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Restricted and Repetitive Behaviors as Predictors of Outcome in Autism Spectrum Disorders

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Restricted and Repetitive Behaviors (RRBs) are core features of Autism Spectrum Disorders (ASDs). Efforts to understand the purpose of RRBs have raised questions about the significance of the presence of RRBs in the long-term outcome of children with ASDs. Some studies have reported that the presence of RRBs during preschool years is a negative prognostic indicator for later childhood (e.g., Charman et al., 2005), while others have failed to replicate this finding (e.g., Bopp et al., 2009). This study examined the effect of RRBs on later functioning in 40 children with ASDs. RRBs were examined at ages 1-2 and 3-5 years using direct observation and parent report. These scores were used to predict cognitive functioning, adaptive abilities, and ASD symptomatology at age 8-10 years. The results suggest that RRBs observed early in the preschool period do not predict later functioning. However, when RRBs are observed at age 3-5 years, they appear to be useful prognostic indicators. Specifically, more severe preoccupations with parts of objects, sensory interests and stereotyped motor movements observed between 3-5 years of age predicted less developed cognitive and adaptive skills, as well as greater ASD symptom severity at age 8-10 years. The relationship between RRBs in the late preschool period and school age outcome is not as strong as the relationship between cognitive functioning in the late preschool period and school age outcome. However, overall, these findings indicate that exhibiting RRBs in the late preschool period does appear to be a negative prognostic indicator for school-age outcome.

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Restricted and Repetitive Behaviors as Predictors of Outcome in Autism Spectrum Disorders

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TABLE OF CONTENTS

Abstract

Restricted and Repetitive Behaviors (RRBs) are core features of Autism Spectrum Disorders (ASDs). Efforts to understand the purpose of RRBs have raised questions about the significance of the presence of RRBs in the long-term outcome of children with ASDs. Some studies have reported that the presence of RRBs during preschool years is a negative prognostic indicator for later childhood (e.g., Charman et al., 2005), while others have failed to replicate this finding (e.g., Bopp et al., 2009). This study examined the effect of RRBs on later functioning in 40 children with ASDs. RRBs were examined at ages 1-2 and 3-5 years using direct observation and parent report. These scores were used to predict cognitive functioning, adaptive abilities, and ASD symptomatology at age 8-10 years. The results suggest that RRBs observed early in the preschool period do not predict later functioning. However, when RRBs are observed at age 3-5 years, they appear to be useful prognostic indicators. Specifically, more severe preoccupations with parts of objects, sensory interests and stereotyped motor movements observed between 3-5 years of age predicted less developed cognitive and adaptive skills, as well as greater ASD symptom severity at age 8-10 years. The relationship between RRBs in the late preschool period and school age outcome is not as strong as the relationship between cognitive functioning in the late preschool period and school age outcome. However, overall, these findings indicate that exhibiting RRBs in the late preschool period does appear to be a negative prognostic indicator for school-age outcome.

Introduction

Autism Spectrum Disorders (ASDs) are a group of neurodevelopmental disorders that affect as many as 1 in 88 individuals (Centers for Disease Control and Prevention [CDC], 2012). ASDs are characterized by deficits in communication and socialization, along with repetitive and stereotyped behaviors. The severity and clinical presentation of symptoms within these clusters vary considerably, as does the outcome of individuals with ASDs (Hus, Pickles, Cook, Risi, & Lord, 2007; Sallows & Graupner, 2005). However, little is known about the factors that account for the variability in outcomes, making it difficult to help parents understand what they can expect for their child's future.

Studies of children with ASDs indicate that the younger the child is at the beginning of treatment, the better the outcome (Harris & Handleman, 2000; Maurice, Green, & Luce, 1996; Woods & Wetherby, 2003). Consequently, substantial progress has been made identifying children at risk for developing ASDs in the earliest stages of their development in order to provide intervention as early as possible. As a result of these efforts, many children with ASDs are now being diagnosed during the preschool period (Baird et al., 2001; Filipek et al., 2000), presenting clinicians with the challenges of describing prognosis to parents of children diagnosed at this early age and recommending appropriate treatment. To address this need, a growing body of research has focused on identifying early markers of outcome in young children with ASDs. Knowledge about the factors that predict later functioning not only helps to determine prognosis, but may also aid in the identification of pretreatment factors that predict response to intervention.

Research examining early factors that predict subsequent outcome have consistently identified early cognitive ability as well as early language functioning as potent predictors of outcome (e.g., Ballaban-Gil, Rapin, Tuchman, & Shinnar, 1996; Bibby, Eikeseth, Martin, Mudford, & Reeves, 2002; Charman et al., 2005; Lord & Paul, 1997; Stevens et al., 2000; Szatmari, Bryson, Boyle, Streiner, & Duku, 2003; Venter, Lord, & Schopler, 1992). Another avenue pursued in the search for early factors that predict outcome has focused on the presence, severity and type of restricted and repetitive behaviors (RRBs). This line of research is particularly interesting because theories proposed to explain the purpose of RRBs predict a negative relationship between the presence of RRBs and the long-term outcome of children with ASDs.

The Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition, Text Revision* (DSM-IV-TR) considers a variety of behaviors within the RRBs cluster, including motor stereotypies (e.g., hand flapping), preoccupation with parts of objects (e.g., spinning the wheels of a car), insistence on sameness, restricted interests, and other ritualistic behaviors (e.g., lining up objects; American Psychiatric Association [APA], 2000). The fifth revision of the DSM (DSM-5; APA, 2012) has proposed to add sensory hypo- and hyper-reactivity, as well as unusual sensory interests, to its diagnostic criteria for the RRBs cluster, as these have reliably distinguished infants later diagnosed with ASDs from typically developing peers (Baranek, 1999; Baranek, David, Poe, Stone, & Watson, 2006; Lord, 1995; Watson et al., 2007; Watt, Wetherby, Barber, & Morgan, 2008).

Although little is known about why individuals with ASDs engage in RRBs, theories proposed thus far have suggested that some types of RRBs may be indicative of overarousal, either tonic or phasic, cognitive impairment, executive dysfunction or weak central coherence (Turner, 1999). Although some of these theories explain some types of RRBs more fully than other types of RRBs, the common element across these theories is that they all predict greater functional impairment among individuals who exhibit more RRBs.

The overarousal theory suggests that RRBs are used to help individuals with ASD compensate for overarousal by decreasing the level of arousal elicited by the environment (Kinsbourne, 1980, 1987, 2011). According to this theory, repetitive motor movements may serve to limit overarousal that is present in the environment, while resistance to change, inflexible behavior and circumscribed interests may reduce the potential for overarousal in the environment. Kinsbourne argues that RRBs have a calming effect because by engaging in RRBs, the child is able to turn his or her attention inward, limiting the sensory input received from the arousing environment and decreasing his or her arousal level. This theory of RRBs suggests that while the child engages in RRBs, attention is directed away from environmental input, increasing social isolation of the child and limiting learning opportunities, which will hinder the child's development.

Baron-Cohen (1989) argued that RRBs develop to compensate for anxiety that results from a specific cognitive impairment evident in ASDs – the inability to understand the mental states of others. This and similar theories argue that RRBs serve the purpose of taking the child's attention away from a social environment that may be difficult to predict (Carruthers, 1996). These theories are particularly well suited to explain insistence on sameness, which limits the unpredictability of the social world, and circumscribed interests which shift the child's attention away from the social environment and onto nonsocial interests. Again, these consequences of RRBs would limit the child's learning from the environment and slow developmental progression.

The executive dysfunction theory proposes that RRBs are evident because of poor behavior regulation that results from a tendency to perseverate and from deficits in planning, self-monitoring, inhibition of ongoing behaviors, and initiation of new behavior (Russell, 1997).

Because of difficulty inhibiting behavior, children with ASDs may become overfocused on one particular behavior, and this perseveration could be exacerbated by difficulty generating new behaviors (Turner, 1997, 1999). This overfocusing and perseveration may explain circumscribed interests, insistence on keeping a similar routine and repetitive motor movements. Deficits in these executive functioning domains may also lead to challenges in cognitive, communication and socialization domains and could explain a negative relationship between the presence of RRBs and future functioning.

The weak central coherence theory proposed by Frith and Happe (1994) postulates that individuals with ASDs are unable to derive global meaning from processed input and for this reason focus on seemingly insignificant details of the environment. According to this theory, this shift in focus results in circumscribed interests, unusual sensory interests and insistence on keeping the details of the environment the same. Deficits in global meaning-making would make it increasingly difficult for individuals to learn from experiences or their environment, and could lead to delays in communication, social or cognitive abilities.

The social-interactionist perspective on language development argues that language is developed through the motivation to interact with others and social experiences facilitate the development of language. Therefore, children who exhibit problem behaviors that take the form of tantrums or distress following change in the environment, overly rigid behavior or repetitive motor behavior may be isolated and be placed at risk for developing disordered or delayed language (Bopp, Mirenda, & Zumbo, 2009).

To summarize, the theories described above argue that the presence of RRBs shifts the child’s attention away from the environment and makes the child unavailable to receive meaningful input from the environment. As a result, children who engage in RRBs may do so at the cost of activities that would promote cognitive, social and communicative development, leading to delays in the development of these skills (Bodfish, Symons, Parker, & Lewis, 2000; Lewis, 2004). Further, the lack of appropriate attentiveness to the environment may prevent the child from receiving environmental input necessary for typical neural development (Lewis, 2004), potentially resulting in further delays in development among those who present with RRBs.

In response to the predictions of the theories of RRBs described above, a number of cross-sectional studies have examined the association between the degree and type of RRBs and an individual's level of functioning. Several studies reported finding a concurrent significant negative relationship between functioning level and repetitive sensory-motor behaviors, such that less developed receptive and expressive language abilities and lower adaptive communication and socialization skills are more commonly observed among children with higher levels of RRBs (Bishop, Richler, & Lord, 2006; Cuccaro et al., 2003; Gabriels, Cuccaro, Hill, Ivers, & Goldson, 2005; Honey, McConaichie, Randle, Shearer, & Le Couteur, 2008; Lam, Bodfish, & Piven, 2008; Mirenda et al, 2010; Mooney, Gray, Tonge, Sweeney, & Taffe, 2009; Richler, Heurta, Bishop, & Lord, 2010; Szatmari et al., 2006). A positive relationship has been found between circumscribed interests and functioning among children with ASDs (Bishop et al., 2006). Finally, several studies have found no clear relationship between functioning and insistence on sameness (Bishop et al., 2006; Cuccaro et al., 2003; Mooney et al., 2009; Szatmari et al., 2006). However, these studies included samples of either very young children (20-55 months; Mooney et al., 2009), or a wide age range of participants (early preschool through late childhood; Bishop et al., 2006; Cuccaro et al., 2003; Szatmari et al., 2006), which may miss or mask a relationship present between these factors in the late preschool period.

In addition, a number of studies have also reported an association between the type of RRB and level of functioning. Specifically, stereotyped motor movements, repetitive use of objects, unusual sensory interests and repetitive self-injurious behaviors are more commonly observed among lower-functioning individuals with ASDs. Conversely, repetitive speech and circumscribed interests are more commonly observed among higher functioning individuals with ASDs (Bishop et al., 2006; Cuccaro et al., 2003; Lam et al., 2008; Militerni, Bravaccio, Falco, Fico, & Palermo, 2002; Turner, 1999). These studies suggest that the relationship between RRBs and functioning level may vary depending on the type of RRB examined. It is worth noting that despite these associations, high-functioning individuals with an ASD exhibit a variety of RRBs, including motor stereotypes, rigid rituals, circumscribed interests and repetitive object use (Bishop et al., 2006; South, Ozonoff, & McMahon, 2005).

