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Repetitive and Stereotyped Behaviors from Age 2 to Age 4: A Look at the Development of High- and Low-Level Repetitive Behaviors in Children with Autism Spectrum Disorders

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Repetitive and Stereotyped Behaviors from Age 2 to Age 4: A Look at the Development
of High- and Low-Level Repetitive Behaviors in Children with Autism Spectrum
Disorders

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B.A., University of Rochester, 2006

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Repetitive and Stereotyped Behaviors from Age 2 to Age 4: A Look at the Development
of High- and Low-Level Repetitive Behaviors in Children with Autism Spectrum
Disorders

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Repetitive Behaviors in ASD

Repetitive and Stereotyped Behaviors from Age 2 to Age 4: A Look at the Development of High- and Low-Level Repetitive Behaviors in Children with Autism Spectrum Disorders

Kelley Knoch, B.A.

University of Connecticut, 2012

Restricted and repetitive behaviors (RRBs) are core features in autism spectrum disorders (ASD). Previous literature has subdivided RRBs into low and high levels. Low-level behavior is characterized by a repetition of movement, such as stereotyped movements, whereas high-level behavior includes insistence on sameness and rigid adherence to a routine. There is conflicting evidence frequency and severity of RRBs in early development in children with ASD. In the current study, we examined developmental differences in the frequency and severity of RRBs in children with ASD ($n = 109$) compared to children with developmental delays (DD) ($n = 34$). Participants were evaluated at age 2 and 4, and individual items from the Autism Diagnostic Interview were categorized as low or high level and assessed for changes in frequency and severity over time. Consistent with the literature, results show an overall significant increase in the number of RRBs over time in children with ASD, but not those with DD. Specifically, the data showed an increase in high-level behaviors, with no significant change in the frequency of low-level behaviors. RRBs were then examined in relation to other developmental markers. In children with ASD, the severity of low-level RRBs was negatively correlated with level of intelligence and adaptive functioning, even when

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controlling for IQ. In addition, children with greater ASD symptom severity were more likely to display more severe RRBs. This suggested that both high- and low-level behaviors are present in 2-year-old children with ASD, who then experienced a significant increase in the frequency of high-level behaviors by age 4, suggesting that when making early diagnoses it is important to continue examining RRBs in relation to other social-communicative markers. Unlike at age 4 where group differences were obtained for both types of RRBs, differences in the frequency of only high-level behaviors were obtained at age 2, suggesting that simple repetitive behaviors do not differentiate 2-year-olds with ASD from those with DD. Furthermore, in children with ASD, the development of low-level repetitive behaviors are associated with lower levels of cognitive functioning, which may interfere with everyday tasks of social and communicative development and be positively related to ASD symptom severity.

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Repetitive and Stereotyped Behaviors from Age 2 to Age 4: A Look at the Development of High- and Low-Level Repetitive Behaviors in Children with Autism Spectrum Disorders

Introduction

Autism is a pervasive developmental disorder first described by Leo Kanner in 1943. He observed a group of children having a “powerful desire for aloneness and sameness” (Kanner, 1943), a description still associated with autism today. Since Kanner’s initial observations, the term autism has expanded to include a class of disorders broadly referred to as Autism Spectrum Disorders (ASDs). ASDs include individuals diagnosed with Autistic Disorder, Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS), and Asperger’s Disorder and are characterized by common behavioral deficits across three areas of functioning; social reciprocity, communication, and the presence of restricted or repetitive behaviors (RRBs; APA. Task Force on DSM-IV, 2000). ASDs are highly prevalent, with the Centers for Disease Control and Prevention estimating that 1 in 88 children are afflicted with the disorder, occurring more often in males than females at a rate of four or five to one (CDC, 2012).

Given the prevalence of Autism Spectrum Disorders, there has been considerable interest in their behavioral presentation. Individuals with ASDs share a defining feature: impairment in social relatedness. In fact, parents of children with ASDs often describe their children as being unaware of those around them, and appearing to operate within their own world (Charman & Baird, 2002). Deficits in social relatedness manifest in several ways, including inappropriate social behavior, inappropriate use of nonverbal

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communication such as eye-gaze or gestures, deficits in regulating social interactions, a failure to develop appropriate relationship with peers, and a lack of spontaneously sharing one's enjoyment with others (APA, 2000). In addition, these individuals also display marked impairments in their communication skills. For example, many individuals have a delay in their overall level of spoken language, or in the pragmatic uses of language. Social and communication deficits can be identified in individuals with ASDs prior to the age of 3, and they represent the hallmark features of the disorder which enable clinicians to make accurate diagnoses, in the absence of available medical or genetic testing (Chawarska, 2007; Cox et al., 1999; Kleinman et al., 2008).

There has been a substantial amount of research on the early development of social and communication deficits in ASDs, but few studies have focused on the third set of criteria of the disorder, engagement in restricted and repetitive patterns of behaviors (RRBs). As a result, less is known about the development of these behaviors and how they relate to the core social deficits seen in these individuals (Lewis & Bodfish, 1998). The current study intends to add to the literature by examining the early development of these behaviors in toddlers with ASDs, in relation to other important developmental and diagnostic factors.

RRBs are, by their nature, difficult to define. In reviewing the available literature, the term RRBs encompasses a wide array of behaviors that include, but are not limited to, stereotypies, compulsions, obsessive interests, an insistence on sameness, echolalia, oversensitivity to noise, interest in parts of objects and perseverations. As such, RRBs represent a broad construct that lacks consistency, making it difficult to interpret results across research studies.

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It is clear, however, that in individuals with ASDs, RRBs can be seen across the lifespan, and they often manifest concurrently, with an individual displaying several RRBs at any one point in his or her development (Lewis & Bodfish, 1998). Furthermore, the literature suggests that the presence of these behaviors may be debilitating for children by interfering with a child's development of adaptive functioning (Matson, Kiely, & Bamburg, 1997) and his or her ability to benefit from early intervention services (Watt, Wetherby, Barber, & Morgan, 2008). One study found that the presence of these behaviors results in a significant decrease on a global measure of quality of life that includes social, physical, emotional, and school functioning (Kuhlthau et al., 2010). In short, these behaviors have a negative impact on the development of children with ASDs, and the behaviors tend to show less improvement over time when compared to deficits in social and communication skills (Piven, Harper, Palmer, & Arndt, 1996).

