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Receptive and Expressive Language as Predictors of Restricted and Repetitive Behaviors in Young Children with Autism Spectrum Disorders

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Abstract

This study examined whether language skills and nonverbal cognitive skills were associated with clinician-observed restricted and repetitive behaviors (RRBs) in a sample of 115 children with ASD at ages 2 and 3. By age 3, RRBs were significantly negatively correlated with receptive and expressive language, as well as nonverbal cognitive skills. Increases in receptive and expressive language from age 2 to 3 significantly predicted decreases in RRBs, controlling for age in months, time between visits, and gains in nonverbal cognitive skills. This study contributes to the limited research that has examined early patterns and predictors of RRBs in young children with ASD.

Keywords

restricted and repetitive behaviors (RRBs); language; autism; nonverbal cognitive skills; toddlers; preschoolers

As a core feature of autism spectrum disorders (ASD), restricted and repetitive behaviors (RRBs) have been a focus of research and theoretical consideration over the years (e.g., Baron-Cohen, 1989; Kanner, 1943; Rimland, 1964; Ritvo, Ornitz, & La Franchi, 1968; Strongman, 1984; Turner, 1999; Cuccaro, Shao, Grubber, Slifer, Wolpert, Donnelly et al., 2003), but not to the same extent as the domains of social interaction and communication (Richler, Huerta, Bishop, & Lord, 2010). RRBs represent a heterogeneous class of behaviors including repetitive motor mannerisms, preoccupation with parts of objects, inflexible adherence to non-functional routines, and preoccupation with restricted patterns of interest (DSM-IV; American Psychiatric Association, 1994). Most factor-analytic research (Cuccaro et al., 2003; Bishop, Richler, & Lord, 2006; Richler, Bishop, Kleinke, & Lord, 2007; Richler et al., 2010; Szatmari, Georgiades, Bryson, Zwaigenbaum, Roberts, Mahoney et al., 2006) has provided evidence for two types of RRBs, as measured by the Autism Diagnostic Interview-Revised (ADI-R; Rutter, LeCouteur, & Lord, 2003): repetitive sensorimotor (RSM) behaviors and insistence on sameness (IS). Repetitive sensorimotor behaviors include unusual sensory interests (e.g., sniffing all toys); hand, finger, and body mannerisms (e.g., hand flapping while jumping); repetitive use of objects or parts of objects (e.g., repeatedly lining up toy cars; Richler et al., 2010; Szatmari et al., 2006). Insistence on sameness includes difficulties with changes in routine (e.g., becoming very upset when school bus takes a new route) or trivial changes in the environment (e.g., becoming distressed when living room furniture is rearranged) and the presence of compulsions or

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rituals (e.g., turning off all the lights in the house in a particular order; Richler et al., 2010; Szatmari et al., 2006). Some researchers have found support for additional distinct types of RRBs, such as circumscribed or restricted interests (Lam, Bodfish, & Piven, 2008; Mirenda, Smith, Vaillancourt, Georgiades, Duku, Szatmari et al., 2010) and self-injurious behaviors (Mirenda et al., 2010).

RRBs in Young Children with ASD

Parent-reported RRBs have been documented in children with ASD as young as 2 years of age and have been shown to be more prevalent and severe than repetitive behaviors in same-age typically developing children and peers with non-spectrum developmental disorders (Richler et al., 2007). Based on parent responses from the ADI-R, Richler and colleagues (2007) found that, as a group, two-year-old children with ASD had a significantly higher prevalence of, and more severe ratings (i.e., a higher proportion of scores of “2”) for, unusual preoccupations, unusual sensory interests, repetitive use of objects, hand/finger and complex body mannerisms, abnormal/idiosyncratic responses to sensory stimuli, and difficulties with changes in routine than same-age children with non-spectrum developmental disorders and typically developing peers. Unusual attachments to objects were also significantly more prevalent among children with ASD than the two comparison groups and were rated as more severe when compared to the typically developing children. A significantly greater mean number of RSM items, in particular, were endorsed for the ASD group than for the other two groups of children (Richler et al., 2007).

Clinician-observed RRBs from the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002) have also been shown to be more prevalent among toddlers and young children with ASD than peers with non-spectrum disorders and typical development, controlling for age, nonverbal cognitive skills, and gender (Kim & Lord, 2010). Kim and Lord did not find that the severity of RRBs was associated with age for children with ASD, which the authors suggested was evidence for the stability of RRBs over time. Girls were more likely to exhibit repetitive behaviors than boys. Aside from the Kim and Lord (2010) study, most research on RRBs has not utilized clinican ratings from the ADOS, although the need to corroborate parent reports of RRBs with observational data has been identified (Bishop et al., 2006; Leekham et al., 2011; Richler et al., 2010). In the present study, we sought to examine clinician-observed RRBs in young children with ASD to extend the limited literature based on this type of RRB measurement.