While these studies are informative, it is difficult to draw conclusions from cross-sectional studies about the long-term effect of RRBs on subsequent outcome and this research question would be most effectively studied longitudinally. Few longitudinal investigations of the role that RRBs play on subsequent school-age outcome have been published. These studies have yielded mixed results and are hindered by methodological limitations (Cox et al., 1999; Lord, 1995; Stone et al., 1999). Some of these studies have suggested that children with ASDs who display RRBs early in their preschool years tend to have poorer school-age language outcomes than children who do not exhibit these movements during this age period (Charman et al., 2005; Paul, Chawarska, Cicchetti, & Volkmar, 2008). Other longitudinal studies have failed to find a relationship between the presence of RRBs during the preschool period and school-age language functioning (Bopp et al., 2009).

These inconsistencies in the results may be explained by variations in the way that RRBs were assessed. Some studies used measures designed to examine RRBs, while others used answers to single items about RRBs that were asked as a part of a comprehensive parent interview designed to evaluate ASD symptoms (e.g., ADI-R). For instance, Bopp et al. (2009) did not include an existing valid and reliable measure to assess RRBs, and, as a result of this methodology, may have failed to find a significant relationship between language development and severity of early RRBs that has been reported previously. The use of different measures may have also lead to samples that included different varieties of RRBs. For instance, some studies investigated repetitive motor movements exclusively, while others included sensory behaviors, resistance to change and restricted interests. This is particularly problematic because studies of repetitive behaviors among adults with RRBs suggest that the presence of rigidities or resistance to change is not related to outcome as strongly as is the presence of repetitive sensory-motor behaviors (Turner, 1999).

In addition to the lack of consensus about how to measure RRBs in children, there is little agreement about how to measure a general outcome in children with ASDs. Because of the variety of core deficits, studies have focused on the development of adaptive skills, cognitive functioning, social abilities, development of language or the severity of symptoms. Although all of these factors are valid measures of functioning, studies examining the impact RRBs have on subsequent functioning have failed to comprehensively examine each aspect of functioning, choosing instead to only focus on one of these outcome domains.

Furthermore, all of the longitudinal studies mentioned above are retrospective and relied exclusively on parent report of RRBs, rather than incorporating direct observation. Using parent report may introduce bias, especially when the parent is asked to recall past behavior. Studies that depended on the accuracy of parent reports are particularly problematic when used in samples that included wide age ranges, as some parents were asked to recall events that occurred more recently than others. The use of direct observation of RRBs would help eliminate this bias.

Finally, studies completed thus far have only included one measurement point during the preschool period, which does not account for changes in the presentation of RRBs commonly reported to exist during the early childhood period (Charman et al., 2005; Cuccaro et al., 2003; Moore & Goodson, 2003; Richler, Bishop, Kleinke, & Lord, 2007; Richler et al., 2010; Stone et al., 1999; Szatmari et al., 2006). Because RRBs are not consistently present in the early preschool years, it is possible that the children who were included in the comparison groups of the studies described above did not exhibit some types of RRBs when evaluated in the early preschool years, but displayed these behaviors later in the preschool period. Conversely, some types of RRBs (e.g., repetitive motor movements, repetitive object use, rigid adherence to routines) may be highest during the preschool period and decrease with age (Moore & Goodson, 2003). The results of these studies indicate that including a single evaluation of RRBs later in the preschool period may fail to capture all types of RRBs exhibited by preschool children with ASDs.

Because the studies published thus far have methodological limitations and yielded mixed findings regarding the role that RRBs play in later functioning, the current study sought to advance the research conducted by using a longitudinal design in order to help clarify the relationship between RRBs and later functioning. The current study included direct observation of RRBs during two time points – at approximately two and four years of age, thereby limiting recall bias and ensuring that the presence and severity of different types of RRBs were measured accurately. The current study also attempted to resolve some of the contradictions in the literature by examining a sample with a narrow age range and by including a comprehensive battery to measure outcome.

The current study aimed to determine whether any type of RRBs seen during the preschool years would predict school-age cognitive and adaptive abilities, as well as symptom severity in children with ASDs. Theories of RRBs and some previous literature suggest that the presence of RRBs is associated with less developed cognitive and adaptive abilities. Based on these theories, Hypothesis 1 predicted that children who engaged in RRBs during the preschool years would exhibit less developed cognitive and adaptive abilities and more severe ASD symptomatology than preschoolers who engaged in RRB less frequently, or not at all. Such a result would suggest that clinicians who are diagnosing preschoolers with ASDs could use these readily apparent behaviors as a marker of prognosis.

In addition, the study sought to determine whether the amount of variance explained in school-aged functioning by RRBs at age 1-2 and 3-5 was beyond the amount of variance accounted for by other factors that have been shown to predict outcome in children with ASD (i.e., preschool cognitive functioning and communication abilities). Again, based on available theories of RRBs in ASDs, Hypothesis 2 predicted that the presence and severity of RRBs during the preschool period would significantly predict school-age functioning independently of the child's preschool IQ and communication abilities.

Finally, the study aimed to examine whether any types of RRBs exhibited during school age correlated with functioning at this age. These analyses helped determine whether RRBs were associated with cognitive and adaptive functioning, as well as ASD symptomatology in children who are of school age. Hypothesis 3 predicted a negative relationship between RRBs and functioning level.

Methods

Sample and Participant Selection

Forty participants were recruited from a sample involved in an ongoing study examining the effectiveness of the Modified Checklist for Autism in Toddler (M-CHAT), a screening instrument designed to identify children at risk for developing ASDs at the age of 16–30 months. As part of this study, children who screened positive on the M-CHAT and a follow-up telephone interview received two comprehensive developmental evaluations when the children were approximately 2 years of age (1-3 years) and 4 years of age (3-5 years). Researchers offered a third evaluation to every child who was 8-10 years old and who received an ASD diagnosis at ages 1-2 and 3-5 (See Figure 1 for a visual guide depicting progression through the study).

Eighty five percent of the sample was male (34 male participants; see Table 1 for participant characteristics). The male to female ratio of this sample was 5.67 to 1 and is consistent with epidemiological reports of autism (Fombonne, 2003). The average age of the participants was 26.23 months (*SD* = 3.76) at the first evaluation, 51 months (*SD* = 5.28) at the second evaluation and 9.87 years (*SD* = 0.81) at the third evaluation. The screening study was conducted in the state of Connecticut and the area in which the screening was conducted includes several large urban cities, suburbs of cities and rural areas. The ethnic breakdown of the participants included in the study was: 90% White, 5% African American and 5% Asian.

At the time of the third evaluation, the cognitive abilities of the participants ranged from extremely low to superior, with the average nonverbal reasoning ability falling in the low end of the average range (*M* = 81.39, *SD* = 27.43) and the average verbal IQ score falling in the low range (*M* = 70.84, *SD* = 31.53). A similar variability was noted in the adaptive functioning of the participants, which again ranged from low to moderately high in some domains. The group's average fell in the moderately low range for daily living skills (*M* = 75.13, *SD* = 14.42) and adaptive communication skills (*M* = 72.60, *SD* = 16.16), while adaptive socialization abilities fell in the low range (*M* = 68.13, *SD* = 16.72). The group's average scores on the Autism Diagnostic Observation Schedule (ADOS, see Measures section below), which was used to assess ASD symptomatology, fell above the cutoff for ASD on both the communication and socialization domains (Communication: *M* = 4.90, *SD* = 2.20; Socialization: *M* = 8.60, *SD* = 2.88).

Inclusion/exclusion criteria. To be included in this study (a) children had to be 8-10 years old, (b) children were evaluated at age 1-2 and 3-5 years as part of the M-CHAT study, (c) children received a primary diagnosis of ASD as a result of both evaluations, (d) parents consented to the study and children whose mental age was 7 years of age or greater gave their assent, and (e) families were primarily English speaking. Exclusion criteria included impairments in sensory (e.g., blindness) or motor functioning (e.g., severe cerebral palsy) that prohibited testing from being completed.

Procedure

The sample consisted of individuals who participated in an ongoing study examining the effectiveness of the M-CHAT. The ongoing study distributed the M-CHAT to pediatricians' offices where children were typically screened at the 18 and 24-month well-child care visits. If the child screened positive, the family was informed that based on the questionnaire it appeared that their child was not doing some of the things that most children of the same age were doing, and the family was offered a free developmental evaluation. Families who did not have a means of transportation were provided cab service.

Two clinicians conducted the initial evaluations: a licensed psychologist or developmental pediatrician and a graduate student. Testing was typically completed within three hours, and verbal feedback was given to the family at the end of the evaluation. Any diagnosis made was based on clinical judgment, using DSM-IV-TR criteria, and took all diagnostic measures into account. When the child turned 42 months of age, the family was contacted to schedule a second developmental evaluation (see Figure 1 for a flowchart of progression through the study and Table 2 for instruments administered during the evaluations).

One hundred and two children met the enrollment criteria of the study: received an ASD diagnosis at both evaluations and were 8-10 years of age. These families were contacted and offered an additional free developmental evaluation. Of these 102 children, parents of 54 children could not be reached by telephone or mail, and of the 49 families who were contacted, parents of 40 children agreed to participate, 1 family moved, and 7 families refused to participate. The retention rate for this study was 39%. Analyses of variance were conducted to explore the possibility of differential attrition; 40 participants were compared with 89 individuals who did not participate in the study. These analyses revealed that when children who participated in this third evaluation were compared to children who were eligible, but who did not participate in this study, no significant group differences were evident on gender, ethnicity, cognitive functioning, adaptive skills or ASD symptom severity at either age 1-2 or age 3-5.

Two graduate students completed the evaluation and were supervised by licensed psychologists. The evaluation was conducted in the Psychological Services Clinic at the University of Connecticut and lasted approximately 4 hours. A concurrent parent interview was conducted to assess the child's adaptive functioning and lasted approximately 2 hours (see Table 2 for instruments included in the evaluation). Researchers also requested the child's teacher to complete a questionnaire measuring the child's adaptive skills. All study components discussed above received the approval of the University of Connecticut Institutional Review Board.

Measures (see Tables 2 and 3)

Predictor measures.

Restricted and Repetitive Behaviors. Presence and severity of RRBs during the preschool period were measured using a chart review that incorporated parent report, direct observation of RRBs and clinical judgment made when the child was seen at age 1-2 and 3-5 years (see below for detail of instruments included in chart review). A rater blind to current participant presentation reviewed the records of the participant's 2-year-old and 4-year-old evaluations and made a severity rating (i.e., none, mild, or moderate to severe) for five categories of RRBs as outlined in the DSM-IV-TR and the DSM-5, as well as self-injurious behaviors (see Table 3 for a list of RRBs evaluated and measures assessed). A second blind rater reviewed ten percent of these ratings and inter-rater reliability was calculated for each type of RRB assessed using Cohen's kappa coefficients. Inter-rater reliability ranged from a kappa value of 0.74 to 1.0 for all types of RRBs indicating good agreement between raters.