RRBs in young children with ASDs may be pervasive and contribute to the negative outcome of some of these children, but the behaviors themselves are not specific to this class of disorders. RRBs are also found in typically developing infants and in individuals with a variety of psychiatric disorders. In normal development these behaviors reach a peak in intensity at age 2 and then dissipate by about the age of 4, with a spike in their frequency when the child first enters school (Berkson & Tupa, 2000). In contrast, children with ASDs show a continued increase in the frequency and severity of these behaviors from early through late childhood (Bishop, Richler, & Lord, 2006; Moore & Goodson, 2003). RRBs are also found in a variety of clinical populations, including individuals with anxiety disorders and mental retardation, with varying degrees of severity and prevalence (Langen, Durston, Kas, Van Engeland, & Staal, 2011). While

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RRBs are an important feature of autistic disorders, their lack of specificity makes it difficult for clinicians and researchers to use these behaviors accurately to distinguish between children with ASDs and those without.

Several studies have explored differences in the pattern of these behaviors when comparing children with ASDs to those who are typically developing, or have a non-autistic developmental delay. Thus far, the research has yielded mixed results. Studies with null findings have used two types of measures: the overall repetitive behaviors algorithm scores of a parent report measure (Autism Diagnostic Interview-Revised, ADI-R; Cox et al., 1999; Lord, Rutter, & Le Couteur, 1994; Ventola et al., 2006) and home videotapes of the children (Werner & Dawson, 2005). In contrast, other studies have used individual items on the ADI-R, an RRB-specific measure, and live behavioral observations, and have found differences in the prevalence rates and severity of RRBs in young children with ASDs. Two studies have found that 2-year-old children with ASDs, when compared to their non-autistic peers, are more likely to engage in hand and finger mannerisms and unusual sensory behaviors (Lord, 1995; Wetherby et al., 2004). In another study, children with ASDs, who were matched based on their mental age to non-ASD peers, displayed an overall greater severity of RRBs when measured by the Repetitive Behavior Scale (RBS; Bodfish et al., 1998). In this study, the severity rating of RRBs also predicted the overall severity of ASD symptoms, suggesting that individuals with severe ASDs are more likely to engage in these behaviors (Bodfish, Symons, Parker, & Lewis, 2000; Krug, Arick, & Almond, 1980). The literature thus far presents mixed findings regarding the prevalence and severity of RRBs in two-year-old children with ASDs compared to other child populations. However, the literature also

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suggests that differences in results may be confounded by the measures used in identifying these behaviors, and that more sensitive analyses may be necessary to pick up subtle group differences in RRBs during early development.

One possible way to increase the sensitivity of measures when examining RRBs is to classify these behaviors based on common features. Turner (1999) developed a categorization system that classifies these behaviors. The first category is low-level repetitive behaviors, which are characterized by repetitive motor movements and include items such as hand flapping and stereotyped movements. These behaviors are thought to be related to an individual's level of intellect, and therefore, are less ASD specific. The second category is high-level behaviors. These are complex cognitive behaviors that include items such as an insistence on sameness, circumscribed interests, and attachment to inanimate objects. Turner further hypothesized that these high-level behaviors may be more ASD-specific, and therefore more useful in distinguishing children with ASDs from those with other types of developmental disabilities.

Since Turner's model was put forth, it has been mainly applied to studying RRBs in adolescents and adults with ASDs (Chowdhury, Benson, & Hillier, 2010; Esbensen, Seltzer, Lam, & Bodfish, 2009). Only recently has this model been applied to toddlers and young children. Bishop and colleagues (2006) performed a cross-sectional study on children with ASDs who were aged 11 months to 12 years. These children's caregivers were given the Repetitive and Restricted Behaviors domain of the ADI-R, and the individual items underwent a factor analysis. Results supported a two-factor model that corresponded to Turner's classification system. Furthermore, the results showed that low-level behaviors were negatively associated with measures of nonverbal IQ (NVIQ),

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whereas high-level behaviors were positively related to measures of NVIQ. However, when examining the effects of age, there was no significant relationship between the two RRB factors and NVIQ in children under the age of 36 months. Cuccaro and colleagues (2003) also examined the individual RRB items on the ADI-R in individuals with ASDs aged 3-21 years, and again found a two-factor model that corresponded to Turner's classification system. In addition, they found that there was a significant negative relationship between low-level behaviors and adaptive functioning, but the authors did not control for the effects of NVIQ. Taken together, these studies suggest that there is a positive relationship between high-level behaviors and nonverbal intelligence in older children with ASD, and a possible negative relationship between low-level repetitive behaviors on the one hand, and intellectual functioning and adaptive skills on the other, in individuals with ASDs. However, it is unclear how or if RRBs, intelligence, and adaptive functioning are related in children under the age of 3.

Only one study to date has focused on applying this model directly to two-year-old children with ASDs. Richler and colleagues (2007) compared the number and severity of the two categories of RRBs in toddlers with ASDs to those with developmental delays, and typical development. The authors found that low-level behaviors were more common and occurred with greater severity in toddlers with ASDs. However, high-level behaviors were relatively uncommon, and thus similar across all three diagnostic groups. Overall, these studies lend significant support to the utility of distinguishing between the two classes of RRBs. The studies further indicated that these classes of behaviors might develop along separate trajectories and therefore have differing associations with NVIQ and adaptive functioning. However, there is a lack of

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research examining how these classes of behaviors change between the ages of 2 and 4, and the relationship between NVIQ, adaptive functioning, and ASD symptomatology in the early development of both high- and low-level repetitive behaviors.

The current study aims to combine these areas of research by exploring the developmental profiles associated with the attainment of low- and high-level RRBs in young children with ASDs and comparing them to a group of children with developmental delays. The study will examine the number and severity of RRBs, as measured by the individual items of the ADI-R, at two time points, 2 and 4 years of age. Consistent with previous literature, it is expected that there will be an overall increase in the presence and severity of RRBs between the ages of 2 and 4 in children with ASDs, all of whom received their initial diagnoses at age 2, whereas these behaviors are expected to decrease in a control sample of children who were diagnosed with either a Developmental Delay or a Developmental Language Disorder.

The current study will further investigate RRBs in young children with ASDs by categorizing these behaviors according to Turner's model to assess any differences in the early developmental trajectories of low- and high- level repetitive behaviors, with the prediction that low-level, rather than high-level RRBs, will occur in greater number and severity at 24 months, but that the number of high level behaviors will increase across the two time points. Last, these behaviors will be analyzed in relation to early markers of cognitive, social, and communicative development.

Overall, it is predicted that at the age of 24 months there will be a predominance of low-level RRBs in children with an ASD, and the presence of these behaviors will

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remain consistent across early development. In contrast, it is hypothesized that the presence of high-level RRBs will be rare in the 2-year-old group of children diagnosed with an ASD, but will increase in both number and severity between the ages of 2 and 4. Furthermore, it is predicted that this increase in high-level behaviors will be positively correlated with cognitive ability in these children, and be directly related to measures of ASD symptomatology and adaptive functioning when controlling for cognitive ability.