Theoretical Explanations of RRBs in ASD

Leekam, Prior, and Uljarevic (2011) recently conducted a comprehensive review of research on RRBs in ASD over the last decade. They noted that, although there has been limited theoretical work exploring the possible causes and functions of RRBs, theoretical explanations have been proposed in the areas of neurobiology, neuropsychology, and developmental psychology. Neurobiological explanations of RRBs focused on gene-environment neuroadaptation have received support from research based on animal models. Neuropsychological perspectives have emphasized the role of executive functioning in RRBs, although research based on these accounts has produced mixed results. Developmental psychological theories have framed RRBs, specifically those with a sensorimotor component, as having adaptive functions in typical infant development and being maintained beyond the typical developmental period in individuals with ASD.

The developmental psychological approach includes the roles of arousal and unstructured environments as proximal triggers for RRBs. For example, Leekham and colleagues (2011) highlight recent evidence that suggests RRBs in very young children with ASD may serve functions such as occupying oneself and self-soothing and can interfere with new learning

and social experience. Leekham et al. interpret these findings in the context of proximal triggers, such that high arousal may lead to self-soothing behaviors and low arousal may lead to the need to occupy oneself. The authors argue for an integrative developmental approach to research on RRBs in ASD and note that, to date, little is known about the developmental trajectories of RRBs in ASD. In the current study, we aimed to contribute to the body of existing research by examining changes in RRBs and their associations with gains in functional skills during early childhood.

Relationship Between RRBs and Cognitive and Language Skills

Although the severity of some RRBs may be relatively stable over time, there is growing evidence that age interacts with the relationship between RRBs and nonverbal cognitive skills among children with ASD (Bishop et al., 2006; Kim & Lord, 2010). For example, in a study of children with ASD under 12 years old, increasing age was associated with a stronger negative relationship between nonverbal IQ and several RRBs, as reported on the ADI-R (Bishop et al., 2006). The results of research by Kim and Lord (2010) indicated that nonverbal cognitive skills were negatively associated with RRBs on the ADOS for children ages 25 to 56 months, but the association was not significant for children under 25 months. Surprisingly, when their sample of young children with ASD was separated by diagnosis (i.e., autism and pervasive developmental disorder, not otherwise specified; PDD-NOS), nonverbal cognitive skills and RRBs were not significantly associated at any age for children with autism but were significantly associated for children with PDD-NOS who were 25 months or older. The authors noted that this finding may have been due to cohort differences in nonverbal IQ distributions within their sample or could possibly be due to older children with higher cognitive skills engaging in less repetitive behavior because of more developed interests and abilities.

The association between nonverbal cognitive skills and RRBs also appears to depend on the general type of RRB (i.e., RSM behaviors or IS; Bishop et al., 2006; Richler et al., 2010). For example, using parent reports on the ADI-R, Bishop and colleagues (2006) found that nonverbal IQ was positively associated with circumscribed interests and negatively associated with self-injurious behaviors, unusual preoccupations, repetitive use of objects, unusual sensory interests, and hand/finger and complex body mannerisms. The findings of Kim and Lord (2010) also showed that nonverbal cognitive scores were a significant predictor of three RSM behaviors on the ADOS for toddlers and preschoolers with ASD: unusual sensory interests, hand/finger mannerisms, and complex body mannerisms. In their longitudinal study of RRBs in children with ASD, Richler et al. (2010) found that higher nonverbal cognitive skills at age 2 were significantly associated with milder RSM behaviors at that age, as reported on the ADI-R, and with a decrease in these behaviors over time. At age 2, nonverbal cognitive skills were not associated with IS behaviors. In general, children's levels of RSM behaviors remained relatively high over time and IS behaviors increased over time (Richler et al., 2010).