The rating of severity of RRBs was based on the following measures:

1. <u>Clinical judgment at 1-2 and 3-5 years of age</u>: was made at the time of the participant's initial evaluation and re-evaluation as part of this study, and was made by a licensed clinical psychologist or developmental pediatrician. These clinicians have extensive experience in diagnosing ASDs and have been trained on the assessment tools included in the study. Clinical judgment was used to determine whether each of the four types of RRBs included in the DSM-IV-TR was present or absent (i.e., preoccupation with abnormal intensity/focus, inflexible adherence to routines/rituals, stereotyped/repetitive motor mannerism, preoccupation with parts of objects). This rating was based on two

diagnostic measures conducted during the evaluation (i.e., Autism Diagnostic Interview and Autism Diagnostic Observation Schedule) and direct observation. Because the DSM-IV-TR does not include sensory interests and self-injurious behaviors, clinical judgment was not available for these types of RRBs.

2. <u>Parent report of RRBs:</u> was gathered by examining responses to 9 items that relate to RRBs on the *Autism Diagnostic Interview-Revised* (ADI, Lord, Rutter, & Le Couteur, 1994). The ADI is a commonly used semi-structured interview that is used to assess current and past behaviors necessary for the diagnosis of ASD. Items are combined to provide a score for each of the three domains specified in the DSM-IV-TR (social, communication and repetitive behaviors). Published inter-rater reliability ranges from 0.63 to 0.89 for each item, and intraclass correlations are above 0.92 for subdomain and domain scores (Lord et al., 1994). RRBs measured by this measure include: verbal rituals, unusual preoccupations, circumscribed interests, compulsions/rituals, difficulties with minor changes in routine or personal environment, resistance to trivial changes in the environment, unusual attachment to objects, hand and finger mannerisms, as well as other complex mannerisms or stereotyped body movements.
3. <u>Direct observation of RRBs:</u> was collected by reviewing clinician ratings on items on the *Autism Diagnostic Observation Schedule* (ADOS; Lord, Risi, & Lambrecht, 2000). The ADOS is a structured play and interview session for the diagnosis of ASD. The instrument consists of a series of activities designed to interest young children and encourage communication, social interaction and imaginative use of materials. In addition, it provides opportunities to observe social interactions including affect sharing, checking adults' reactions, and symbolic play. Inter-rater reliability of this instrument is

0.82 or above on all domains, and test-retest reliability is 0.73 or above, except for restricted interests (0.59)(Lord et al., 2000). Direct observation of repetitive motor behaviors, unusual sensory interests, restricted interests and stereotyped behavior were included. The ADOS Calibrated Severity Score system was used for scoring; higher scores are indicative of more severe ASD symptomatology and scores greater than 4 fall in the Autism Spectrum range (Gotham, Pickles, & Lord, 2009).

Cognitive Functioning. During the 2- and 4-year-old evaluations cognitive functioning was assessed using the *Mullen Scales of Early Learning* (Mullen, 1995). This instrument assesses the development of expressive and receptive language, visual reception and fine motor skills. Test-retest reliability for the domain scores range from 0.76 to 0.96, inter-rater reliability ranges from 0.91 to 0.96 and alpha coefficients range from 0.75 to 0.83 (Mullen, 1995). Performance on this measure was used to determine whether the presence of RRBs during the preschool period accounted for more variability in outcome than did cognitive functioning during this period.

Outcome measures.

Autism symptomatology. The calibrated severity score of the ADOS was used as a metric of ASD severity (Gotham et al., 2009). Calibrated severity scores range from 1-10 and higher scores are indicative of greater ASD symptomatology, with a score greater than 4 falling in the Autism Spectrum range, and a score greater than 6 falling in the Autistic Disorder range. In addition, the *Childhood Autism Rating Scale* (CARS; Schopler, Reichler, De Vellis, & Daly, 1980) was also used to measure the severity of ASD symptoms. This measure consists of 15 items used for rating aspects of autistic behavior; children were rated on each item based on the clinician's observation. Scores on each item range from 0-4 and higher scores indicate greater severity of ASD symptoms. Inter-rater reliability is 0.71 and internal consistency is 0.94 (Schopler et al., 1980). The *Repetitive Behavior Scale-Revised* (RBS-R; Bodfish et al., 2000) was used to gather parent report of RRBs at the time of the third evaluation (age 8-10). The RBS-R is a parent report measure of a child's repetitive behaviors, which are grouped in six domains: stereotyped, self-injurious, compulsive, ritualistic, sameness and restricted behaviors. Each item The subscale scores are totaled to arrive at an overall score. Recent data support the usefulness of this scale with ASD (Lam & Aman, 2006); subscale inter-rater reliability ranges from 0.57 to 0.73.

Cognitive functioning. The *Differential Ability Scales-II* (DAS-II, Elliott, 2007) was used to measure intellectual ability during the 8- to 10-year-old evaluation. This measure produces verbal, nonverbal and spatial reasoning scores. The test-retest reliabilities for all subtests range from 0.54 to 0.94 (Elliott, 2007). Unlike many other commonly used tests of intelligence, the DAS-II can be used with children whose mental ages range from 2 years, 6 months through 17 years 11 months and has less verbal loading on the General Cognitive Ability score. When a participant's developmental level fell below 2 years, 6 months, the *Stanford-Binet Intelligence Scales, Fifth Edition* (Stanford-Binet; Roid, 2005) was used to measure verbal and nonverbal ability. The Stanford-Binet is a standardized measure of cognitive functioning and extends down to the developmental age of 2 years. Internal consistency composite reliability for both verbal and nonverbal reasoning scores are above 0.95; subtest score reliabilities range from .84 to .89. Test-retest reliability for the age range included in this study was fairly high, ranging from 0.76 to 0.91 for all subtests (Roid, 2005).

Adaptive skills. Adaptive behavior was measured with the *Vineland Adaptive Behavior Scales – Second Edition* (Vineland; Sparrow, Cicchetti, & Balla, 2005). The Vineland is a widely used scale of adaptive behavior that contains language (receptive, expressive, and written), daily living skills (self-care, domestic, and community) and socialization skills (interpersonal, play, and coping). Test-retest reliability ranges from 0.8 to 0.9 and inter-rater reliability ranges from 0.62 to 0.78 for all domains (Sparrow et al., 2005).

Data Analysis

Multiple regression was used to determine whether the types of RRBs seen during the preschool years accounted for a significant amount of variance in school-age adaptive and cognitive abilities in children with ASDs. Dependent variables (outcome measures: cognitive and adaptive functioning, severity of ASD symptoms and presence of RRBs at age 8-10) were simultaneously regressed on the independent variables (ratings of six types of RRBs at age 1-2 and again at age 3-5). Standardized regression coefficients were compared to examine the relative influence of each type of RRB. Additional multiple regressions included examining whether RRBs at age 8-10 significantly predict adaptive and cognitive functioning at age 8-10. Finally, hierarchical multiple regressions were used to determine whether RRBs at 1-2 and 3-5 years of age predicted outcome to the same degree as preschool cognitive functioning and language skills, which are known predictors of outcome in ASD. In these hierarchical regressions, preschool cognitive and language ability was entered in Step 1 and RRBs were entered in Step 2.

Results

Hypothesis 1

To address the first hypothesis of the study, multiple regression analyses were conducted to determine whether the RRBs seen during the preschool years accounted for a significant amount of variance in school-age outcome in children with ASDs. Preliminary analyses were conducted to ensure that the assumptions underlying multiple regression (i.e., normality, linearity, multicollinearity and homoscedasticity) were not violated. Following the preliminary analyses, each dependent variable (outcome measures: cognitive and adaptive functioning, severity of ASD symptoms and presence of RRBs at age 8-10) were simultaneously regressed on the independent variables (ratings of six types of RRBs at age 1-2 and again at age 3-5). The relative influence of each type of RRB within each regression was examined by comparing the standardized regression coefficients. Two separate multiple regressions were run to assess the effect of RRBs at age 1-2 and age 3-5 separately on outcome at age 8-10.

Cognitive functioning. To determine whether RRBs observed during the preschool period predicted subsequent cognitive functioning, verbal and nonverbal reasoning at age 8-10 were separately simultaneously regressed on the six types of RRBs observed at age 1-2 and 3-5. Cognitive functioning was separated into the two reasoning domains because this sample exhibited a clinically significant discrepancy (more than 1 SD) between verbal and nonverbal reasoning scores at age 8-10 (see Table 4).

These analyses indicated that RRBs at age 1-2 were *not* a significant predictor of verbal and nonverbal reasoning at age 8-10, with all six types of RRBs explaining less than one percent of the variance in verbal and nonverbal reasoning (VIQ: $F(6, 28) = 0.37$, $p = 0.89$, *Adjusted* $R^2 = -0.13$; NVIQ: $F(6, 28) = 0.38$, $p = 0.88$, *Adjusted* $R^2 = -0.12$; see Table 4 for beta values of each type of RRB). An examination of standardized regression coefficients revealed that no type of RRB at age 1-2 significantly predicted verbal or nonverbal reasoning at age 8-10.

At age 3-5, the regression model that included the six types of RRBs was not significant in predicting verbal reasoning at age 8-10 ($F(6, 27) = 1.97$, $p = 0.11$, *Adjusted* $R^2 = 0.15$), but accounted for 15% of the variance in verbal reasoning. When standardized regression coefficients for each type of RRB were examined, only preoccupations with parts of objects at age 3-5 significantly predict verbal reasoning ability at age 8-10 (*beta* = –0.36, p = 0.048; see Table 5). In this model, more severe preoccupations with parts of objects at age 3-5 were associated with decreased verbal reasoning ability. RRBs at age 3-5 were not a significant predictor of nonverbal reasoning ability and accounted for 12.9% of the variance in nonverbal IQ ($F(6, 27) = 1.81$, $p = 0.14$, *Adjusted* $R^2 = 0.13$). Standardized regression coefficients indicated that sensory interests were the only type of RRB at age 3-5 that significantly predicted nonverbal reasoning ability at age 8-10 (*beta* = –0.36, p = .049; see Table 5). In this model, more severe sensory interests were associated with lower nonverbal reasoning ability.

Adaptive functioning. In order to determine whether RRBs during the preschool years significantly predicted adaptive functioning at age 8-10, the Vineland Adaptive Behavior Composite was simultaneously regressed on the six types of RRBs evident at age 1-2 and 3-5. RRBs exhibited during the preschool period were not found to be a significant predictor of adaptive functioning at age 8-10 (age 1-2: $F(6, 28) = 0.62$, $p = 0.71$, *Adjusted* R^2= –0.07; age 3-5: $F(6, 27) = 1.81$, $p = 0.13$, *Adjusted* R^2=0.13). RRBs observed at age 1-2 accounted for less than one percent of the variance in school age adaptive functioning and no type of RRB observed at this age was a significant predictor of adaptive functioning at age 8-10. When RRBs were observed at age 3-5, they accounted for 13% of the variance in adaptive functioning at age 8-10. At age 3-5, only stereotyped motor movements approached significance in predicting later adaptive functioning (*beta* = –0.32, p = .06; see Table 6 for individual beta values), with more severe stereotyped motor movements being associated with less developed adaptive functioning.