Methods

Participants

Two hundred and seventy-four participants screened positive on the Modified Checklist for Autism in Toddlers (M-CHAT; Robins, Fein, Barton, & Green, 2001) between the ages of 16 and 30 months and received a developmental and diagnostic evaluation at the approximate ages of 2 and 4. Of those individuals, 196 received an ASD diagnosis at age 2, 27 received a diagnosis of developmental delay, and 18 were diagnosed with a developmental language disorder. In order to examine the development of repetitive behaviors in conjunction with other important diagnostic factors, all participants needed to have been administered the measures of interest at both evaluations. Individuals who did not receive the restricted and repetitive behaviors items of the ADI-R, the Mullen Scales of Early Learning, or the ADOS, were excluded due to insufficient data ($n = 98$). The final sample contained 109 children who received an ASD diagnosis at age 2 (ASD sample), and 34 children who received a diagnosis of either a Developmental Delay or a Developmental Language Disorder at age 2 (developmental comparison sample).

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ASD Sample.

During the initial evaluation (age 2), 59 children received a diagnosis of Autistic Disorder, and 50 children received a diagnosis of Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS). In the current study, this group is collectively referred to the ASD sample. Of the 109 children originally diagnosed with an ASD at age 2, 64 children went on to receive a diagnosis of Autistic Disorder during the reevaluation at age 4, 30 children received a diagnosis of PDD-NOS, and 15 children received a non-ASD diagnosis (i.e., developmental delay, typical development, other). The gender breakdown for the ASD sample was as follows: 18.3% female and 81.7% male. The mean chronological age at the time of the initial evaluation and re-evaluation were 26 months and 51 months, respectively. The sample was self-identified by the caregivers as predominantly White or Caucasian (81.7%), with the remainder of the participants identified as African American (3.7%), Hispanic/Latino (10.1%), Asian or Pacific (2.8%), Biracial (0.9%), or unknown (0.9%; Table 1).

Developmental Comparison Sample.

Thirty-four children comprised the developmental comparison sample. At the initial evaluation (age 2), 15 children were diagnosed with a developmental language disorder and 19 children were diagnosed with a developmental delay. At the second evaluation (age 4), 14 children were diagnosed with a developmental delay, 2 were diagnosed with a developmental language disorder, 5 children received a different DSM-IV diagnosis (e.g., ADHD), 9 did not receive a diagnosis but also did not meet the study's criteria for typical development and 4 were judged to be typically developing. The

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majority of the sample was male, with 29 males and 5 females. The average age at the initial evaluation was 26 months and during the reevaluation was 53 months. The sample was self-identified by the caregivers as predominantly White or Caucasian (85.3%), with the remainder of the participants identified as African American (5.9%), Hispanic/Latino (5.9%), or unknown (2.9%) (Table 1).

There were no significant differences in the age of the children in the two groups when evaluated at age 2 or at age 4. The groups also had a comparable distribution of gender and ethnicity ($p > .05$). However, the groups differed in their overall developmental levels or cognitive ability during the initial evaluation, as measured by the Mullen Scales of Early Learning ($t(141) = -2.88, p = .005$). On this measure, the ASD group (mean t-score = 29 (SD = 9)) performed significantly worse on measures of visual reception abilities when compared to the developmental comparison group (mean t-score = 36 (SD = 12)). The ASD group also (mean T-score = 29 (SD = 10)) performed significantly worse on measures of fine motor abilities when compared to the developmental comparison group (mean T-score = 35 (SD = 12)). Differences in visual reception and fine motor abilities were not found during the reevaluation ($p > .05$), as both groups performed similarly on these measure (Table 1).

The groups also differed on measures of language ability on the Mullen Scales of Early Learning. At the initial evaluation, the ASD group (mean T-score = 24 (SD = 8)) performed significantly worse on receptive but not expressive language when compared to the developmental comparison group (mean T-score = 29 (SD = 13)). In contrast, the ASD group (mean T-score = 28 (SD = 13)) performed significantly worse than the

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developmental comparison group (mean T-Score = 35 (SD = 13)) on expressive but not receptive language during the reevaluation.

Procedures

Participants were a subset of a sample from a larger federally funded project at the University of Connecticut. The goals of the original study focused on creating and validating the Modified Checklist for Autism in Toddlers (M-CHAT; Robins, Fein, Barton, & Green, 2001), a population-based screening instrument used to detect ASDs in young children. Caregivers were given the M-CHAT to complete at their pediatrician's office during his or her child's 18 or 24-month well-child visit, or by their Early Intervention service provider. Participants were screened between the ages of 16 and 30 months. The screeners were then mailed to the University of Connecticut where they were scored. For screen positives, the child's caregiver received a follow-up phone interview to confirm the failed items on the screener. Children who continued to screen positive after the telephone interview were invited to the University of Connecticut to receive a free developmental and diagnostic evaluation.

The evaluations occurred at the Psychological Services Clinic at the University of Connecticut. The tests were administered when a child was between the ages of 17 and 37 months (age 2). Participants who did not have transportation were provided with a free taxi service. A team of clinicians, consisting of one licensed psychologist or developmental pediatrician, and one doctoral student, completed the evaluations. Each assessment lasted approximately three hours, and included a feedback session where the results were reviewed with the child's caregiver.

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During the assessment, each child received a measure of his or her cognitive abilities, adaptive functioning, and ASD symptom severity. Measures were determined based on the child's age and developmental level, and typically consisted of the Mullen Scales of Early Learning, Vineland Adaptive Behavior Scales, Autism Diagnostic Observation Schedule, Autism Diagnostic Interview-Revised, and the Childhood Autism Rating Scale. Diagnoses of the participants were determined based on the results of behavioral measures, parental report, and the observations of an experienced clinical psychologist or developmental pediatrician. Diagnoses were assigned based on DSM-IV criteria (APA, 2000). Children who did not meet diagnostic criteria for an ASD were further categorized as having a developmental delay (defined as having a delay more than 1.5 standard deviations from the mean on one language and one non-language measure), a developmental language disorder (defined as having a delay more than 1.5 standard deviations from the mean on a measure of expressive and receptive language or a delay of more than 2 standard deviations from the mean on either a measure of receptive or expressive language), typical development, or "other", which applied to children who did not meet criteria for a DSM-IV disorder but whose development or behavior was not felt to be typical. All children who received an initial evaluation were invited back for a second evaluation when the child was between the ages of 41 and 69 months (age 4).