There is little published research examining the relationship between language skills and RRBs in young children with ASD, and this has been highlighted by researchers as an important area for future research (Richler et al., 2010). In one study of 37 toddlers with ASD by Paul, Chawarska, Cicchetti, and Volkmar (2008), RRBs on the ADOS at 22 months (range = 15 – 25 months) significantly predicted expressive language at 47 months (range = 36 – 58 months). Paul et al. suggested that, among toddlers diagnosed with ASD, those with significant RRBs should be viewed as at "especially high risk for language disabilities" (p. 104). Bishop et al. (2006) also noted that it would be useful for future research to "determine if the acquisition of productive behaviors occurs at approximately the same time as the reduction in repetitive behaviors" (p. 265). In our study, we sought to address this issue by

examining whether changes in RRBs were associated with gains in language and cognitive skills during early childhood. We were also interested in extending the literature in this area by investigating the associations between RRBs and both receptive and expressive language skills, as researchers have found that young children with ASD demonstrate significantly greater deficits in receptive language skills relative to their expressive language skills (Ellis Weismer, Lord, & Esler, 2010; Volden, Smith, Szatmari, Bryson, Fombonne, Mirenda et al., 2011).

Purpose of the Current Study

The purpose of the current study was to enhance our understanding of RRBs in young children with ASD from a developmental perspective by examining the presence of RRBs in association with functional skills, such as language and nonverbal cognition, at ages two and three and changes in RRBs over this one-year period. In addition, we sought to utilize a measure of clinician-observed RRBs to contribute to the research in this area, which has primarily been based on parent report measures. Overall, this research aims to contribute to our understanding of early developmental trajectories of RRBs in individuals with ASD.

Specifically, we addressed the following research questions:

1. Are receptive and expressive language and nonverbal cognition significant predictors of clinican-observed restricted and repetitive behaviors in children with ASD at ages 2 and 3?

   We hypothesized that language and cognitive skills would be negatively associated with RRBs at these ages.

2. Do gains in cognitive and/or language skills from age 2 to 3 predict decreases in restricted and repetitive behaviors?

   We hypothesized that increases in language and cognitive skills would be associated with a decrease in RRBs during this one-year period.

Methods

Participants

Participants were 115 children who were seen at two time points (mean age at Visit 1 = 31 months, SD = 4.1 months; mean age at Visit 2 = 44 months, SD = 4.1 months) as part of a longitudinal study of early language development in children with ASD. Boys comprised 84% (n = 97) of the sample. 92% of participants were given a diagnosis of autism/Autistic Disorder (n = 106) and 8% were given a diagnosis of Pervasive Developmental Disorder, Not Otherwise Specified (PDD-NOS). Participants in both diagnostic groups exhibited some amount of RRBs, as none of the participants obtained a score of “0” on the RRB composite variable at Visit 1 or Visit 2. Approximately 86% (n=99) of the participants were white and 37% (n = 42) of participants’ mothers had 4 years or more of college education. Demographic characteristics of the sample are summarized in Table 1. At the time of Visit 1, 89% (n = 100) of the children had received some amount of speech-language, occupational, and/or physical therapy through a statewide Birth to 3 program. Seven participants were receiving private speech-language therapy and only two were receiving 10 or more hours of in-home, autism-specific therapy. Two participants had missing information regarding intervention services received at the time of their initial visit. At Visit 2, nearly half (n=56) of the sample was attending a private preschool or a public Early Childhood program for at least 10 hours each week. Thirty-six children were receiving private speech-language therapy at Visit 2, 15% (n = 17) were receiving 10 or more hours

per week of in-home, autism-specific therapy, and 10% of participants were receiving one to nine hours of in-home, autism-specific therapy.

Measures

Autism Diagnostic Observation Schedule—The Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002) is a standardized, semi-structured assessment of social interaction, communication, and behaviors relevant to ASD. There are four modules, one of which is selected for an individual based on his or her expressive language and developmental level. An additional toddler module (Luyster, Gotham, Guthrie, Coffing, Petrak, Pierce et al., 2009) was used for participants under 30 months of age. The revised diagnostic algorithms (Gotham, Risi, Pickles, & Lord, 2007), which were used in the present study, have demonstrated reliability and validity (Gotham et al., 2007; Gotham, Risi, Dawson, Tager-Flusberg, Joseph, Carter, et al., 2008). We used calibrated ADOS severity scores, which were developed by Gotham, Pickles, and Lord (2009) for the purpose of comparing scores across modules and time. These scores range from 1 to 10. A composite RRB variable was created by summing participants' scores for the following three items: *Unusual Sensory Interest in Play Material/Person*, *Hand and Finger and Other Complex Mannerisms* (or the higher value from either *Hand and Finger Movements/Posturing* or *Other Complex Mannerisms* for those who received the Toddler module), and *Unusually Repetitive Interests or Stereotyped Behaviors* (or *Excessive Interest in or References to Unusual or Highly Specific Topics or Objects or Repetitive Behaviors* for those who received Module 3). Scores on this composite variable have a possible range of 0 to 7. Given the young age of our participants and the nature of the composite RRB score we created for this study, our measure of RRBs reflects primarily behaviors characterized by a repetitive sensorimotor component rather than an insistence on sameness.