Symptom severity. To determine whether RRBs at ages 1-2 and 3-5 significantly predicted ASD symptom severity when the child was 8-10 years of age, simultaneous multiple regressions were conducted. The results indicated that RRBs at age 1-2 were not a significant predictor of ASD symptom severity at age 8-10 as measured by the ADOS calibrated severity score ($F(6, 28) = 0.23$, $p = 0.75$, *Adjusted* $R^2 = -0.16$) or the CARS total score ($F(6, 27) = 0.58$, $p = 0.75$, *Adjusted* $R^2 = -0.08$). Furthermore, in both models, all six types of RRBs accounted for less than one percent of the variance in ASD symptom severity and no type of RRB at age 1-2 significantly predicted ASD symptom severity at age 8-10 (see Table 7 for individual beta values). At age 3-5, RRBs were also not a significant predictor of ASD symptom severity at age 8-10 as measured by the ADOS calibrated severity score and accounted for only nine percent of the variance ($F(6, 27) = 1.53$, $p = 0.21$, *Adjusted* $R^2 = 0.09$; see Table 8 for beta values). However, the model approached significance when ASD symptom severity was measured by the CARS ($F(6, 26) = 2.39$, $p = 0.06$, *Adjusted* $R^2 = 0.20$; see Table 8 for individual beta values). The six types of RRBs exhibited at age 3-5 accounted for 20.4% of the variance in the CARS total score at age 8-10. In this model, sensory interests significantly predicted the CARS total score (*beta* = 0.38, $p = .03$), while the predictive relationship between stereotyped and repetitive motor mannerisms and the CARS total score approached significance (*beta* = 0.33, $p = .05$). Standardized beta values revealed that increased severity of both of these types of RRBs was associated with higher (more severe) CARS total scores. Because of the difference in results across the two measures of ASD symptom severity, the relationship between the ADOS calibrated severity score and CARS total score at age 8-10 was examined and found to be significant ($r = 0.48$, $p = .002$).

Repetitive behaviors. To determine whether RRBs during the preschool period predicted RRBs at age 8-10, RRBs at age 8-10 (as measured by the total score on the RBS-R) were simultaneously regressed on the six types of RRBs at age 1-2 and again at age 3-5. RRBs at age

1-2 were not a significant predictor of RRBs at age 8-10 ($F(6, 27) = 1.73$, $p = 0.15$, *Adjusted* $R^2 = 0.12$) and explained 11.8% of the variance in the RBS-R total score. An examination of standardized regression coefficients (see Table 9) revealed that adherence to routines and rituals at age 1-2 approached significance in predicting RRBs at age 8-10 (*beta* = .33, $p = .07$), such that greater adherence to routines was associated with higher RBS-R scores. At age 3-5, the six types of RRBs were a significant predictor of RRBs at age 8-10 ($F(6, 26) = 3.46$, $p = 0.01$, *Adjusted* $R^2 = 0.32$) and accounted for 31.6% of the variance in the RBS-R total score. Of the six types of RRBs measured at age 3-5, special interests that were unusual in focus or intensity and adherence to routines or rituals were found to be significant predictors of the degree of RRBs at age 8-10 (special interests: *beta* = 0.46, $p = 0.01$; adherence to routines/rituals: *beta* = 0.40, $p = 0.01$; see Table 9 for remaining beta values). In both cases, a greater degree of these RRBs at age 3-5 predicted a greater degree of RRBs at age 8-10.

Summary of results for hypothesis 1. The results indicated that RRBs at age 1-2 did not predict cognitive functioning, adaptive skills or ASD symptom severity at age 8-10 (explained less than 1% of the variance in the outcome measures). At age 3-5, RRBs were not a significant predictor of cognitive and adaptive functioning at age 8-10, but explained 13-15% of the variance in these outcome measures. RRBs at age 3-5 were not a significant predictor of ASD symptom severity as measured by the ADOS (only accounted for nine percent of the variance), but approached significance in predicting symptom severity as measured by the CARS and explained 20% of the variance in the CARS total score. An examination of individual standardized regression coefficients in the models above indicated that some types of RRBs observed at age 3-5 were significant predictors of school age functioning. Specifically, a greater degree of preoccupations with parts of objects at age 3-5 significantly predicted lower verbal reasoning at age 8-10. In addition, more severe sensory interests at age 3-5 predicted lower nonverbal reasoning and greater ASD symptom severity at age 8-10. Finally, more extensive stereotyped and repetitive motor movements at age 3-5 approached significance in predicting lower adaptive behavior scores and more severe ASD symptom presentation as measured by the CARS at age 8-10. RRBs at age 3-5, but not 1-2, significantly predicted RRBs at age 8-10, with more severe circumscribed interests and stricter adherence to routines or rituals significantly predicting more extensive RRBs at age 8-10.

Hypothesis 2

The second aim of this study was to compare the amount of variance explained in school-aged functioning by RRBs to the amount of variance accounted for by cognitive functioning and language ability, which have been shown to predict outcome in children with ASD. To examine this aim, hierarchical multiple regressions were used. In the first set of regressions cognitive functioning and language measured at age 1-2 was entered in Step 1 and RRBs at age 1-2 were entered in Step 2. In a separate set of hierarchical multiple regressions, cognitive functioning and language measured at age 3-5 was entered in Step 1 and RRBs at age 3-5 were entered in Step 2. At both age 1-2 and age 3-5, the multicollinearity assumption made by multiple regression was violated because the three Mullen domain scores used to measure cognitive and language functioning were highly intercorrelated (age 1-2: all $r > 0.5$; age 3-5: all $r > 0.7$). In order to address this, the Mullen Early Learning Composite (Mullen ELC) was used in the regression as a measure of cognitive and language functioning instead of the three individual Mullen domain scores. The Mullen ELC was highly correlated with the three domain scores at age 1-2 and age 3-5 (all $r > 0.7$).

Cognitive functioning. Hierarchical multiple regressions revealed that the Mullen ELC at ages 1-2 and 3-5 significantly predicted verbal and nonverbal reasoning at age 8-10 (age 1-2: VIQ: $F(1, 31) = 7.60$, $p = 0.01$, *Adjusted* $R^2 = 0.20$; NVIQ: $F(1, 31) = 6.02$, $p = 0.02$, *Adjusted* $R^2 = 0.14$; age 3-5: VIQ: $F(1, 31) = 21.38$, $p < 0.001$, *Adjusted* $R^2 = 0.41$; NVIQ: $F(1, 31) = 24.54$, $p < 0.001$, *Adjusted* $R^2 = 0.44$). At age 1-2, the Mullen ELC score explained 19.7% of the variance in verbal reasoning at 8-10 and 13.6% of the variance in nonverbal reasoning at age 8-10. By age 3-5, cognitive and language ability became a stronger predictor of cognitive functioning at age 8-10 and explained 40.8% of the variance in verbal IQ and 44.2% of the nonverbal IQ at age 8-10. After controlling for the Mullen ELC at age 1-2, the six types of RRBs observed at age 1-2 did not explain a significant amount of additional variance in verbal or nonverbal reasoning at age 8-10 (VIQ: R^2 change = 0.11, F change (6, 25) = 0.69, $p = 0.66$; NVIQ: R^2 change = 0.10, F change (6, 25) = 0.54, $p = 0.77$). Similarly, RRBs at age 3-5 also failed to explain a significant amount of additional variance in cognitive functioning at age 8-10, after cognitive and language functioning at age 3-5 was controlled for (VIQ: R^2 change = 0.06, F change (6, 25) = 0.49, $p = 0.81$; NVIQ: R^2 change = 0.08, F change (6, 25) = 0.68, $p = 0.68$). Examining the standardized regression coefficients in these models revealed that only the Mullen ELC scores obtained at age 1-2 and 3-5 were significant in predicting cognitive functioning at age 8-10; no type of RRB at age 1-2 or 3-5 received a significant beta value in these models (see Tables 10-11 for beta values). At both time points, higher scores on the Mullen ELC predicted higher verbal and nonverbal reasoning at age 8-10.

Adaptive functioning. Hierarchical multiple regressions were also used to compare the amount of variance explained in adaptive functioning at age 8-10 by preschool cognitive and language functioning, as measured by the Mullen ELC, and early RRBs. The results indicated that cognitive and language ability at age 1-2 approached significance in predicting adaptive functioning at age 8-10 and accounted for 10.9% of the variance in the Vineland Adaptive Behavior Composite (F(1, 31) = 3.79, p = 0.06, *Adjusted* R^2 = 0.11). RRBs at age 1-2 did not contribute a significant amount of variance in this model after controlling for the Mullen ELC score, but accounted for an additional 15.3% of the variance in adaptive functioning at age 8-10 (R^2 change = 0.15, F change (6, 25) = 0.87, p = 0.53). The Mullen ELC score obtained at age 3-5 was significant in predicting adaptive functioning at age 8-10 and accounted for 17.9% of the variance (F(1, 31) = 6.77, p = 0.01, *Adjusted* R^2 = 0.18). RRBs observed at age 3-5 explained an additional 13.4% of the variance in adaptive functioning at age 8-10, after controlling for the variance explained by the Mullen ELC score; however, this contribution was not statistically significant (R^2 change = 0.13, F change (6, 25) = 0.82, p = 0.57). Standardized regression coefficients in these models revealed that a higher Mullen ELC score at ages 3-5 only significantly predicted higher adaptive functioning at age 8-10; no type of RRB at either time point were found to significantly predict school-age adaptive functioning (see Table 12).

Symptom severity. Hierarchical multiple regression was also used to assess the ability of preschool RRBs to predict ASD symptom severity at age 8-10, after controlling for the influence of preschool cognitive and language functioning as measured by the Mullen ELC. Cognitive and language ability at age 1-2 and 3-5 were not found to be significant predictors of ASD symptom severity at age 8-10 when measured by the ADOS calibrated severity score (age 1-2: F(1, 31) = 2.94, p = 0.10, *Adjusted* R^2 = 0.09; age 3-5: F(1, 31) = 2.32, p = 0.14; *Adjusted* R^2 = 0.07). The Mullen ELC score obtained at age 1-2 explained only 8.7% of the variance in the ADOS score at age 8-10, while the Mullen ELC score obtained at age 3-5 accounted for 7% of the variance in the ADOS score at age 8-10. The addition of RRBs observed at age 1-2 to the Mullen ELC score from this age only explained an additional 5.4% of the variance in the ADOS score (R^2 change =

0.05, *F* change (6, 25) = 0.26, $p = 0.95$) and did not make this model significant in predicting the ADOS score at age 8-10 ($F(7, 25) = 0.58$, $p = 0.76$). Including RRBs observed at age 3-5 to the Mullen ELC score from this age accounted for an additional 19.2% of the variance in the ADOS score at age 8-10; however, this was not a statistically significant contribution (*F* change (6, 25) = 1.08, $p = 0.40$, R^2 change = 0.19) and the addition of RRBs did not make the final model significant ($F(7, 25) = 1.27$, $p = 0.31$). Neither the Mullen ELC scores, nor any of the six types of RRBs at either age point received a significant standardized regression coefficient in these models (see Tables 13-14).

When the CARS total score was used to measure ASD symptom severity at age 8-10, the Mullen ELC scores at ages 1-2 and 3-5 were found to be significant predictors (age 1-2: $F(1, 31) = 4.93$, $p = 0.03$, *Adjusted* $R^2 = 0.14$; age 3-5: $F(1, 31) = 13.19$, $p = 0.001$, *Adjusted* $R^2 = 0.30$). The Mullen ELC score obtained at age 1-2 explained 13.7% of the variance in the CARS total score at age 8-10 and adding the six types of RRBs observed at age 1-2 to this model resulted in the explanation of an additional 10.9% of the variance in the CARS total score at age 8-10, but was not a significant contribution (R^2 change = 0.11, *F* change (6, 25) = 0.60, $p = 0.73$). The Mullen ELC score from age 3-5 accounted for 30.0% of the variance in the CARS score and when the six types of RRBs observed at age 3-5 were added to the Mullen ELC score, an additional 15.1% of the variance was accounted for in the CARS total score at age 8-10; however, this contribution was not statistically significant (R^2 change = 0.15, *F* change (6, 25) = 1.14, $p = 0.37$). Only the Mullen ELC scores at ages 1-2 and 3-5 were statistically significant in predicting the CARS score at age 8-10, with higher Mullen ELC scores predicting lower CARS total scores (see Tables 13-14). However, sensory interests observed at age 3-5 approached significance in predicting the CARS score at age 8-10, with more severe sensory interests predicting higher CARS scores.