Individual items from the repetitive and stereotyped behaviors domain of the ADI-R were analyzed. At the initial evaluation, some of the participants received the toddler version of the ADI-R. As a result, only items that occurred on both the ADI-R and ADI-R Toddler Forms were utilized, allowing comparison of items between ages 2 and 4. Items were further classified according to the high-low model (Turner 1999). A

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total of seven items were included in the current study. Two of the items measure low-level behaviors (hand and finger mannerisms, and complex mannerisms or stereotyped body movements) and five that measure high-level behaviors (unusual preoccupations, compulsions or rituals, difficulties with changes in the subject's routine, difficulty with changes to the environment, unusual attachment to objects; Table 2). Individual items on the ADI-R are scored on a scale from 0-3 based on the severity of the child's repetitive behavior. A score of 0 indicated that the behavior was not present, and scores of 1-3 indicated that the child engaged in the behavior with increasing levels of severity. In addition to severity scores, the responses were also analyzed in terms of their frequency by collapsing all scores between 1 and 3 to indicate that a child exhibited the behavior, and using scores of 0 to indicate that the behavior was not present. On the ADI-R, parents are questioned on whether the child currently exhibited a certain behavior and whether the child had ever exhibited that same behavior in the past. The present study only utilized the responses that pertain to the child's current behavior.

Measures

The *Modified-Checklist for Autism in Toddlers, or M-CHAT* (Robins, Fein, Barton, & Green, 2001), is a parent-report checklist designed to screen for ASDs in 16-30-month-old children. The checklist consists of 23 items presented in a yes/no format. A failed screener is defined as any three items failed, or any two critical items failed. The critical items were identified by a discriminant function analysis of children with and without an ASD, and include items concerning joint attention, conveying an interest in other children, responding to name, and imitation. Internal reliability of the measure has been established and is considered high when based on the entire checklist and the critical

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items ($\alpha = .85$, $\alpha = .83$, respectively; Robins, Fein, Barton, & Green, 2001, Kleinman et al., 2008).

The *Autism Diagnostic Observation Schedule - Generic, ADOS-G* (Lord et al., 2000) is a semi-structured assessment designed to measure potential ASDs. The ADOS-G includes four modules, one of which is administered depending on the child's expressive language level and chronological age. The current study used modules one and two. On this measure, exceeding cut-off scores in the following domains dictates diagnostic classifications: social, communication, combined social and communication, and restricted repetitive behaviors. The inter-rater reliability is considered good across all domains: social ($r = .93$), communication ($r = .84$), social communication ($r = .92$), and restricted repetitive behaviors ($r = .82$). The cut-off scores are used to classify each child as having an Autistic Disorder, ASD, or not having an ASD.

The *Autism Diagnostic Interview – Revised, ADI-R* (Lord, Rutter, & Le Couteur, 1994) and the *Autism Diagnostic Interview – Toddler Form, ADI-R-Toddler Form* (Rutter, Lord, & Le Couteur, 1991) are semi-structured parent report interviews used to evaluate communication, social development, play, and restricted, repetitive, and stereotyped behaviors. The ADI-R consists of 111 questions, and the ADI-R-Toddler Form consists of 123 questions. For both editions, the items are scored based on severity ratings that range from 1-3, with 1 indicating a mild impairment and a score of 3 indicating very impaired or atypical behaviors. Both forms yield summary scores across the three domains of social interactions, communication, and repetitive and stereotyped behaviors that are used to classify the child as either having autism or not having autism. Internal consistency has been established on the ADI-R in the domains of social

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interactions ($\alpha = .95$), communication ($\alpha = .84$), and repetitive and stereotyped behaviors ($\alpha = .69$; Lord et al., 1994).

The *Vineland Adaptive Behavior Scales: Interview Edition Survey Form, VABS* (Sparrow, Balla, & Cicchetti, 1984) is a parent interview survey that assesses adaptive functioning in the areas of socialization, communication, daily living, and motor skills. Each item is scored from 0-2, with a 0 indicating that the child does not perform the particular behavior, 1 meaning that the child sometimes performs the behavior, and 2 indicating that the child performs the behavior on a regular basis.

The *Mullen Scales of Early Learning* (Mullen, 1995) is a developmental assessment of cognitive and motor abilities. The measure consists of five scales including, gross motor, visual reception, fine motor, and both expressive and receptive language. The current study did not include the gross motor domain.

Data Analytic Plan

Analyses focused on the number and severity of low and high level RRBs reported by parents in each group. To calculate a participant's average severity rating, each individual item or repetitive behavior was scored on a scale from 1-3, with a score of 1 indicating a mild impairment and a score of 3 indicating a severe behavior that has a marked impairment on the child's daily functioning. Participants who received a score of 0 (behavior not present) were excluded from severity analyses. Scores across all items are then averaged to receive a mean RRB severity score. Scores were then separated into high- and low-level repetitive behaviors and then averaged within the two separate categories. To obtain the total number of RRBs reported for each participant, each

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individual item was scored as a 0 or a 1, with a 0 indicating that the behavior does not exist for a particular child and a 1 indicating that the behavior does exist. For each participant, the number of repetitive behaviors that existed was then summed to produce a total score, as well as to count the total number of low- and high-level RRBs.

Initial analyses measured group differences (ASD and developmental comparison sample) in the number and severity of RRBs between the two time points (age 2 and 4). A 2x2 repeated measures analysis of variance was used to measure group differences in the number and severity of high- and low-level RRBs over time. Independent samples t-tests were then used to measure group differences in the number and severity of RRBs at each time point (age 2 and 4).

To measure overall changes in the number and severity of RRBs within groups, the current analytic strategy used paired samples t-tests. The same statistics were applied when comparing high- and low-level RRBs between the ages of 2 and 4. For each group, the individual items within each of the RRB categories (high and low) were then analyzed for changes in the number of behaviors reported over time using McNemar Tests (McNemar, 1947), and for changes in severity over time using paired samples t-tests. Finally, we used Pearson correlations to measure the relationships between the severity of RRBs on the one hand, and cognitive abilities, adaptive functioning, and autism symptom severity on the other hand, separately for each group.

Results

Change in the Frequency and Severity of RRBs from Age 2 to Age 4

Between Groups

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Separate one-way repeated measures ANOVAs were used to analyze differences in the number of low- or high-level repetitive behaviors with two diagnostic groups (ASD and developmental comparison group) and repeated measures at two ages (age 2 and age 4). When examining the average number of low-level behaviors over time there was a significant main effect for group ($F = 10.19, p = .002$), where the parents of children with an ASD on average reported a higher number of low-level behaviors when compared to parents of children with a developmental delay. Interaction effects for group by repeated measures over time were not significant. Analyses yielded similar results for high-level behaviors, with a significant main effect for group ($F = 13.04, p < .001$), where parents of children with an ASD on average reported a higher number of high-level behaviors when compared to parents of children with a developmental delay, but no significant interaction effect for group by time.

