converted to ADOS-2 scores using the revised ADOS algorithm (Gotham, Risi, Pickles, & Lord, 2007).

The Vanderbilt Institutional Review Board – Human Subjects Committee approved this study. This study was carried out consistent with the Declaration of Helsinki (as revised in 2000).Written informed consent was obtained from parents and child participants prior to study inclusion. Study participation required two visits to Vanderbilt University. Visit 1 consisted of a 2- to 3-hour assessment in which the ADOS and other neuropsychological measures were administered. Visit 2 consisted of the Peer Interaction Paradigm (PIP). The visits occurred within a 1-month period, and Visit 2 was always conducted in the afternoon between 2:00 and 5:00 pm.

Diagnostic and Inclusion Variables

Autism Diagnostic Observation Schedule—The ADOS-G and ADOS-2 (Lord et al., 2000, 2012). use structured and unstructured activities to elicit specific behaviors. These behaviors are scored by trained observers in the degree to which they are characteristic of ASD-like behavior. These behaviors are divided between three subscales, the Communication and Reciprocal Social Interaction subscales, which together form the Social Communication total, and the Restricted Interests and Repetitive Behaviors subscale. All participants received the ADOS if one had not been completed in the last two years or if their previous scores were not available. A total Social Communication score of 7 or greater was required for inclusion in this study. The mean scores and standard deviations for these

subscales are shown in Table 1. All of our participants were at or above the verbal ability level needed to be assessed with the Module 3 of the ADOS.

The psychometric properties of the ADOS reported in the literature indicate that it is a valid and reliable instrument. On the Module 3, all items rated received an inter-rater agreement of more than 80%. Test-retest reliabilities have been found to be excellent in the Social and Communication domains that make up the Social-Communication score, and good for the Stereotyped Behaviors and Restricted Interests score. Cronbach's alpha, which measures internal consistency, was very high for the Social-Communication totals for all modules (.91 – .94), fairly high for the Social domain (.86–.91), slightly lower for the Communication domain (.74 – .84), and lower still for the Stereotyped Behaviors and Restricted Interests domain (.47 – .65; Lord et al., 2012).

Wechsler Abbreviated Scale of Intelligence—The Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) measures cognitive ability to estimate intellectual functioning. Inclusion in the study required an estimated IQ of 70 or higher. Average Verbal, Performance, and Full-Scale IQs are displayed in Table 1. Verbal IQ and Performance IQ were analyzed as separate variables due to the impact that Verbal IQ could have on social communication with peers (see Hauck et al., 1995).

Social Communication Questionnaire—The Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003) is a 40-item parent report measure for ages 4 and up that assesses a child's risk for ASD based on current and past behaviors. The Lifetime form, which asks about behaviors observed at any point during a child's life in addition to behaviors seen between four and five years of age, was used as a part of the screening process for ASD (scores ≥ 15 are suggestive of ASD). Mean SCQ scores for ASD participants are displayed in Table 1. Participants with ASD all scored 15 or higher and TD participants scored 10 or lower.

Social Responsiveness Scale-Second Edition—The Social Responsiveness Scale-Second Edition (SRS-2; Constantino & Gruber, 2012) is a 65-question parent rating form that provides a measure of a child's social reciprocity and social communication. The School-Age Form, which applies to ages 4 to 18, was used as a part of the screening process for ASD (scores ≥ 70 are suggestive of ASD). Mean SRS scores for ASD participants are displayed in Table 1. Participants with ASD all scored 70 or higher and all TD participants scored below 70.