Summary of results for hypothesis 2. The second aim of the study sought to compare the amount of variance accounted for in outcome measures by RRBs at age 1-2 and 3-5 and by previously identified prognostic indicators in young children with ASD (i.e., preschool cognitive functioning and language abilities). The results of these analyses revealed that cognitive functioning and language ability at age 1-2 and 3-5 significantly predicted cognitive and adaptive functioning, as well as ASD symptom severity at age 8-10 as measured by the CARS (but not the ADOS). In these models, higher cognitive and language functioning during preschool years predicted better outcomes at age 8-10. These results indicated that cognitive and language functioning measured at age 3-5 accounted for more variance in outcome, than did cognitive and language functioning at age 1-2. When RRBs at age 1-2 or 3-5 were added to the Mullen ELC score in these models, they did not account for a statistically significant amount of variance. However, when RRBs observed at age 1-2 were added to the Mullen ELC, these behaviors explained an additional 10-15% of the variance in all outcome measures at age 8-10, except ASD symptom severity as measured by the ADOS (in which only 5.4% of additional variance was accounted for). Adding RRBs observed at age 3-5 to the Mullen ELC score from that age accounted for an additional 6-8% of the variance in cognitive functioning, 13% of the variance in adaptive skills, and 15-19% of the variance in ASD symptom severity at age 8-10. In all of these models, no type of RRB at either age 1-2 or 3-5 significantly predicted outcome at age 8-10; however, sensory interests at age 3-5 approached significance in predicting CARS scores at age 8-10.

Hypothesis 3

The final aim of the study was to examine whether RRBs at age 8-10 (as measured by the

RBS-R) correlated with cognitive and adaptive functioning, as well as ASD symptom severity at age 8-10.

Cognitive functioning. The results of these analyses indicated that RRBs at age 8-10 were not significantly correlated with cognitive functioning at that age (VIQ: $F(6, 25) = 2.00$, $p = 0.10$, *Adjusted* $R^2 = 0.16$; NVIQ: $F(6, 25) = 1.56$, $p = 0.20$, *Adjusted* $R^2 = 0.10$), but accounted for 16.1% of the variance in verbal IQ and 9.8% of the variance in nonverbal IQ. Of the six RRBs assessed at age 8-10, the relationship between insistence on sameness (i.e., resistance to change) and verbal reasoning approached significance (VIQ: *beta* = –0.53, $p = 0.07$), while the relationship between insistence on sameness and nonverbal reasoning was significant (NVIQ: *beta* = –0.70, $p = 0.03$; see Table 15 for the remaining beta values). In these models, greater insistence on sameness was associated with lower verbal and nonverbal reasoning scores. Ritualistic behaviors (i.e., performing daily living activities in a repetitive manner) were also significantly associated with NVIQ and the standardized regression coefficient was positive suggesting that greater ritualistic behaviors were associated with higher NVIQ (*beta* = 0.80, $p = 0.045$). However, the correlation between ritualistic behaviors and NVIQ was close to zero ($r = –0.07$, $p = 0.34$). Ritualistic behaviors and insistence on sameness are highly correlated ($r = 0.77$, $p < 0.001$), which along with the change in sign between the correlation coefficient and the regression coefficient, indicates the presence of net suppression and suggests that ritualistic behavior is a suppressor variable. These findings indicate that ritualistic behaviors are not a predictor of NVIQ, but rather share a strong correlation with a significant predictor of NVIQ (insistence on sameness). Because of the high correlation between insistence on sameness and ritualistic behaviors, the two variables are accounting for error variance in the predictors and resulted in a stronger predictive relationship between these RRBs and NVIQ.

Adaptive functioning. A significant relationship was found between RRBs and adaptive functioning at age 8-10 (F(6, 27) = 4.04, p = 0.01, *Adjusted* R^2 = 0.36, see Table 16 for individual beta values), with RRBs accounting for 35.6% of the variance in adaptive skills at this age. In this model, a greater degree of stereotyped behaviors (i.e., seemingly purposeless repetitive movements) was significantly associated with lower adaptive functioning (*beta* = –0.53, p = 0.01). In addition, the relationship between insistence on sameness and adaptive functioning at age 8-10 approached significance (*beta* = –0.47, p = 0.07), with a greater degree of insistence on sameness being associated with lower adaptive functioning.

Symptom severity. Examining the relationship between RRBs and ASD symptomatology at age 8-10 revealed no significant relationship between these factors when ASD severity was measured by the ADOS (F(6, 27) = 1.42, p = 0.24, *Adjusted* R^2 = 0.07; see Table 17 for beta values), with only 7% of the variance in the ADOS severity score being accounted for by RRBs. However, when ASD symptom severity was measured by the CARS total score, the relationship between RRBs and ASD symptom severity at age 8-10 was significant (F(6, 25) = 3.93, p = 0.01, *Adjusted* R^2 = 0.36) and RRBs accounted for 36.2% of the variance in CARS scores. When individual beta values were examined, stereotyped behavior was the only type of RRB that was significantly associated with the total CARS score at age 8-10 (*beta* = 0.83, p = .001; see Table 17 for the remaining beta values). In this regression, a greater degree of stereotyped behaviors was associated with greater symptom severity.

Summary of results for hypothesis 3. The final aim of the study explored whether RRBs at age 8-10 were associated with cognitive and adaptive functioning, and ASD symptomatology at age 8-10. The relationship between RRBs and cognitive functioning at age 8-10 was not significant, but RRBs did account for 16% of the variance in verbal IQ. A significant relationship was found between RRBs at age 8-10 and adaptive functioning, as well symptom severity when measured by the CARS (but not the ADOS) at this age. Examining standardized regression coefficients in these models revealed that more extensive stereotyped behaviors at this age were associated with lower adaptive functioning and greater severity of ASD symptomatology. In addition, greater resistance to change was associated with lower nonverbal reasoning and approached significance in predicting lower verbal reasoning and adaptive functioning.

Discussion

The purpose of the current study was to determine whether RRBs present during the preschool years predict school-aged functioning. Theories proposed to explain the function RRBs serve for children with ASDs suggest that RRBs interfere with the ability to engage in the external environment where learning opportunities are present. These theories argue that while engaging in RRBs, children with ASD may miss important learning opportunities and, as a result, experience developmental delays (Bodfish et al., 2000; Lewis, 2004). Knowing that RRBs predict subsequent functioning would allow professionals who work with young children with ASD to use these readily observable behaviors to describe prognoses of these children and help parents and intervention providers understand what to expect for the child's future.

Previous research on the prognostic value of RRBs consists of a small number of studies that have generated mixed findings and included important methodological limitations. The current study sought to advance this research by addressing the limitations of previous studies and employing a longitudinal design that assessed RRBs twice during the preschool period (when the child was 1-2 and 3-5) and outcome at age 8-10. This study measured outcome more comprehensively than has been done previously and included measures of cognitive and adaptive functioning, as well as ASD symptomatology at age 8-10. In addition, the current study included direct observation, clinician judgment and parent report of six types of RRBs, rather than collapsing across these behaviors. Finally, assessing for RRBs at around the age of two and again at around four years of age accounted for changes in the presentation of RRBs during the preschool period. These methods helped to ensure that the presence and severity of the different types of RRBs were accurately measured.

The results of the current study indicated that, contrary to our predictions, no type of RRB observed early in the preschool period (age 1-2) significantly predicted any measure of outcome during school age (8-10 years). In fact, RRBs observed early in the preschool period accounted for less than one percent of the variance in school age cognitive and adaptive functioning, as well as ASD symptom severity. These results indicate that RRBs observed early in the preschool period are not helpful in determining prognosis among children diagnosed with ASDs. As mentioned in the introduction, the presentation, severity and frequency of RRBs change considerably during the early preschool years (Charman et al., 2005; Cuccaro et al., 2003; Moore & Goodson, 2003; Richler et al., 2007; Richler et al., 2010; Stone et al., 1999; Szatmari et al., 2006). Furthermore, these studies suggest that the onset of some types of RRBs does not typically begin until the late preschool years. Consequently, it is likely that RRBs observed during the early preschool years did not predict school age functioning because at this young age, RRBs have not yet fully developed and do not accurately depict the full range of types, severities and frequencies of RRBs that will be displayed by the child later in the preschool period. This idea is supported by this study's finding that RRBs observed early in the preschool period are not strong predictors of RRBs observed during school age, while RRBs observed later in the preschool period are strong predictors of school age RRBs. This finding suggests that RRBs are more stable and are more accurately captured when measured later in the preschool years (i.e. age 3-5).

The finding that RRBs observed early in the preschool period are not stable and do not predict later functioning, including ASD symptom severity and school age RRBs, has important implications for the diagnosis of ASD in toddlers. These results indicate that when toddlers are being evaluated because of autism-related concerns, it is likely that their behaviors do not contain the full array of RRBs that will be evident later in the preschool period and later in childhood. Consequently, these results suggest that during the toddler years, the lack of RRBs should not be used to rule out ASD, because at this age RRBs are not predictive of later ASD symptomatology or subsequent RRBs. These results raise important concerns about the proposed changes to the ASD diagnostic criteria in the upcoming revision of the DSM-5 (APA, 2012). The DSM-5 has proposed to use the lack of RRBs to rule out ASDs and outlined diagnostic criteria that require children of any age to demonstrate two different types of RRBs in order to qualify for an ASD diagnosis (APA, 2012). The results of this study suggest that if these criteria are used with toddlers, it is likely that toddlers will be misdiagnosed as not having ASD because they have not yet developed the full array of RRBs that they will exhibit later in the preschool years. These results are consistent with a recent study by Barton, Robbins, Jashar, Brennan and Fein (2013), which found a significant loss of ASD diagnosis when the DSM-5 criteria were applied to toddlers who were diagnosed with ASD according to the DSM-IV-TR criteria.

According to these results, RRBs measured later in the preschool period appeared to be more useful in predicting school age functioning and explained substantially more variance (13-15%) in cognitive and adaptive functioning during school age, as compared to RRBs measured in the early preschool years. Of the six types of RRBs measured during the late preschool period, more severe preoccupations with parts of objects predicted lower verbal reasoning at age 8-10, and more severe hyper- or hypo-reactivity to sensory input or interest in the sensory aspect of the environment predicted lower nonverbal reasoning at age 8-10. In addition, more extensive stereotyped and repetitive motor movements approached significance in predicting lower adaptive functioning. These findings support our predictions and indicate that children who engage in more severe preoccupations with parts of objects, sensory interests and stereotyped motor movements during the late preschool period exhibited less developed cognitive and adaptive skills during school age than did 3-5 year old children who engaged in less severe forms of RRB. These findings are consistent with previous studies that found a negative relationship between these types of RRBs and cognitive and adaptive functioning (Bishop et al., 2006; Cuccaro et al., 2003; Turner, 1999). Furthermore, these results indicate that these readily apparent behaviors during the late preschool period are useful in predicting the child's school age cognitive and adaptive functioning.