Independent samples t-tests were used to compare the total number of low- and high-level repetitive behaviors endorsed by parents in the ASD and DD groups at age 2 and age 4. Nonsignificant results were obtained when comparing the total number of low-level repetitive behaviors endorsed by parents in the ASD group ($M = 1$) and developmental comparison sample ($M = .76$) ($p > .05$) at age 2. However, significant results were obtained when comparing the number of high-level repetitive behaviors ($t(141) = 2.18, p = .03$), with parents of children with an ASD reporting on average a higher number of high-level repetitive behaviors ($M = 1.1$) than parents of children with a developmental delay ($M = .68$). There were no significant group differences in the severity of the behaviors for either low- or high-level repetitive behaviors ($p > .05$) at age 2.

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At the second evaluation (age 4), parents of children with an ASD ($M = 1.1$) reported a significantly higher number of low-level RRBs ($t(141) = 3.6, p < .001$) when compared to parents of children with developmental delays ($M = .59$). Similarly, these same parents reported a significantly higher number ($M = 1.4$) of high-level RRBs ($t(141) = 3.5, p = .001$) compared to parents of children with developmental delays ($M = .59$). Significant group differences were also obtained when comparing the severity of low-level RRBs ($t(141) = 2.3, p = .02$) between the ASD ($M = 1.2$) and developmental comparison group ($M = .76$) and when comparing the severity of high-level RRBs ($t(141) = 2.5, p = .01$) between the ASD ($M = 1.1$) and developmental comparison group ($M = .69$) at age 4.

Within the ASD Group

Paired samples t-tests were conducted to evaluate changes in the average number and severity ratings of RRBs in children with an ASD from the age of 2 to the age of 4. Analyses were initially conducted using the broad construct of RRB. Significant results were obtained when examining the change in the frequency with which these behaviors occurred ($t(108) = -2.56, p = .012$) from age 2 ($M = 2.11$) to age 4 ($M = 2.5$). This finding is consistent with previous literature, which found a significant increase in the presence of RRBs during early development in children with ASDs. However, when the number ratings were broken down into high- and low-level behaviors, significant results were only obtained for changes in the number of high level behaviors ($t(108) = -2.13, p = .035$). Within the sample, 41% of parents reported an increase in the number of high-level behaviors at age 4, 28% reported that the number of these behaviors remained the same across the two time points, and 31% reported a decrease in the number of high-level

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repetitive behaviors by age 4. There were no statistically significant changes in the number of low-level behaviors over time. In addition, there were no significant changes ($p > .05$) in the severity of RRBs from age 2 ($M = 1.48$) to age 4 ($M = 1.55$). Therefore, the global increase in RRBs over time appears to be driven by a significant increase in the number of high-level behaviors between the ages of 2 and 4; however, the severity in which these behaviors are being reported appears to be relatively similar between the two time points.

Individual items within the low- and high-level domains were then examined. Changes in the number of RRBs over time were assessed using the McNemar Test (McNemar, 1947). There were no significant differences in the number of the individual low-level behavior items. Within the high-level behaviors, however, there were significant increases in the number of compulsions ($p < .001$) from age 2 ($M = .15$) to age 4 ($M = .38$) and difficulties with changes to the child's own routines ($p < .001$) from age 2 ($M = .20$) to age 4 ($M = .43$). Changes in severity across the two time points were analyzed with paired samples t-tests, the results of which indicated a significant increase in the severity of complex mannerisms or stereotyped body movements ($t(52) = -10.31$, $p < .001$) from age 2 ($M = .57$) to age 4 ($M = 1.74$).

Within the Developmental Comparison Group

Within the developmental comparison group there were no significant differences in the overall number or severity ($p > .05$) of RRBs at age 2 compared to age 4 on the ADI-R. These findings remained when analyzing the data according to the high-low

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model. While the means decreased for all seven of the RRB items across the two time points, no significant changes were found.

Frequency and Severity of RRBs at Age 2

Within the ASD Group

With regard to the frequency with which parents of children with ASDs endorsed repetitive behaviors on the ADI-R, 86.2% of the sample indicated that their child engaged in at least one type of repetitive or restricted behavior. When the items were categorized based on Turner's (1999) model, we found that 80% of children engaged in at least one low-level repetitive behavior, and similarly, 80% of children engaged in at least one high-level repetitive behavior. Within the low-level items, hand and finger mannerisms (53.2%) and other complex mannerisms (47.7%) were endorsed in approximately half of the sample. On the other hand, the frequency of reporting high-level behaviors varied by item (see Table 3), with the majority of parents responding that their child has unusual preoccupations (48.6%) and fewer indicating that their child has difficulties with trivial changes to the environment (9%). Furthermore, when examining the severity at which these behaviors occurred, there was no significant difference between the severity of low- (M = 1.0) and high-level (M = .98) repetitive behaviors ($t(108) = .94, p > .05$) in two-year-old children with an ASD.

Within the Developmental Comparison Group

Within the developmental comparison sample, parents endorsed at least one type of repetitive or restricted behavior in 79% of the sample. When the items were examined based on Turner's (1999) model, we found that 59% of the sample engaged in at least one

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low-level behavior, and 47% engaged in at least one high-level behavior. Items endorsed the most were as follows: unusual preoccupations (32%), hand and finger mannerisms (38%), and complex body mannerisms (38%). No parents endorsed that their child had difficulties with trivial changes to the environment and few parents endorsed difficulties with changes to the child's own routine (9%) or unusual attachments to objects (9%). Similarly to the ASD group, there were no significant differences in which the severity of low- ($M = 1.0$) and high-level ($M = .88$) behaviors were reported at age 2 ($t(33) = .4, p > .05$).

RRBs in Relation to other Developmental and Diagnostic Measures

Cognitive abilities.

Pearson correlations were used to assess the relationship between severity of RRBs and cognitive abilities as measured by the Mullen Scales of Early Learning at age 2 and 4. Results were significant in the ASD sample for low-level behaviors at age 4 ($r = -0.285, p = .006$), where four-year-olds who had lower overall cognitive abilities, as measured by the Early Learning Composite standard score, were more likely to display a high severity of low-level behaviors. This relationship was not significant at age 2. In contrast, there were no significant relationships for the severity of high-level behaviors in relation to overall cognitive abilities at age 2 or age 4 ($p > .05$). Similar results were obtained when analyzing the individual scales of the Mullen Scales of Early Learning at age 4, where children with an ASD who performed more poorly on measures of visual spatial skills ($r = -.22, p = .026$), fine motor ability ($r = -.20, p = .039$), and expressive ($r = -.375, p < .001$) and receptive language ($r = -.378, p < .001$) displayed a higher severity

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of low-level behaviors. As a result of the significant relationship between low-level behaviors and cognitive abilities at age 4, all further analyses within the ASD sample involving the severity of low-level behaviors were performed while controlling for this relationship (Table 4). Within the developmental comparison sample, there were no significant relationships between the severity of low- and high-level behaviors and cognitive abilities at age 2 or age 4; however, at age 4, the negative relationship between low-level behaviors and visual spatial abilities was approaching significance ($p=.06$).