The Peer Interaction Paradigm—The Peer Interaction Paradigm (PIP) was developed to observe social exchanges between children with and without ASD in a naturalistic playground setting (Corbett et al., 2010). The paradigm lasts 20 minutes and alternates between periods of unstructured play and periods where social interaction is solicited by a typically developing confederate of the same age and gender. The 40 by 36.5 m (130 by 120 ft) fenced-in playground is attached to the Susan Gray School at Vanderbilt University and contains swings, large equipment with walkways, and open space for cooperative games. Adult researchers monitor the interactions from the behavioral lab inside the building, which allowed the participants to play more naturally. The protocol was video recorded using four

professional 70 Sony PTZ (New York, NY, USA) remotely operated cameras housed in glass cases and affixed to the four corners of the playground. The cameras had the ability to pan, tilt, and zoom, which allowed the playground to be fully viable to the research personnel. Participants were audio recorded using Sennheiser body packs (Old Lyme, CT, USA) and Audio-Technica transmitters and receivers (Stow, OH, USA) were used to communicate with the confederate. Battery-operated microphones were clipped to the shirt of each child and recorded simultaneously using an eight-channel mixing board.

Each interaction paradigm involved three children, a TD confederate of the same age and gender as the participants, a TD child, and a child with ASD. The children were unfamiliar with each other prior to participation in the study. The confederate and TD participant had no significant mental health diagnoses and no siblings with ASD, which was confirmed by the parent during the initial screening. The confederate structured the play according to instructions given by the research personnel, which allowed certain interactive sequences to occur at the appointed times while giving the appearance of a natural interaction. The confederate invited both participants to play when cued by research personnel.

Each 20-minute interaction period was subdivided into four 5-min time (T) periods of free play and invited play. The first period (T1) consisted of independent free play. For the second time period (T2), the two participants were invited to play on the equipment by the confederate. The confederate was instructed to leave during the third period (T3) and to allow the participants to play independently once more. During the fourth time period (T4), the confederate invited the participants to play with toys that had been placed by the research staff during the beginning of T3.

Behavioral Coding—Analysis of the interaction observation data was done in Noldus: The Observer XT Version 8.0 (Noldus Information Technology Inc., 2008). The previously established protocol was used to analyze the data (Corbett et al., 2010; Corbett, Swain, Newsom, et al., 2014; Schupp, Simon, & Corbett, 2013). Social communication and interaction variables used included Verbal Bout (reciprocal verbal exchange between two or more children) and Self-play (independent play with a toy or object alone but in the presence of others), among others that were not used in this analysis. Verbal Bout was chosen to be analyzed because it represented social communication between peers, which was the focus of this study. Self-play was chosen to be analyzed because it is a variable which has previously been found to differ between children with ASD and TD during the PIP (Corbett, Swain, Newsom, et al., 2014). Its inclusion in the analysis would indicate if the ADOS Social Communication subscale predicted peer communication specifically, or if it also predicted other aspects of ASD symptomology (indicated by Self-play). A verbal bout was coded whenever a participant had at least a two-point conversation with another participant. For example, the exchange “Do you like this truck?” “I do” would fit the criteria for a verbal bout. The verbal bout code lasted as long as the pair was engaged in back and forth conversation, and a new verbal bout was started whenever fifteen seconds of silence had passed between the pair. Self-play was coded whenever a child was engaged in meaningful playful activity with a toy or object alone but nearby others. The self-play code lasted as long as the child was playing, and a new self-play code was started if the child started playing again after fifteen seconds had elapsed since the last code ended. Each of the four

time periods was coded separately. The amount of time a participant was engaged in each behavior was standardized by using the percent duration of the video that the behavior was taking place (from 0% to 100%). Inter-rater reliability was calculated for a random sample of 25% of observations. Observer (Noldus Information Technology Inc., 2008) reliability calculations for the specific behaviors were Verbal Bout 90% ($k = 0.85$) and Self-play 90% ($k = 0.85$; see Table 1 for Verbal Bout and Self-play mean values).