RRBs observed during the late preschool period also approached significance in predicting one of the two measures used to assess ASD symptom severity during school age. RRBs observed during the late preschool period were stronger predictors of the CARS total score than the ADOS calibrated severity score (20% vs. 9% of the variance accounted for). It is interesting that such a difference was evident across these measures as both are validated measures of ASD symptom severity and the total scores on these measures were strongly related in this sample.

The difference in results across the two measures of ASD symptom severity may relate to a major difference in the way the ADOS and the CARS assess RRBs. The administration guidelines of the ADOS instruct clinicians to only endorse an item if the behavior is directly observed during the administration of the ADOS, which consists of a 30-45 minute period. Conversely, a clinician completes the CARS after conducting the entire evaluation (including the ADOS) and interviewing the parent. This difference in administration makes it less likely that RRBs would be captured by the ADOS than the CARS. In addition, the CARS total score is a summation of scores across all items, with each item ranging from 0 to 4. This results in a continuous score that ranges from 0 to 60. The items of the ADOS range from 0-2 and the scores are summed, and then converted into a calibrated severity score that ranges from 0 to 10. As a result of the scoring of the ADOS, the impact of RRBs is less influential for the overall calibrated severity score as compared to the total score of the CARS. This is particularly important to consider because in this study, RRBs observed late in the preschool period predicted RRBs observed during school age. Therefore, it is possible that RRBs at age 3-5 are actually predicting RRBs at age 8-10, which are resulting in higher CARS scores, but having little impact on the ADOS.

To understand why the two measures of symptom severity appear to lead to differing conclusions about the value of preschool RRBs in predicting symptom severity, it is also important to consider which types of RRBs predicted school age ADOS and CARS scores. The results showed that no type of RRB predicted ADOS scores. However, sensory interests predicted CARS scores and the relationship between CARS scores and repetitive motor mannerisms approached significance. In both cases, more severe RRBs predicted greater ASD symptom severity as measured by the CARS. It is possible that the difference in findings across the two measures of ASD symptom severity can be attributed to the fact that the CARS contains considerably more items that would be elevated by sensory interests and repetitive motor movements (5 of 15 items) than does the ADOS (2 of 14 items). Therefore, the presence of sensory interests and repetitive motor mannerisms would result in a higher CARS score, but would not have as strong of an impact on the ADOS. These differences in the items included on the two measures lend further support to the possibility that sensory interests and repetitive motor movements at age 3-5 are actually predicting these types of RRBs at age 8-10, which are then resulting in a higher CARS score, but not impacting the ADOS score. If this is the case, then the current findings suggest that RRBs observed during the late preschool period are predicting a greater extent of RRBs at 8-10, but these behaviors may not be predictive of the severity of communication and socialization deficits associated with ASDs.

The second aim of this study examined whether RRBs observed during the preschool period predicted school age outcome to the same degree as previously identified prognostic indicators, namely preschool cognitive functioning and communication ability. The results were consistent with previous studies and revealed that higher cognitive and communicative functioning both early and later in the preschool period predicted higher school age cognitive and adaptive functioning (e.g., Ballaban-Gil et al., 1996; Bibby et al., 2002; Charman et al., 2005; Lord & Paul, 1997; Stevens et al., 2000; Szatmari et al., 2003; Venter et al., 1992). The results of this study also indicated that, as expected, cognitive and communicative ability was a stronger predictor of school age outcome when measured later in the preschool period rather than earlier.

Higher cognitive functioning and language skills measured late in preschool period also predicted less severe symptoms of ASD at school age as measured by the CARS, but not the ADOS. It is likely that the difference in results across the two measures of ASD symptom severity reflects how strongly each of these measures relates to cognitive ability. The CARS includes items that assess a child’s development, including level of intelligence, language ability and imitation ability. As a result, the CARS yields scores that correlate negatively with IQ (e.g., Mayes et al., 2012, Perry, Condillac, Freeman, Dunn-Geier, & Belair, 2005). On the other hand, the ADOS calibrated severity score was designed to be relatively independent of IQ scores (Gotham et al., 2009), which may explain why early cognitive and language functioning does not predict later ADOS scores, but does predict CARS scores.

The next step in these analyses included determining how much of the variance left unexplained by cognitive and communicative ability was accounted for by RRBs observed during the preschool years. While adding RRBs observed at age 1-2 did not result in a statistically significant contribution of explained variance in outcome measures, it did explain an additional 10-15% of variance across all of the outcome measures. This finding suggests that while RRBs alone are not helpful in predicting prognosis early in the preschool period, considering RRBs alongside cognitive functioning may be somewhat helpful in predicting school age cognitive and adaptive functioning. Based on these findings, it appears that early in the preschool period, higher cognitive and communicative abilities, and less severe RRBs, predict stronger school age cognitive and adaptive functioning.

Adding RRBs observed late in the preschool period to cognitive and communicative ability measured at this age, did not add a significant amount of explained variance in school age cognitive ability. Furthermore, the addition of RRBs at age 3-5 accounted for less additional variance in cognitive functioning than did adding these behaviors to cognitive and adaptive functioning at age 1-2 (6-8% at age 3-5 as compared to 10-15% at age 1-2). It is possible that later in the preschool period, RRBs are more related to cognitive and communicative ability than is the case earlier in the preschool period. However, it is more likely that this finding was attributable to the relationship between preschool cognitive and communicative ability, and school age cognitive functioning, which was much stronger in the late preschool period than the early preschool period. Specifically, cognitive ability and language functioning accounted for less variance in school age cognitive functioning when measured earlier rather than later in the preschool period (41-44% of variance at age 3-5 vs. 13-20% of the variance at age 1-2). Therefore, at age 1-2, less variance was explained by cognitive and communicative ability and more variance was left available for RRBs to explain at this age than was left over at age 3-5.

The results of this study suggest that at the age of 3-5, cognitive and language skills are the strongest predictors of school age cognitive functioning. Adding RRBs observed at age 3-5 is only minimally helpful in predicting school-age functioning beyond cognitive and communicative ability measured at this age. It is worth noting that RRBs are more readily apparent than cognitive ability, which requires some form of assessment. Therefore, when IQ is available among 3-5 year old children, it should be used to determine prognosis as it is the strongest predictor of later cognitive functioning. However, in the absence of an IQ estimate, RRBs can be helpful in predicting subsequent cognitive functioning.

RRBs observed later in the preschool period were useful in predicting school age adaptive functioning and ASD symptom severity after controlling for cognitive and communicative ability measured in the late preschool period. Similarly to age 1-2, RRBs observed at age 3-5 accounted for an additional 13% of the variance in school age adaptive functioning, beyond the contribution of cognitive and language ability measured at age 3-5. In addition, after controlling for the impact of cognitive and language ability at age 3-5, RRBs observed at age 3-5 accounted for an additional 15-19% of the variance in ASD symptom severity as measured by both the ADOS and the CARS. These findings suggest that among children who are of late preschool age, professionals should consider RRBs along with estimates of cognitive and communicative ability in order to make a more accurate prediction about later adaptive functioning and symptom severity.

The final aim of the study examined whether any type of RRBs exhibited during school age was associated with cognitive and adaptive functioning, as well as ASD symptomatology at this age. Contrary to our predictions, a significant relationship was not found between cognitive functioning and RRBs during school age. However, RRBs did explain a substantial amount of variance in verbal reasoning (16%), with greater resistance to change approaching significance in predicting less developed verbal IQs. In addition, a positive relationship was found between RRBs and ASD symptom severity as measured by the CARS score, but not by the ADOS calibrated severity score. As was discussed earlier, the difference in results between the two measures of symptom severity is likely attributable to the fact that RRBs contribute more strongly to the CARS total score than the ADOS, and the fact that the ADOS only uses direct observation, while the CARS is based on both direct observation and parent report of RRBs.

To explore the relationship between RRBs observed during school age and school age functioning, six types of RRBs were examined to identify those that shared a relationship with school age cognitive and adaptive functioning, as well as ASD symptom severity. These results revealed that stereotyped behaviors were associated with adaptive functioning and ASD symptom severity in children of school age. According to these findings, greater stereotyped behaviors were found more frequently among participants who had lower adaptive functioning and more severe symptoms of ASD. These findings suggest that stereotyped behaviors impact the acquisition of adaptive skills more so than they impact the child's IQ scores in this age range. These results are also consistent with numerous previous studies that have reported that more severe repetitive sensory-motor movements were associated with less developed communicative ability, and adaptive communication and socialization skills (Bishop et al., 2006; Cuccaro et al., 2003; Gabriels et al., 2005; Honey et al., 2008; Lam et al., 2008; Mirenda et al, 2010; Mooney et al., 2009; Richler et al., 2010; Szatmari et al., 2006). These findings are consistent with theories described earlier, which predict a negative relationship between RRBs and some acquired skills, but not necessarily between RRBs and the child's potential to learn (IQ). These theories propose that a relationship between RRBs and acquired skills exists because RRBs interfere with the child's ability to engage with their environment, which is needed for the acquisition of new skills. Therefore, among children who exhibit more stereotyped behaviors, the acquisition of adaptive abilities will be delayed as compared to children who do not exhibit fewer stereotyped behaviors.

In addition to stereotyped behaviors, greater insistence on sameness among school age children was associated with school age cognitive and adaptive functioning. It is interesting that in this study, greater insistence on sameness was associated with lower adaptive and cognitive functioning, while in previous studies no clear relationship was found between insistence on sameness and level of functioning (Bishop et al., 2006; Cuccaro et al., 2003; Mooney et al., 2009; Szatmari et al., 2006). One possible explanation for this discrepant finding relates to the difference in the age range included in the current study as compared to the age range included in previous studies. Prior studies included wide age ranges including children of preschool age. The current study found that insistence on sameness was not related to functioning when observed during the preschool period and was only related to functioning in the participants when they were older. Therefore, it is possible that insistence on sameness serves an adaptive purpose, such as reducing anxiety, in younger children with ASD. However, when the child begins school, the need for flexibility becomes more important for learning and the lack of flexibility may hinder the child's ability to learn more extensively during school age. Alternatively, insistence on sameness may cause avoidance of novel activities from a young age, and interfere with learning early in development. However, it may take a number of years of such avoidance during the preschool period, for a delay in learning from this avoidance to become substantial enough to be detected. In this case, a relationship between insistence on sameness and functioning would be observed only among older children.

Taken together, these results provide evidence for the use of RRBs observed in the late preschool period as prognostic indicators. In particular, more severe preoccupations with parts of objects, sensory interests and stereotyped motor movements at this age predicted less developed cognitive and adaptive skills, as well as greater ASD symptom severity during school age. The overall pattern of results indicated that the relationship between RRBs at age 3-5 and school age outcome was not as strong as the relationship between cognitive functioning at age 3-5 and school age outcome. However, RRBs observed during the late preschool period consistently predicted poorer school age outcome, with no type of RRB predicting a more positive school age outcome. Furthermore, RRBs may be particularly useful in predicting outcome because they are more easily observable than is a child's cognitive functioning ability. Despite the fact that preschool RRBs were not as strong as preschool cognitive and language functioning in predicting school age outcome, RRBs still accounted for a substantial amount of variance in school age adaptive functioning and ASD symptom severity, independently of preschool IQ. These results suggests that even when a child's cognitive ability is known, considering RRBs would likely help in determining a more accurate prediction of the child's subsequent functioning. Finally, the results of this study showed that a greater degree of stereotyped motor movements and insistence on sameness observed during school age was associated with lower cognitive and adaptive functioning.