ASD Symptom Severity.

The relationship between RRBs and CARS total severity score were analyzed with Pearson correlations for the ASD group. Results yielded significant positive relationships for both low-level ($r = .274, p = .004$) and high-level behaviors ($r = .217, p = .024$) at age 2. Thus, there is a positive relationship between ASD symptom severity and severity of repetitive behaviors at age 2, regardless of the type of repetitive behavior. In contrast, there was only a significant relationship between low-level behaviors (when controlling for cognitive abilities) and ASD symptom severity at age 4 ($r = .223, p = .039$; Table 4).

Adaptive Functioning.

Within the ASD group, non-significant results were obtained for the relationship between the Daily Living Skills standard score and the Socialization standard score and severity of low-level repetitive behaviors at age 2, whereas there was a significant negative relationship when analyzing the Communication standard score ($r = -.185, p = .05$). Similar findings were found for the developmental comparison sample when

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analyzing the Communication standard score and severity of low-level repetitive behaviors at age 2 ($r = -.364$, $p = .035$). All other analyses between low and high level repetitive behaviors and adaptive functioning at age 2 were nonsignificant (Table 4). However, when examining repetitive behaviors at age 4, Pearson correlations were significant, or approaching significance, for low-level behaviors and all three measures of adaptive functioning within the ASD sample; Daily Living Skills ($r = -.401$, $p < .001$), Communication ($r = -.197$, $p = .06$), and Socialization ($r = -.230$, $p = .033$).

In the developmental comparison sample, results were only significant between the severity of low-level repetitive behaviors at age 4 and the Daily Living Skills standard score ($r = -.628$, $p < .001$). Within the ASD sample at age 4, the negative relationship between all three variables of adaptive functioning and low-level repetitive behaviors indicate that children who scored lower on measures of the Vineland had a greater severity of low-level behaviors, even when controlling for nonverbal abilities in the ASD sample.

Discussion

Overview of Results

ASD Sample

One of the primary goals of the current study was to examine the development of repetitive behaviors in young children with an ASD and then compare them to children with developmental delays. In the ASD sample, 86% of parents reported on the ADI-R that their child engages in at least one type of repetitive behavior at age 2. Based on the children's resulting ASD diagnoses and the fact that the presence of RRBs are required

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for a diagnosis of Autistic Disorder, it was not unexpected that these items were witnessed at such a high rate. Also, it is important to note that this percentage may under-represent the overall frequency of repetitive behaviors in the sample, due to the fact that only items found across all versions of the ADI-R were included.

When the tested behaviors were further categorized into high- and low-levels, we found the frequency rates between these two categories to be equal at age 2. This finding was unexpected, since previous literature has found high-level behaviors to be rare in a 2-year-old population of children with ASDs (Richler, Bishop, Kleinke, & Lord, 2007), whereas in the current sample a high percentage of parents endorsed that their child had unusual preoccupations (48.6%). Within our 2-year-old sample, unusual preoccupations included an unusual interest in objects, such as fans, lights, or toilets flushing, as well as lining up objects in an unusual manner. Furthermore, there were no significant differences in the average severity ratings between high- and low-level RRBs at this young age. Our results suggest that both types of RRBs are prevalent in two-year-old children with ASD, specifically with the following behaviors occurring with the greatest frequency: abnormal finger and hand mannerisms, complex body mannerisms, and unusual preoccupations.

The current study also compared the number and severity of RRBs reported at age 4 to those reported at age 2. Results yielded a significant increase in the number of RRBs in children with an ASD across the two time-points. These results confirmed previous findings that RRBs worsen in individuals with ASDs from early to late childhood (Bishop, Richler, & Lord, 2006; Moore & Goodson, 2003) and that repetitive behaviors may show less improvement over time compared to difficulties with communication and

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social relatedness, when given intensive intervention services (Piven, Harper, Palmer, & Arndt, 1996). When the behaviors were separated according to the high-low model, there was only a significant increase in the number of high-level behaviors, but no changes in the reporting of low-level behaviors. Thus, the data suggests that previous findings of an increase in the number of RRBs across the development of children with ASD is being driven by an increase in high-level behaviors between the ages of 2 and 4. More specifically, when examining the individual types of behavior, there was a significant increase in the reported frequency of compulsions and difficulties with changes to the child's own routine. Perhaps as children with ASDs mature, and have greater cognitive capacities, their inherent repetitive tendencies are seen in a wider variety of behaviors. Cognitive functioning in many of these children at age 2 is probably insufficient for them to be acutely aware of routines and changes to these routines.

Finally, previous literature supported a negative relationship between low-level behaviors and nonverbal IQ, as well as with adaptive functioning. However, these studies mainly focused on older children with ASDs (Bishop et al., 2006; Cuccaro et al., 2003) and the relationship between these variables was unclear in children with ASDs under the age of 3. The current study explored these relationships in younger children, as well as how these behaviors correlated with measures of ASD severity. Consistent with previous literature, there was a significant negative relationship between measures of cognitive abilities and low-level behaviors at age 4. These results suggest that the presence of low-level RRBs may interfere with a child's ability to learn and reach appropriate developmental milestones, thereby reducing their overall cognitive abilities. It is important to note that no significant relationships between low-level RRBs and

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cognitive ability were found at age 2 or with high-level behaviors at either time-point. Thus, low-level behaviors at age 2 may be more normative and provide a useful function, such as allowing a child to express their emotions (e.g., excitement, frustration) in the absence of appropriate self-regulatory or language skills, by flapping their hands. However, the continued presence and increased severity of these behaviors beyond the normative time point may negatively impact a child's ability to learn and develop cognitive skills independently, or in conjunction with other social and communicative deficits given that these same children are more likely to display a greater severity of autism symptomatology.

Similar to the relationship between RRBs and cognitive functioning, there was no relationship between measures of daily living skills and the severity of RRBs at age 2, but there was a significant negative relationship between low-level behaviors and measures of adaptive functioning at age 4, even when controlling for the child's nonverbal abilities. The current study replicated previous findings that RRBs are negatively related to cognitive abilities in older children with ASDs and that this relationship appears to be specific to low-level behaviors. In addition, there is a significant negative relationship between RRBs and adaptive functioning in four-year-old children with ASDs, even when controlling for cognitive abilities, a finding that has not previously been reported. One possible interpretation is that the presence of low-level behaviors may interfere with the development of daily living skills, above and beyond their relationship with intellectual abilities.