Mullen Scales of Early Learning—The Mullen Scales of Early Learning (Mullen, 1995) is a comprehensive developmental assessment for children from birth to 68 months that includes five scales: Gross Motor, Visual Reception, Fine Motor, Receptive Language, and Expressive Language. In this study, we used participants' Visual Reception raw scores as a measure of nonverbal cognition, as this scale is designed to assess young children's visual discrimination and visual memory abilities. It includes tasks such as matching objects, shapes, pictures, and letters. The publishers report a median, split-half internal consistency coefficient of .79 and a test-retest coefficient (for ages 26 to 56 months) of .75 for the Visual Reception scale (Mullen, 1995). Although *T* scores are available for the Visual Reception scale, they have a floor of 20 on the Mullen and some of our participants did not obtain raw scores that were high enough to calculate a *T* score for their age. Therefore, we used raw scores, controlling for chronological age, as a more sensitive measure of the full range of our sample's nonverbal cognitive skills. At Visit 1, Visual Reception raw scores are missing for 11 participants, as the Mullen was not initially part of the research testing protocol at the beginning of the larger study. Complete administrations of the Mullen were not conducted for a few participants at Visit 1 (n = 3) and Visit 2 (n = 3) due to the child's resistant behavior.

Preschool Language Scale, Fourth Edition—The Preschool Language Scale, Fourth Edition (PLS-4; Zimmerman, Steiner, & Pond, 2002) is intended for use with children from birth through 6 years, 11 months of age and is comprised of two core subscales: Auditory Comprehension and Expressive Communication. The Auditory Comprehension subscale measures children's understanding of language and includes tasks that target skills such as attention to speaker and comprehension of basic vocabulary and grammatical markers. The Expressive Communication subscale assesses children's ability to communicate with others and includes tasks that measure skills such as vocalizing different sounds, naming common

objects, and using grammatical markers. Cronbach's alpha was reported as .86 for the Auditory Comprehension subscale and .91 for the Expressive Communication subscale (Zimmerman et al., 2002). Test-retest stability coefficients ranged from .83 to .95 for Auditory Comprehension and from .82 to .95 for Expressive Communication. Standard scores, with a mean of 100 and standard deviation of 15, are available for both subscales. Because both subscales have a standard score floor of 50, we used raw PLS-4 subscale scores, controlling for chronological age, to measure participants' expressive and receptive language skills for this study. Complete administrations of the PLS-4 were not conducted for 5 participants at Visit 1 and 5 participants at Visit 2 due to the child's resistant behavior or examiner error. Therefore, raw scores are missing for these participants.

Procedure

As part of a larger longitudinal study, children ages 24 to 36 months who were diagnosed with ASD or suspected to be on the autism spectrum were recruited from various community sources including a statewide early intervention program for infants and toddlers with developmental delays (Birth to 3 Program), pediatricians, and a university-based developmental disabilities clinic. This research was approved by the institutional review board at the University of Wisconsin-Madison and parents provided written informed consent for their child's participation. At Visit 1, participants received a comprehensive diagnostic evaluation that included, among other assessments, a toddler research version of the ADI-R, ADOS or ADOS-T, Mullen, and PLS-4. Best estimate clinical DSM-IV diagnoses were made using all available information and assessment results. At Visit 2, which was scheduled approximately one year after Visit 1 (mean = 13.4 months between visits, SD = 1.3), participants also received the ADOS, Mullen, and PLS-4 in addition to other standardized assessments for the larger study's protocol. Demographic and treatment/educational services information was collected via parent-completed questionnaires. Twelve participants were lost to attrition in the larger study between Visits 1 and 2 but only participants with RRB data at both time points were included in the present study. Parents were not made aware of the purpose of this current study on RRBs but were informed of the general purpose of the larger longitudinal study.

Results

Predictors of RRBs at Ages 2 and 3

Descriptive statistics for PLS-4, Mullen, and ADOS scores for both time points are presented in Table 2. At age 2, the partial correlations between RRB composite scores and PLS-4 Auditory Comprehension raw scores (−.32, $p<.01$) and Mullen Visual Reception raw scores (−.31, $p<.01$), controlling for chronological age, had medium effect sizes, according to Cicchetti Koenig, Klin, Volkmar, Paul, and Sparrow's (2011) revision and expansion of Cohen's criteria. The partial correlation between RRB composite scores and PLS-4 Expressive Communication raw scores (−.16) was not statistically significant.