Limitations and Future Directions

These results should be generalized with caution for a number of reasons. Most notably, the sample included in this study was relatively small. The size of this sample was limited by the longitudinal component of the current study, which required that all participants be evaluated twice during the preschool period and be given an ASD diagnosis at both evaluations. Furthermore, the third evaluation was conducted 4-6 years after the second and during this time many eligible participants moved or changed telephone numbers. A hypothetical power analysis revealed that with the sample size included in this study, only a large sized effect could be detected. To detect a smaller effect, a larger sample would be required. It is possible that more types of RRBs observed later in the preschool period would become significant predictors of school age functioning if a larger sample size was used, especially because RRBs at age 3-5 appeared to account for a substantial amount of variance in outcome measures. A hypothetical power analysis indicated that in order to detect a medium effect, 90 participants would be needed, and 215 participants would be needed to detect a small effect. While it would be difficult to collect a large sample of children who were diagnosed with ASD at the age of 1-2 years using a standardized battery that included gold standard measures of ASD, and then follow such a sample for 7-8 years, doing so would allow researchers to draw more definitive conclusions about the prognostic value of different types of RRBs.

In addition to the sample being relatively small, it was also homogeneous in that the participants were recruited from Connecticut and Massachusetts, and were predominantly Caucasian. Consequently, it is difficult to determine how the results of this sample would generalize to a broader ASD community both with regard to geographical location and ethnicity. Future studies should attempt to replicate these findings in more diverse samples and in other geographic areas.

The generalizability of the current findings may have also been limited by the enrollment criteria of the study. To be eligible, participants had to receive an evaluation and be diagnosed with ASD at the age of 1-2 years. It is possible that this sample is unique because as a result of the evaluation received through this study, all of the families were provided with documentation of eligibility for early intervention services mandated by the state of Connecticut, as well as recommendations for parents to further the child's development. It is possible that the impact of early RRBs on outcome measures was marginalized in this sample because participants received intervention so early in development. The effect of early RRBs on prognosis may be stronger among individuals who did not receive intervention until they were older. It is possible that at the time of the evaluation or while in early intervention services, parents of study participants may have been instructed to limit the amount of time their child engaged in RRBs. It is also possible that as a result of early intervention or the recommendations provided by the research team, participants in this study were engaged in learning more forcefully than would have been the case among children who were not enrolled in early intervention services at such a young age. Both of these actions may have counteracted the effect that RRBs may have otherwise played on learning. Future studies that focus on different geographic locations where children are not diagnosed with ASD and do not receive intervention until they are older may find that RRBs observed in the late preschool period may predict outcomes more strongly than was found in this study.

A related limitation has to do with all of the participants in this study being recruited because their parents endorsed concerns about ASD when participants were between the ages of 16 and 33 months of age. This group of children may differ in their presentation of RRBs from children whose parents did not observe any behaviors that raised concerns of ASD until the child was older. Therefore, it is difficult to determine whether the results of this study would apply to equally well to children with ASD whose parents did not become concerned about their development until the children were older.

Finally, while this study advanced current research on the prognostic validity of early RRBs by including direct observation and limiting parent recall bias, that observation only lasted the length of the developmental evaluation, or about 2-3 hours. To ensure that the full range of RRBs is measured accurately, a longer observation of the child would be beneficial. Future studies may also consider videotaping observations of participants and using observation coding software such as Noldus Pro Observer (Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000) to temporally tag repetitive movements in order to more accurately measure the frequency and duration of each type of RRB.

In addition to addressing these limitations, several extensions of the current study would inform our understanding of the prognostic value of RRBs. These results indicate that RRBs observed in the late preschool period and at age 8-10 are useful in predicting the child's scores on many outcome measures. Future studies should examine whether RRBs observed during the late preschool period and during school age could predict outcomes in later stages of development including adolescence and adulthood. In addition, the current study included a sample of both low- and high-functioning children. Future studies may wish examine the prognostic value of early RRBs among high-functioning children with ASD. With a high-functioning sample, outcome measures could include more extensive tests of cognitive functioning, including executive functioning abilities, memory and language. A fuller battery of cognitive tasks may help inform theories that explain the reason children engage in RRBs, as some of these theories point to executive dysfunction and other cognitive deficits.

Figure 1: Flowchart of Progression Through the Study

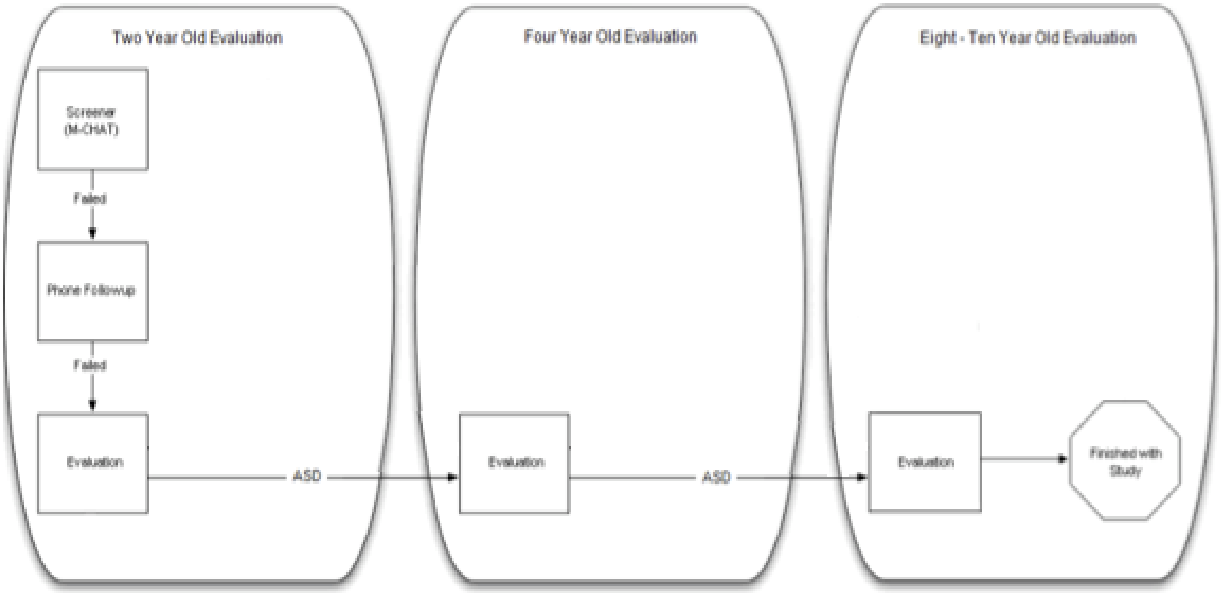

Table 1: Participant characteristics.

	Mean	**SD**	**Minimum**	**Maximum**
N		40		
Sex		34 Male; 6 Female		
2-year-old Evaluation Age (mos)	26.23	3.76	19.25	33.70
4-year-old Evaluation Age (mos)	51.37	5.28	42.72	70.10
8-10-year-old Evaluation Age (yrs)	9.87	0.81	8.12	10.82
Vineland Communication[b] – Age 8-10	72.60	16.16	47.00	117.00
Vineland Socialization[b] – Age 8-10	68.13	16.72	45.00	129.00
Vineland Daily Living[b] – Age 8-10	75.13	14.42	55.00	107.00
ADOS Calibrated Severity Score[c -] – Age 8-10	6.78	2.44	1	10
N		38		
Nonverbal IQ[a] – Age 8-10	81.39	27.43	25.00	127.00
Verbal IQ[a] – Age 8-10	70.84	31.53	25.00	120.00

Note. [a]IQ was measured by the DAS-II or Stanford Binet, both have a mean of 100, and SD of 10. [b]Vineland subtest means are 100 and SD is 10. [c]ADOS was scored using (Gotham et al., 2009) calibrated severity score system; higher scores are indicative of greater ASD symptomatology, with a score greater than 4 falling in the Autism Spectrum range, and a score greater than 6 falling in the Autistic Disorder range.

Table 2: Measures Included at Evaluations

Two- and Four-Year-Old Evaluation	
ASD Symptom Severity	• Autism Diagnostic Interview – Revised • Autism Diagnostic Observation Schedule • Childhood Autism Rating Scale
Cognitive Functioning	• Mullen Scales of Early Learning
Adaptive Skills	• Vineland Adaptive Behavior Scales
RRBs	• Parent Report: Autism Diagnostic Interview – Revised • Observation: Autism Diagnostic Observation Schedule • Clinical Judgment
Eight- to Ten-Year-Old Evaluation	
ASD Symptoms	• Autism Diagnostic Observation Schedule • Childhood Autism Rating Scale • Repetitive Behavior Scale – Revised
Cognitive Functioning	• Differential Ability Scales – II or Stanford-Binet 5
Adaptive Functioning	• Vineland Adaptive Behavior Scales, Second Edition

Table 3: Predictor and Outcome Measures.

<table>
<tr><th colspan="3">Predictor Measures (Collected at 2 -& 4-Year-Old Evaluations)</th></tr>
<tr><th colspan="2">Domain</th><th>Measure</th></tr>
<tr><td rowspan="6">Restricted and Repetitive Behaviors</td><td>Encompassing preoccupation with stereotyped and restricted patterns of interest, abnormal either in intensity or focus</td><td>1. Clinician rating
2. Parent report (ADI-2 items)
3. Direct observation (ADOS-1 item)</td></tr>
<tr><td>Inflexible adherence to specific, nonfunctional routines and rituals</td><td>1. Clinician rating
2. Parent report (ADI-3 items)
3. Direct observation (ADOS-1 item)</td></tr>
<tr><td>Stereotyped and repetitive motor mannerisms</td><td>1. Clinician rating
2. Parent report (ADI-3 items)
3. Direct observation (ADOS-1 item)</td></tr>
<tr><td>Persistent preoccupation with parts of objects</td><td>1. Clinician rating
2. Parent report (ADI-1 item)
3. Direct observation (ADOS-1 item)</td></tr>
<tr><td>Hyper-or hypo-reactivity to sensory input or unusual sensory interest</td><td>1. Parent report (ADI-2 items)
2. Direct observation (ADOS-2 items)</td></tr>
<tr><td>Self-Injurious Behaviors</td><td>1. Parent report (ADI-1 item)
2. Direct observation (ADOS-1 item)</td></tr>
<tr><td colspan="2">Cognitive Functioning</td><td>Mullen Scales of Early Learning</td></tr>
<tr><th colspan="3">Outcome Measures (Collected at 8-10 Years of Age)</th></tr>
<tr><td colspan="2">Autism Symptomatology</td><td>1. Childhood Autism Rating Scale
2. Repetitive Behavior Scale – Revised</td></tr>
<tr><td colspan="2">Cognitive Functioning</td><td>Differential Ability Scales-II or Stanford-Binet, 5</td></tr>
<tr><td colspan="2">Adaptive Functioning</td><td>Vineland Adaptive Behavior Scales-Second Edition</td></tr>
</table>

Table 4: RRBs at Age 1-2 as Predictors of Cognitive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: Verbal IQ					
Preoccupation with abnormal intensity/focus	3.45	11.78	0.06	0.29	0.77
Adherence to routines/rituals	-8.55	10.88	-0.15	-0.79	0.44
Stereotyped/repetitive motor mannerisms	-0.51	9.46	-0.01	-0.05	0.96
Preoccupation with parts of objects	-0.90	9.72	-0.02	-0.09	0.93
Sensory Interests	-9.65	10.21	-0.18	-0.94	0.35
Self-Injurious behaviors	3.20	8.93	0.07	0.36	0.72
Outcome Measure at Age 8-10: Nonverbal IQ					
Preoccupation with abnormal intensity/focus	0.06	10.24	0.00	0.01	1.00
Adherence to routines/rituals	-11.59	9.45	-0.24	-1.23	0.23
Stereotyped/repetitive motor mannerisms	2.04	8.22	0.05	0.25	0.81
Preoccupation with parts of objects	6.80	8.45	0.16	0.80	0.43
Sensory Interests	-1.92	8.87	-0.04	-0.22	0.83
Self-Injurious behaviors	0.64	7.76	0.02	0.08	0.93

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). IQ was measured by the *Differential Ability Scales, Second Edition* or *Stanford-Binet Intelligence Scales for Early Childhood, Fifth Edition*.