Furthermore, both types of repetitive behaviors were positively correlated with measures of ASD symptom severity at age 2. This relationship only remained for low-

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level behaviors at age 4, a finding that contrasts with a paper put forth by Turner (1999), where it was suggested that high-level behaviors may be more ASD specific and therefore would be expected to directly correlate with measures of symptom severity in older children with ASDs. Overall, it remains unclear what the function of these behaviors may be in early development, but as children with ASDs age, those with a greater severity of ASD symptoms display an increased severity of low-level repetitive behaviors, even when controlling for nonverbal abilities.

Comparison to a Developmental Comparison Sample

The second goal of the current study was to compare the development of RRBs in young children with ASDs to children diagnosed with a developmental delay. Previous research has questioned the utility of RRBs in differentiating children with ASDs from those with other developmental disabilities and has yielded mixed results (Cox et al., 1999; Lord, Rutter, & Le Couteur, 1994; Ventola et al., 2006; Lord, 1995; Wetherby et al., 2004). Results from the current study suggest that parents of children with developmental disabilities are reporting similar types and severity of repetitive behaviors when compared to parents of children with an ASD at age 2, even though the children with ASD had significantly lower cognitive abilities and receptive language skills. In this case, parents in both groups reported the presence of unusual preoccupations, repetitive hand mannerisms, and other complex mannerisms with greatest frequency, while reporting only minor difficulties with changes to the child's environment. When comparing the number and severity of these behaviors among the two groups during the initial evaluation, the only significant difference was in parent reporting of the number of high-level behaviors, where parents of children with ASD reported a higher number of

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these behaviors, therefore making it difficult to distinguish between these two groups, clinically, at an early age.

However, there were striking differences between the two groups by the age of 4. At the follow-up evaluation, parents of children with an ASD reported a significantly higher number and severity rating of both low- and high-level RRBs, creating a clear distinction between the two groups. These differences occurred even though the groups did not differ on measures of cognitive ability or receptive language during the reevaluation. However, it is interesting to note that the children with ASD had significantly worse expressive language skills (a form of higher-order cognition) and yet their parents reported a higher frequency and severity of high-level behaviors. When comparing severity levels of RRBs to other diagnostic measures, the two groups displayed similar relationships between low-level behaviors and daily-living skills, where 4-year-old children who displayed a higher severity level of low-level behaviors also showed worse daily living skills, however, no significant relationships were found between low-level behaviors and other measures of adaptive functioning in the developmental comparison group. The groups displayed different relationships when comparing severity of RRBs to cognitive abilities and to measures of ASD symptom severity. Taken together, the results indicate that RRBs may be difficult to use when distinguishing among diagnostic groups at age 2, but may differentiate children with ASDs from those with other developmental disabilities by age 4, given differences in the rate with which these behaviors are being reported and their relationship to other important diagnostic factors.

Limitations and Future Directions

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The current study has several important limitations. As mentioned previously, all children in the sample presented for the initial evaluation with ASD concerns. As a result, the children with a developmental delay (DD) and developmental language disorder (DLD) may not be representative of the broader group of children with these disorders. In addition, we had a smaller sample size in the developmental comparison group and it included both children who received a diagnosis of DD and those who were diagnosed with a DLD. It is possible that these two diagnostic classifications represent different samples of children with varying presentations of RRBs, which we were unable to explore with our limited sample size. Even so, our results indicated striking differences in the development of these behaviors through early childhood when compared to children with an ASD.

A second limitation in the current study is that the data on repetitive behaviors were based solely on parental report. Previous literature has shown differences in the prevalence rates of RRBs based on the means by which data were collected (Bodfish, Symons, Parker, & Lewis, 2000; Werner & Dawson, 2005). It will be important for future research to compare our results to other measures that are based on behavioral observations, such as the ADOS, or parent journals that record the amount of time a child spends engaged in these behaviors throughout the day. Furthermore, the use of a RRB specific measure, such as the Repetitive Behaviors Scale (RBS) (Lam & Aman, 2007), may provide greater specificity and clarification into the subtle differences between these types of behaviors in young children with ASDs. The RBS would also provide a greater number of items that measure high- and low-level behaviors, giving the analyses greater power. A further limitation in relying on parent report is that once these parents have

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been given the diagnosis of an ASD at the initial evaluation, they may become more aware of the symptoms of ASDs that their child displays and therefore report an increase in symptoms at age 4, a response bias that we were unable to control for in the current study.

Finally, data for the current study were only collected at two time points. In order to gauge changes in the number and severity of repetitive behaviors over time, a longitudinal design with 3 or more time points would be preferable. This would allow for the creation of developmental trajectories that outlines the change in the number of RRBs over time in order to measure if these changes are linear or non-linear. Unfortunately, studies such as these are more labor intensive and require greater financial resources. The time points used in the current study, while limited, are important. The age at which children have been receiving initial ASD diagnoses within the United States has been decreasing over the past ten years. As a result, many children are now being diagnosed and referred for early intervention services at the age of 2. This marks a point in development where the knowledge of the number and specificity of repetitive behaviors are crucial for clinicians in order to provide accurate diagnoses and intervention services for children with ASDs. Also, by the age of 4, these children have transferred into the school system and an increased knowledge of the effect these behaviors have on academic success and the ability of these children to learn, will be important.

The results of the current study provide further support to the importance of analyzing repetitive behaviors either based on individual behaviors, or with a categorical system similar to Turner's low-high model, that separates the behaviors based on similar features. By utilizing the distinction between high- and low-level behaviors, this may

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help to clarify discrepancies found in the previous literature, and allow for more specific research questions to be assessed. Furthermore, when working with individuals with ASDs above the age of 3, it is important for future research to control for measures of both verbal and nonverbal abilities when assessing low-level repetitive behaviors. These methods will help to reduce research error and provide greater certainty in the results.

Conclusion

The current study demonstrated that children with ASDs display an increase in the number of RRBs between the ages of 2 and 4 that differentiates them from children with developmental delays. During the initial evaluation, children with ASDs displayed similar frequencies and severities of low- and high-level repetitive behaviors, a finding that has not been reported by previous literature. However, by age 4, 41% of these same children displayed a significant increase in the number of some high-level repetitive behaviors. This result was driven by an increase in the frequency of the following items on the ADI-R: resistance to changes in the child's own environment and routine, and compulsions and rituals. Low-level behaviors, on the other hand, were reported at the same level of frequency between these two time points. As a result, the data suggests that the increase in the number of RRBs found in the previous literature is driven by an increase in the number of high-level behaviors found by age 4. Furthermore, high-level repetitive behaviors differentiated these children from those with a developmental delay at age 2 and 4. When examining low-level behaviors, the current results suggest that children with ASDs who have frequent and severe low-level behaviors are more likely to have lower nonverbal abilities, as well as decreased daily living skills, which correlate with measures of ASD symptom severity.