At age 3, Auditory Comprehension (−.49, $p<.01$) and Expressive Communication raw scores (−.40, $p<.01$) were significantly correlated with RRB scores, controlling for age. This was also the case for Mullen Visual Reception raw scores (−.42, $p<.01$), controlling for chronological age. The effect sizes for these partial correlations are considered medium (Cicchetti et al., 2011). Table 3 displays the partial correlations for both time points.

Predictors of Decreases in RRBs from Age 2 to 3

Unstandardized residual change scores were computed by regressing the RRB composite scores at Visit 2 on the same scores from Visit 1. This procedure was also followed to create residual change scores for the Mullen Visual Reception raw scores and the PLS-4 Auditory

Comprehension and Expressive Communication raw scores. Partial correlations were then conducted between the RRB change scores and the language and cognition change scores, controlling for age at Visit 1 (in months) and time between Visits 1 and 2 (in months). These analyses revealed that reductions in RRBs from age 2 to 3 were significantly correlated with both gains in receptive language (−.32, p<.01, ES = medium; Cicchetti et al., 2011) and expressive language (−.35, p<.01, ES = medium) during this same period. RRB residual change scores were not significantly correlated with Mullen Visual Reception residual change scores.

An ordinary least squares regression was conducted with the RRB residual change scores as the dependent variable and PLS-4 Auditory Comprehension residual change scores as the primary independent variable, with participants' age at Visit 1, time between Visits 1 and 2, and Mullen Visual Reception residual change scores entered simultaneously as covariates. Nonverbal cognitive skill was included as a covariate because of the established relationship between performance on nonverbal cognitive assessments and receptive and expressive language tests for young children with ASD (Ellis Weismer et al., 2010; Volden et al., 2011). These results indicated that increases in receptive language skills from age 2 to 3 significantly predict decreases in RRBs, controlling for increases in nonverbal cognitive skills, age, and time between visits ($\beta = -.33$, $t = -2.95$, p<.01, $R^2 = .11$).

A similar regression analysis was completed with PLS-4 Expressive Communication residual change scores as the primary independent variable. This analysis revealed that gains in expressive language from age 2 to 3 significantly predict decreases in RRBs, controlling for gains in nonverbal cognitive skills, age, and time between visits ($\beta = -.34$, $t = -3.11$, p<.01, $R^2 = .12$).

Discussion

In this study we examined associations between RRBs and cognitive and language skills in young children with ASD. Specifically, we investigated whether RRBs were related to these types of functional skills at ages 2 and 3 and whether increases in these skills over a one-year period were associated with decreases in RRBs. We found that nonverbal cognitive skills and receptive language skills were negatively associated with RRBs at ages 2 and 3. Expressive language skills were negatively associated with RRBs at age 3 but not at age 2, which may be due to reduced variability in expressive language skills at age 2 compared to age 3. Overall, these functional skills were associated with fewer clinician-observed RRBs in this sample of young children with ASD. Increases in receptive and expressive language skills, but not nonverbal cognitive skills, from ages 2 to 3 were associated with decreases in RRBs over this period. Our findings suggest that growth in language skills, controlling for gains in nonverbal cognition, is predictive of decreased RRBs in young children with ASD.

Although nonverbal cognitive skills were found to be negatively associated with RRBs in our sample, we did not find evidence to suggest that gains in nonverbal cognitive skills from age 2 to 3 are associated with decreased RRBs during this period. This negative association between nonverbal cognition and RRBs such as unusual sensory interests, repetitive hand and body mannerisms, unusual preoccupations, and repetitive use of objects is consistent with previous research (Bishop et al., 2006; Kim & Lord, 2010). However, our results suggest that nonverbal cognitive development from age 2 to 3 does not appear to contribute to a reduction in RRBs for children with ASD.

The results of our study extend the limited extant literature examining the association between RRBs and language skills in young children with ASD by providing evidence that, in addition to the presence of a significant relationship between language and RRBs, gains in

both receptive and expressive language skills predict decreases in RRBs from age 2 to 3, controlling for nonverbal cognitive gains. Our results corroborate those of Paul et al. (2008) who found that RRBs during the second year of life predicted expressive language outcomes two years later for children with ASD. The findings from our study suggest that RRBs, particularly those characterized by RSM behavior, may decline as young children with ASD gain the ability to better understand language and use language to communicate, both of which are critical for learning from and interacting with others in the environment. From a developmental perspective, as language skills develop in young children with ASD and they are better able to understand and communicate with those in their environment, they may have less of a need to occupy or soothe themselves with repetitive behaviors.