Statistical Analysis

All statistical analyses were conducted using SPSS Software, Version 21.0 (SPSS Inc., Chicago, IL, USA). Preliminary analyses included a correlation matrix of all of the major variables, as well as a univariate between-subjects analysis of variance to test for a difference in percentage duration of Verbal Bout between participants with ASD and TD participants. For the primary analysis, separate linear regressions models were performed with Verbal Bout or Self-play as the dependent variables and diagnostic and demographic variables (verbal IQ, age, the ADOS Social Communication, and the Restricted Interests and Repetitive Behaviors subscales) as predictors. Time period 4 of the PIP was chosen for analysis as this was one of the time periods during which participants were solicited for play, thus giving all participants a chance to display interactive behaviors.

Results

Preliminary Analyses

Demographic data are presented in Table 1. To rule out the effects of age and verbal IQ, a correlation matrix was run with the major variables (see Table 2). Age did not correlate with either Verbal Bout [$r = .11$, $p = .34$] or Self-play [$r = -.08$, $p = .51$], and Verbal IQ did not correlate with either Verbal Bout [$r = .17$, $p = .18$] or Self-play [$r = -.18$, $p = .15$].

These correlations were also examined to see if parent-reported social reciprocity and social communication on the SRS-2 was related to Verbal Bout and Self-play in the PIP. There was a significant negative correlation between Verbal Bout and the SRS-2 [$r = -.28$, $p = .02$] and a significant positive correlation between Self-play and the SRS-2 [$r = .25$, $p = .04$]. These correlations are in the expected direction, because longer Verbal Bouts would indicate less ASD symptomology and more Self-Play would indicate more ASD symptomology.

A univariate between-subjects analysis of variance (ANOVA) was performed to test for significant differences in Verbal Bout duration between participants with ASD and TD participants. There was a significant effect of diagnosis on percent duration of Verbal Bout, $F(1,71) = 4.96$, $p < .05$, partial $\eta^2 = .07$ (medium effect size), with Verbal Bout percent duration of participants with ASD ($M = 73.88$, $SD = 35.74$) being significantly lower than that of TD participants ($M = 89.34$, $SD = 18.37$).

Primary Analyses

A linear regression was performed with Verbal Bout as the criterion variable and with the Social Communication subscale, the Restricted and Repetitive Behaviors subscale, age, and verbal IQ as predictors. The overall regression was found to be significant with a large effect

size, R^2 = .37, p = .017. Among the predictors, only the Social Communication subscale was significant t = −3.32, p = .003 (see Figure 1). The other variables were not significant (see Table 3). A separate linear regression was conducted to examine the predictors of Self-play. The Social Communication subscale, the Restricted and Repetitive Behaviors subscale, age, and verbal IQ were included as predictors. The regression was not found to be significant, R^2= .10, p = 0.59. The diagnostic and demographics variables (ADOS Social Communication, ADOS Restricted Interests and Repetitive Behaviors subscale, age, and verbal IQ) did not predict Self-play behavior on the playground, t = 1.158, p = .26 (see Table 3).

Discussion

The study examined the degree to which the gold-standard diagnostic measure, the ADOS, predicted reciprocal social behavior in children with ASD during natural play with peers. Our preliminary analyses found that parent ratings of social reciprocity and social communication on the SRS-2 were significantly correlated in the expected direction with variables of social interaction in the PIP, and that participants with ASD spent less time in reciprocal social communication with peers than TD participants.

Our primary hypothesis was that higher ADOS Social Communication symptom severity would be associated with less reciprocal social exchange with peers during play. Additionally, we hypothesized that there would be no relationship between Restricted and Repetitive Behavior symptom severity and social exchange with peers during play. The results supported these hypotheses by indicating that the Social Communication score on the ADOS was predictive of reciprocal social communication in a natural playground setting for children with ASD. In contrast, there was no significant relationship between the Restricted and Repetitive behavior subscale and reciprocal social communication. Verbal IQ was also found not to predict reciprocal social communication with peers. That is, the Social Communication subscale alone, and not verbal ability or other aspects of ASD symptomology, relates to the degree to which children with ASD verbally interact in a natural setting. Additionally, the fact that Social Communication did not predict Self-play highlights the specificity of the subscale to reflect what it was designed to predict, which is suggestive of good construct validity.