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The findings of the current study yield several important clinical implications. First, broad measures of RRBs may not be appropriate for the early diagnosis of ASDs in young children with ASDs, since they were only differentiated from children with developmental delays in the number of high-level behaviors at age 2. Low-level repetitive behaviors appear to be more robust across development in children with ASDs, whereas high-level behaviors may not be seen in some children until the age of four. This seems to occur because of a divergent trajectory in the development of repetitive behaviors between children diagnosed with an ASD and those diagnosed with a developmental delay. Therefore, all of these behaviors need to continue to be assessed in relation to social and communication difficulties typically seen in children with ASDs, when giving an initial diagnosis before the age of 4. Finally, the current study supported the need to find appropriate ways to categorize RRBs and the utility these classification systems can have in clarifying previous findings.

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Table 1

Participant Demographic Information

Participant Demographic Information				
	ASD Sample n = 109		Developmental Control Sample n = 34	
	<i>Initial Evaluation</i>	<i>Follow Up Evaluation</i>	<i>Initial Evaluation</i>	<i>Follow Up Evaluation</i>
Age in Months				
Mean (SD)	26 (4.3)	51 (5.3)	26 (4.2)	53 (7.5)
Mullen Mean T-Score (SD)				
Fine Motor	29 (10) ¹	35 (18)	35 (12) ¹	41 (15)
Visual Reception	29 (9) ²	30 (13)	36 (12) ²	35 (14)
Receptive Language	24 (8) ³	31 (16)	29 (13) ³	36 (14)
Expressive Language	26 (10)	28 (13) ⁴	27 (8)	35 (13) ⁴
Diagnosis (n)				
Autistic Disorder	59	64	0	0
PDD-NOS	50	30	0	0
Developmental Language Disorder	0	0	15	2
Developmental Delay	0	5	19	14
No Diagnosis	0	7	0	9
Other Diagnosis	0	1	0	5
Typical Development	0	2	0	4
Gender (n)				
Male		89		29
Female		20		5
Ethnicity (%)				
White		81		85
Hispanic/Latino		10		6
Black		4		6
Asian/Pacific Islander		3		0
Biracial		1		0
Unknown		1		3

Superscripts denote a significant group difference ($p < .05$).

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Table 2

ADI-R Items measuring Low- and High-Level Repetitive Behaviors

ADI-R Items and Definitions From the Repetitive and Stereotyped Behaviors	
Domain	
<i>Low-Level Items</i>	<i>High-Level Items</i>
<i>Hand and Finger Mannerisms</i> : typically involving rapid, voluntary, repetitious movements of the fingers and hands.	<i>Unusual Preoccupations</i> : an interest that is odd or peculiar in quality, such as an intense interest in metal objects, lights, or street signs.
<i>Other Complex Mannerisms or Stereotyped Body Movements (Does Not Include Isolated Rocking)</i> : complex, stereotypic, voluntary, whole-body movements, such as arm waving while rocking up onto tiptoes.	<i>Compulsions/Rituals</i> : fixed sequences that are performed as if the subject feels pressure to complete them in a particular order.
	<i>Difficulties with Minor Changes in Subject's Own Routines or Personal Environment</i> : marked negative reactions to a variety of minor changes in the subject's daily activities.
	<i>Resistance to Trivial Changes in the</i>

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	<p><i>Environment (Not Directly Affecting the Subject):</i> marked negative reactions to minor changes to the subject's environment.</p>
	<p><i>Unusual Attachment to Objects:</i> an unusual interest and dependence on a particular object that the subject carries around with him or her.</p>

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Table 3

Frequency of Restricted and Repetitive Behaviors at Age 2 and Age 4

Frequency of Restricted and Repetitive Behaviors Based on Individual Items of the ADI-R		
	Percentage of Sample %	
ASD Sample (n = 109)	<i>Age 2</i>	<i>Age 4</i>
<i>Low-Level Behaviors</i>		
Hand and Finger Mannerisms	53.2	64.8
Other Complex Mannerisms	47.7	49.5
<i>High-Level Behaviors</i>		
Preoccupations	48.6	39.4
Compulsions/Rituals	14.7 ¹	37.6 ¹
Difficulty with Changes to Routine	16.5 ²	43.4 ²
Difficulty with Changes to Environment	9.2	18.6
Unusual Attachments	21.1	23.1
Developmental Comparison Sample (n = 34)		
<i>Low-Level Behaviors</i>		
Hand and Finger Mannerisms	38.2	32.4
Other Complex Mannerisms	38.2	26.5
<i>High-Level Behaviors</i>		
Preoccupations	32.4	11.8
Compulsions/Rituals	17.6	32.4
Difficulty with Changes to Routine	8.8	25
Difficulty with Changes to Environment	0	3.3
Unusual Attachments	8.8	7.7

Superscripts denote a significant group difference ($p < .05$).

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Table 4

Pearson Correlations Between Low- and High-Level RRBs and Developmental and Diagnostic Factors

Pearson Correlations Examining the Relationship Between Low- and High-Level RRBs and Important Developmental and Diagnostic Factors				
ASD Sample	<i>Age 2 Severity</i>		<i>Age 4 Severity</i>	
	LLB	HLB	LLB	HLB
<u>Mullen Scales of Early Learning</u>				
Early Learning Composite	ns	ns	r = -.285, p = .006	ns
Visual Reception T-Score	ns	ns	r = -.220, p = .026	ns
Fine Motor T-Score	ns	ns	r = -.204, p = .039	ns
Expressive Language T-Score	ns	ns	r = -.375, p < .001	ns
Receptive Language T-Score	ns	ns	r = -.378, p < .001	ns
<u>CARS Total Severity</u>	r = .274, p = .004	r = .217, p = .024	r = .223, p = .039*	ns
<u>Vineland Standard Score</u>				
Daily Living Skills	ns	ns	r = -.401, p < .001*	ns
Communication	r = -.185, p = .05	ns	r = -.197, p = .06*	ns
Socialization	ns	ns	r = -.230, p = .033*	ns
Developmental Control Sample				
<u>Mullen Scales of Early Learning</u>				
Early Learning Composite	ns	ns	ns	ns
Visual Reception T-Score	ns	ns	r = -.330, p = .06	ns
Fine Motor T-Score	ns	ns	ns	ns
Expressive Language T-Score	ns	ns	ns	ns
Receptive Language T-Score	ns	ns	ns	ns
<u>CARS Total Severity</u>	ns	ns	ns	ns
<u>Vineland Standard Score</u>				
Daily Living Skills	ns	ns	r = -.628, p < .001	ns
Communication	r = -.364, p = .035	ns	ns	ns
Socialization	ns	ns	ns	ns

*While controlling for Early Learning Composite standard scores on the Mullen Scales of Early Learning.