Implications for Research and Practice

The results of this study have implications for research and clinical practice focused on understanding and treating ASD during early childhood. An implication for research is that clinician-observed RRBs, even at 2 years of age, have important associations with functional skills, such as nonverbal cognition and language abilities. These findings are consistent with those of previous research based on parent-reported RRBs. Another implication is that language development in these early years, rather than nonverbal cognitive development, may contribute to a reduction in early RRBs. Regarding clinical practice, the association between gains in language skills and a decrease in RRBs from age 2 to 3 underscores the importance of emphasizing communication development in early intervention, not only to make gains in this area but also, perhaps, to see greater decreases in RRBs.

Limitations and Directions for Future Research

One limitation of this study is that, although the ADOS provides a standardized method for assessing RRBs, it consists of a relatively brief observation period that may not fully capture the range or extent of RRBs that a child with ASD may display in daily life, particularly behaviors characterized by an insistence on sameness (e.g., difficulty handling changes in routine, presence of rituals). However, the ADOS does offer activities and stimuli that often elicit behaviors with a repetitive sensorimotor component (e.g., hand flapping, lining up objects). Given the composition of the RRB composite score we created for this study and the young age of our sample, we were intending to measure primarily RSM actions and the ADOS provides a standardized measure of clinician observations of these behaviors. The use of clinician-observed RRBs extends the current knowledge base, as related research in this area has largely relied on parent reports of RRBs from the ADI-R.

A second limitation is that our standardized language measure captures structural language skills such as receptive and expressive vocabulary and grammatical abilities, but does not target pragmatic abilities. In spite of this, our study contributes to the limited extant literature examining the relationship between language skills and RRBs in young children with ASD by including measures of both expressive and receptive language at two time points. Additional investigation of the association between pragmatic language skills and RRBs in children with ASD would be warranted.

Future research in this area should investigate the relationship between RRBs and language skills over a longer developmental period to examine how this relationship may change with age. It would also be beneficial for future research to examine the overlap between parent reports of RRBs and direct observations within a single sample. Another area for future research would be to study the association between IS behaviors, in particular, and language skills over time as the RRBs captured in the current study were largely RSM behaviors.

Conclusions

We found that, by age 3, nonverbal cognitive skills and receptive and expressive language skills were negatively correlated with clinician-observed RRBs on the ADOS. Gains in receptive and expressive language from age 2 to 3 predicted decreases in RRBs over this period, controlling for increases in nonverbal cognitive skills. This study adds to the limited research on the relationship between RRBs and language skills, and further research in this area is important to increasing our understanding of developmental trajectories in ASD.

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Table 1

Demographic Characteristics of the Sample (n=115)

Characteristic	n	%
Gender		
Female	18	15.7
Male	97	84.3
Diagnosis		
Autism	106	92.2
PDD-NOS	9	7.8
Race/Ethnicity		
African American/Black	2	1.7
Caucasian/White	99	86.1
Hispanic	3	2.6
Multiracial and Other	11	9.6
Maternal Education (n = 114)		
11 to 12 years	35	30.7
13 to 16 years	65	57.0
More than 16 years	14	12.3

Table 2

Descriptive Statistics for the PLS-4, Mullen, and ADOS

Measure	Visit 1				Visit 2			
	N	Mean	SD	Range	N	Mean	SD	Range
PLS-4								
Auditory Comprehension Raw Score	113	20.35	5.21	32	111	28.44	11.58	48
Expressive Communication Raw Score	112	24.96	5.92	29	110	32.25	9.27	45
Mullen								
Visual Reception Raw Score	101	26.29	5.04	27	112	34.54	8.22	35
ADOS								
RRB Composite Score	115	4.67	1.41	6	115	4.50	1.39	6

Table 3

Partial Correlations with RRB Composite Scores at Visit 1 (age 2) and Visit 2 (age 3)

	Restricted and Repetitive Behaviors	
Measure	**Visit 1**	**Visit 2**
PLS-4 Auditory Comprehension Raw Score	−.32**	−.49**
PLS-4 Expressive Communication Raw Score	−.16	−.40**
Mullen Visual Reception Raw Score	−.31**	−.32*

Note. All correlations are controlling for chronological age (in months).

* p < .05,

** p<.01