This predictive ability of the diagnostic measure suggested by this study is important due to the time constraints of a typical assessment and the need to accurately identify a child's deficits. The specificity of this relationship indicates that the ADOS and PIP are measuring communication characteristics in ASD that carry across settings (between a clinic and a playground) and conversational partners (adults and peers). The capacity of the ADOS Social Communication scale to measure comparable communication difficulties that are present with peers in the playground allows the clinician to make appropriate recommendations for social skills training. This is an important distinction given that children with ASD usually converse more with adults, such as the examiners performing the ADOS, than peers in play settings (Hauck et al., 1995).

While other studies have compared ADOS composite scores to general play behaviors and developmental skills (e.g., Pierucci et al., 2015; Rodman et al., 2010), this study is the first that compares scores of Social Communication on the ADOS to peer communication in a structured, naturalistic setting. The activities and questions used to elicit behaviors that are scored on the ADOS Social Communication algorithm are able to be performed by a clinician in a short span of time in a clinical environment. However, as this study shows, the results obtained from that algorithm are representative of social communication behaviors that children with ASD display in a natural play environment. These results should encourage further study of the construct validity of diagnostic and neuropsychological measures.

Strengths

Our participants were a well-characterized, un-medicated sample of prepubescent children with ASD between 8 to 12 years of age. Additionally, the PIP is an ecologically valid and established paradigm that represents real world social interaction patterns among children with and without ASD and correlates significantly with parent measures of social reciprocity and social communication. Our analysis also examined potentially confounding variables (age and verbal IQ) and was able to confirm that they did not influence our findings. Additionally, we were able to test the specificity of the interaction by ruling out the Social Communication scale of the ADOS as a predictor of other behaviors previously found to be associated with an ASD diagnosis (i.e., Self-play).

Limitations

The participants in this sample were mainly on the higher-functioning end of the autism spectrum (an IQ >70 was required in order to participate). Therefore, we were not able to examine if the relationship between ADOS Social Communication and reciprocal communication with peers is predictive for individuals with symptom profiles considered to be lower-functioning. Additionally, the sample was moderate in size with a narrow age range, but as stated above, the participants were well-characterized by experts in ASD.

Future Directions

Based on the findings above for the Module 3 of the ADOS, it may be valuable to examine the scales on other modules of the ADOS for their ability to predict behavior in a natural setting. As stated above, modules are selected based on the verbal ability of the child being assessed, and the activities that form the Social Communication score differ between modules. Given these factors, the scales from each module would need to be assessed independently to find evidence of content validity. Additionally, it may be useful to examine the relationship between performance on the PIP and the calibrated severity scores present on the ADOS-2 to determine how overall ASD symptomology relates to play with peers.

Finally, these findings resemble those of our previous paper on the ecological validity of a facial memory task in relation to playground behavior (Corbett, Newsom et al., 2014). In comparing diagnostic and psychological measures to careful observations of natural interaction, researchers can methodically examine the representativeness of clinical instruments. Olson and colleagues found that the relationship between scores on a particular

measure and real-world functioning in children was an under-studied topic (Olson, Jacobson, & Van Oot, 2013). This is problematic considering that diagnostic and psychological tests are used to predict outcomes in adaptive and everyday functioning (Chaytor & Schmitter-Edgecombe, 2003). In addition, Spooner and Pachana (2006) argue that tests designed to be ecologically valid may be the most effective in predicting daily functioning if these tests measure the same skills that are required in daily living. Since many psychologists are slow to abandon traditional tests (Spooner & Pachana, 2006), it could be useful to compare diagnostic and neuropsychological measures that currently exist to new paradigms that are created to be more characteristic of daily functioning.

Implications

Social communication is one of the major impairments shown in autism spectrum disorder. Having a measure of social communication that is reliable, easy to give in a clinical setting, and that maps onto real-world reciprocal communication behavior is important to the clinicians who may use it as a basis for their treatment recommendations. The results suggest that the communication difficulties with which individuals on the autism spectrum struggle in daily life correlate to those measured by the ADOS Social Communication construct. Furthermore, these conversational impairments appear across contexts and conversational partners. Since these scores given by trained clinicians who perform the ADOS reflect an individual's socially communicative functioning in multiple environments, practitioners can confidently use ADOS Social Communication scores to make appropriate treatment recommendations to improve that individual's social communication skills.

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Highlights

- Social Communication on the ADOS predicts reciprocal communication with peers.
- Verbal IQ and Restrictive and Repetitive Behaviors do not show this relationship.
- Social Communication score can be used to plan interventions for children with ASD.

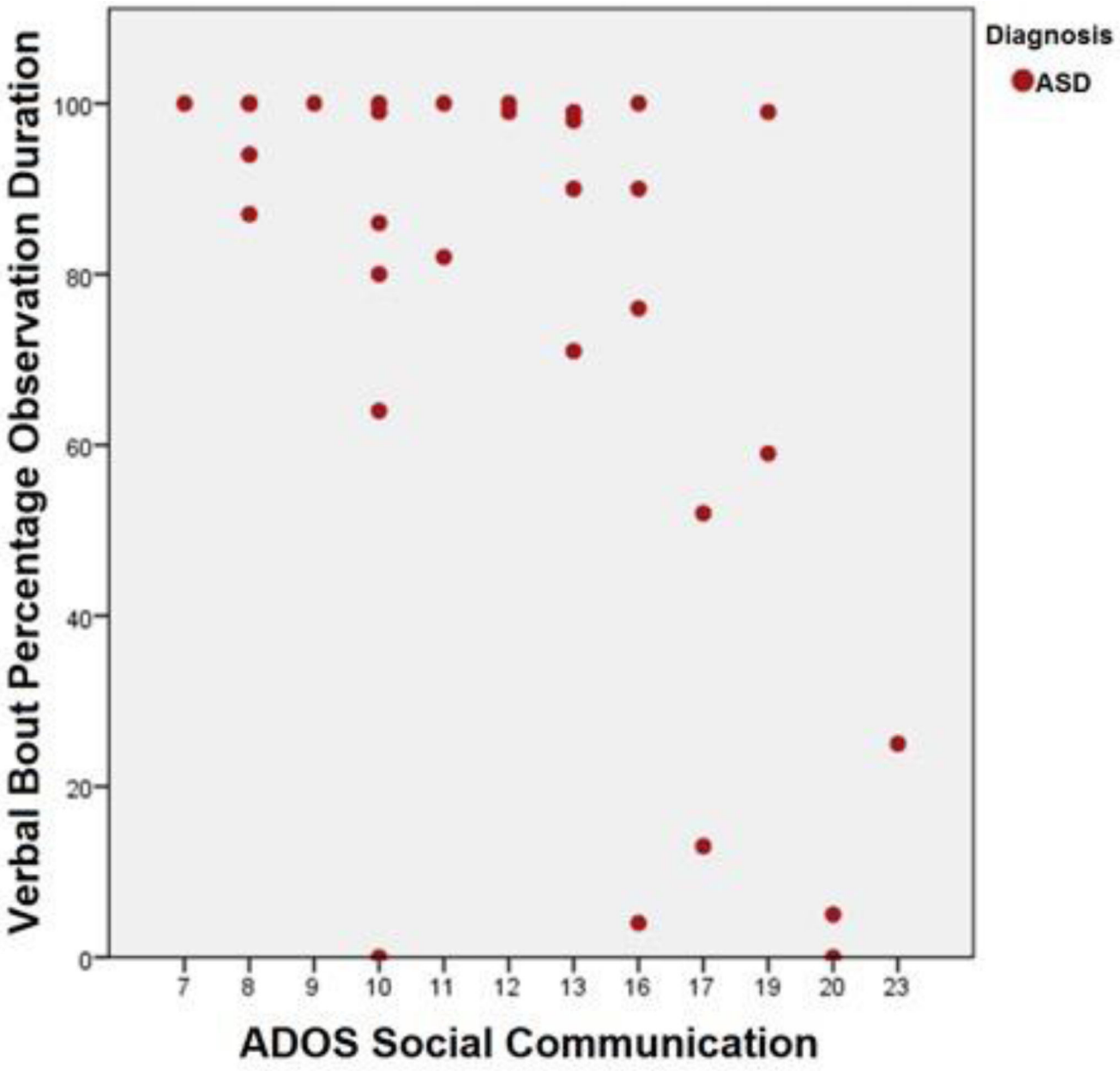

Figure 1.
The correlation between percent time spent in a verbal bout and scores on the ADOS Social Communication Scale

Table 1

Means and Standard Deviations of Descriptive Variables for ASD Participants

Descriptive variables	Mean	SD
Age	9.96	1.60
Verbal IQ	102.87	22.90
Performance IQ	103.80	20.22
Full-Scale IQ	106.27	25.02
SCQ	21.27	7.01
SRS-2	80.51	9.49
ADOS Social Communication	12.83	4.17
ADOS Restricted/ Repetitive Behaviors	2.73	1.51
PIP Verbal Bout	75.73	33.11
PIP Self-play	23.50	27.89

Note: SCQ = Social Communication Questionnaire, SRS-2 = Social Responsiveness Scale-Second Edition, ADOS = Autism Diagnostic Observation Schedule, PIP = Peer Interaction Paradigm

Table 2

Correlations Among Primary Variables

	2	3	4	5	6	7	8	9	10
1. Age	−.15	−.11	−.15	.01	.12	−.11	−.11	.11	−.08
2. Verbal IQ	-	.64**	.82**	−.40**	−.43**	−.46**	−.07	.17	−.18
3. Performance IQ		-	.75**	−.16	−.23	−.11	−.10	−.09	−.09
4. Full-Scale IQ			-	−.33**	−.34**	−.26	−.04	.02	−.09
5. SCQ				-	.88**	.26	−.14	−.41**	.30*
6. SRS-2					-	.14	−.18	−.28*	.25*
7. ADOS Social Communication						-	.13	−.57**	.20
8. ADOS Restricted/ Repetitive Behaviors							-	−.34*	.27
9. PIP Verbal Bout								-	−.74**
10. PIP Self-play									-

Note

* $p \leq .05$,

** $p \leq .01$, SCQ = Social Communication Questionnaire, SRS-2 = Social Responsiveness Scale-Second Edition, ADOS = Autism Diagnostic Observation Schedule, PIP = Peer Interaction Paradigm

Table 3

Summary of Simple Regression Analyses for Variables Predicting PIP Verbal Bout and Self-Play

	Verbal Bout				Self-play			
Predictors	**B**	**SE B**	**β**	**t**	**B**	**SE**	**β**	**t**
ADOS Social Communication	−4.70	1.42	−.59	−3.317**	1.65	1.42	0.25	1.16
ADOS Restricted/ Repetitive Behaviors	−4.99	3.69	−.23	−1.35	2.08	3.71	0.11	0.56
Age	1.21	3.46	.06	0.35	−2.51	3.48	−0.14	−0.72
Verbal IQ	−0.29	0.26	−.20	−1.13	0.21	0.26	0.17	0.79
R^2		.37				.10		
F		3.68*				0.72		

Note. $N = 30$;

* $p \leq .01$,

** $p \leq .005$. ADOS = Autism Diagnostic Observation Schedule, PIP = Peer Interaction Paradigm

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