Table 5: RRBs at Age 3-5 as Predictors of Cognitive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: Verbal IQ					
Preoccupation with abnormal intensity/focus	-3.60	11.24	-0.06	-0.32	0.75
Adherence to routines/rituals	5.64	7.09	0.13	0.79	0.43
Stereotyped/repetitive motor mannerisms	-16.19	8.48	-0.31	-1.91	0.07
Preoccupation with parts of objects	-17.87	8.64	-0.36	-2.07	**0.048**
Sensory Interests	-8.31	9.15	-0.15	-0.91	0.37
Self-Injurious behaviors	-8.20	9.67	-0.15	-0.85	0.40
Outcome Measure at Age 8-10: Nonverbal IQ					
Preoccupation with abnormal intensity/focus	0.85	9.90	0.02	0.09	0.93
Adherence to routines/rituals	5.85	6.25	0.16	0.94	0.36
Stereotyped/repetitive motor mannerisms	-11.86	7.47	-0.26	-1.59	0.12
Preoccupation with parts of objects	-9.15	7.61	-0.21	-1.20	0.24
Sensory Interests	-16.65	8.06	-0.35	-2.07	**0.049**
Self-Injurious behaviors	-5.09	8.52	-0.10	-0.60	0.56

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). IQ was measured by the *Differential Ability Scales, Second Edition* or *Stanford-Binet Intelligence Scales for Early Childhood, Fifth Edition*.

Table 6: RRBs at Age 1-2 and 3-5 as Predictors of Adaptive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 40					
RRBs at Age 1-2					
Preoccupation with abnormal intensity/focus	0.32	5.11	0.01	0.06	0.95
Adherence to routines/rituals	-4.21	4.72	-0.17	-0.89	0.38
Stereotyped/repetitive motor mannerisms	3.79	4.10	0.18	0.92	0.36
Preoccupation with parts of objects	1.85	4.22	0.09	0.44	0.66
Sensory Interests	-5.67	4.43	-0.24	-1.28	0.21
Self-Injurious behaviors	3.20	8.93	0.07	0.36	0.72
RRBs at Age 3-5					
Preoccupation with abnormal intensity/focus	-2.60	5.06	-0.09	-0.51	0.61
Adherence to routines/rituals	2.25	3.19	0.12	0.70	0.49
Stereotyped/repetitive motor mannerisms	-7.56	3.82	-0.32	-1.98	0.06
Preoccupation with parts of objects	-6.03	3.89	-0.28	-1.55	0.13
Sensory Interests	-6.10	4.12	-0.25	-1.48	0.15
Self-Injurious behaviors	-1.83	4.35	-0.07	-0.42	0.68

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). Adaptive functioning was measured by the Adaptive Behavior Composite score of the *Vineland Adaptive Behavior Scales, Second Edition*.

Table 7: RRBs at Age 1-2 as Predictors of ASD Symptom Severity at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 40					
Outcome Measure at Age 8-10: ADOS					
Preoccupation with abnormal intensity/focus	-0.09	0.93	-0.02	-0.10	0.92
Adherence to routines/rituals	0.60	0.86	0.14	0.70	0.49
Stereotyped/repetitive motor mannerisms	0.27	0.74	0.07	0.36	0.72
Preoccupation with parts of objects	0.04	0.76	0.01	0.05	0.96
Sensory Interests	0.40	0.80	0.10	0.49	0.62
Self-Injurious behaviors	-0.18	0.70	-0.05	-0.26	0.80
Outcome Measure at Age 8-10: CARS					
Preoccupation with abnormal intensity/focus	2.74	2.40	0.23	1.14	0.26
Adherence to routines/rituals	1.63	2.22	0.14	0.74	0.47
Stereotyped/repetitive motor mannerisms	-1.52	1.93	-0.16	-0.79	0.44
Preoccupation with parts of objects	-0.49	1.98	-0.05	-0.25	0.81
Sensory Interests	2.02	2.08	0.19	0.97	0.34
Self-Injurious behaviors	0.45	1.82	0.05	0.25	0.81

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). Symptom severity was measured by the *Autism Diagnostic Observation Schedule* (ADOS) Calibrated Severity Score and the *Child Autism Rating Scale* (CARS) Total Score.

Table 8: RRBs at Age 3-5 as Predictors of ASD Symptom Severity at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 40					
Outcome Measure at Age 8-10: ADOS					
Preoccupation with abnormal intensity/focus	1.17	0.90	0.23	1.29	0.21
Adherence to routines/rituals	-0.53	0.57	-0.16	-0.93	0.36
Stereotyped/repetitive motor mannerisms	0.35	0.68	0.09	0.51	0.61
Preoccupation with parts of objects	1.26	0.69	0.33	1.82	0.08
Sensory Interests	0.92	0.73	0.22	1.26	0.22
Self-Injurious behaviors	-1.17	0.78	-0.27	-1.50	0.14
Outcome Measure at Age 8-10: CARS					
Preoccupation with abnormal intensity/focus	1.06	2.26	0.08	0.47	0.64
Adherence to routines/rituals	-1.63	1.42	-0.18	-1.14	0.26
Stereotyped/repetitive motor mannerisms	3.50	1.70	0.32	2.05	0.05
Preoccupation with parts of objects	2.20	1.74	0.22	1.27	0.22
Sensory Interests	4.16	1.84	0.38	2.26	**0.03**
Self-Injurious behaviors	0.47	1.94	0.04	0.24	0.81

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). Symptom severity was measured by the *Autism Diagnostic Observation Schedule* (ADOS) Calibrated Severity Score and the *Child Autism Rating Scale* (CARS) Total Score.

Table 9: RRBs at Age 1-2 and 3-5 as Predictors of RRBs at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 40					
RRBs at Age 1-2					
Preoccupation with abnormal intensity/focus	7.58	6.68	0.21	1.13	0.27
Adherence to routines/rituals	11.60	6.17	0.33	1.88	0.07
Stereotyped/repetitive motor mannerisms	-3.06	5.36	-0.10	-0.57	0.57
Preoccupation with parts of objects	1.28	5.51	0.04	0.23	0.82
Sensory Interests	0.30	5.79	0.01	0.05	0.96
Self-Injurious behaviors	8.83	5.06	0.30	1.74	0.09
RRBs at Age 3-5					
Preoccupation with abnormal intensity/focus	18.76	6.46	0.46	2.90	**0.01**
Adherence to routines/rituals	10.90	4.08	0.40	2.68	**0.01**
Stereotyped/repetitive motor mannerisms	4.30	4.88	0.13	0.88	0.39
Preoccupation with parts of objects	2.17	4.97	0.07	0.44	0.67
Sensory Interests	3.72	5.26	0.11	0.71	0.49
Self-Injurious behaviors	2.17	5.56	0.06	0.39	0.70

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). RRBs at age 8-10 were measured by the Total Score of the *Repetitive Behaviors Scale, Revised.*

Table 10: Mullen ELC and RRBs at Age 1-2 as Predictors of Cognitive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: Verbal IQ					
Mullen ELC[a]	1.88	0.64	0.51	2.93	**0.01**
Preoccupation with abnormal intensity/focus	9.44	10.94	0.16	0.86	0.40
Adherence to routines/rituals	-7.18	9.94	-0.13	-0.72	0.48
Stereotyped/repetitive motor mannerisms	1.94	8.67	0.04	0.22	0.82
Preoccupation with parts of objects	-2.48	8.89	-0.05	-0.28	0.78
Sensory Interests	-13.12	9.39	-0.25	-1.40	0.17
Self-Injurious behaviors	6.58	8.23	0.14	0.80	0.43
Outcome Measure at Age 8-10: Nonverbal IQ					
Mullen ELC[a]	1.44	0.58	0.45	2.48	**0.02**
Preoccupation with abnormal intensity/focus	4.63	9.88	0.09	0.47	0.64
Adherence to routines/rituals	-10.54	8.97	-0.22	-1.17	0.25
Stereotyped/repetitive motor mannerisms	3.90	7.83	0.10	0.50	0.62
Preoccupation with parts of objects	5.58	8.02	0.13	0.70	0.49
Sensory Interests	-4.57	8.48	-0.10	-0.54	0.59
Self-Injurious behaviors	3.22	7.43	0.08	0.43	0.67

Note. The table reports hierarchical multiple regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). [a]Cognitive and language ability at age 1-2 was measured using the Early Learning Composite on the *Mullen Scales of Early Learning* (Mullen ELC). IQ was measured by the *Differential Ability Scales, Second Edition* or *Stanford-Binet Intelligence Scales for Early Childhood, Fifth Edition*.

Table 11: Mullen ELC and RRBs at Age 3-5 as Predictors of Cognitive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: Verbal IQ					
Mullen ELC[a]	0.82	0.29	0.51	2.80	**0.01**
Preoccupation with abnormal intensity/focus	-4.56	10.20	-0.07	-0.45	0.66
Adherence to routines/rituals	3.33	6.48	0.08	0.51	0.61
Stereotyped/repetitive motor mannerisms	-6.83	8.39	-0.13	-0.81	0.42
Preoccupation with parts of objects	-7.20	8.72	-0.15	-0.83	0.42
Sensory Interests	-3.52	8.47	-0.07	-0.42	0.68
Self-Injurious behaviors	-7.63	8.78	-0.14	-0.87	0.39
Outcome Measure at Age 8-10: Nonverbal IQ					
Mullen ELC[a]	0.84	0.24	0.60	3.46	**<0.001**
Preoccupation with abnormal intensity/focus	-0.14	8.47	0.00	-0.02	0.99
Adherence to routines/rituals	3.48	5.38	0.09	0.65	0.52
Stereotyped/repetitive motor mannerisms	-2.25	6.96	-0.05	-0.32	0.75
Preoccupation with parts of objects	1.80	7.24	0.04	0.25	0.81
Sensory Interests	-11.73	7.03	-0.25	-1.67	0.11
Self-Injurious behaviors	-4.51	7.28	-0.09	-0.62	0.54

Note. The table reports hierarchical multiple regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). [a]Cognitive and language ability at age 3-5 was measured using the Early Learning Composite on the *Mullen Scales of Early Learning* (Mullen ELC). IQ was measured by the *Differential Ability Scales, Second Edition* or *Stanford-Binet Intelligence Scales for Early Childhood, Fifth Edition*.

Table 12: Mullen ELC and RRBs as Predictors of Adaptive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Mullen ELC and RRBs at Age 1-2					
Mullen ELC[a]	0.65	0.30	0.40	2.22	0.04
Preoccupation with abnormal intensity/focus	2.41	5.03	0.09	0.48	0.64
Adherence to routines/rituals	-3.73	4.57	-0.15	-0.82	0.42
Stereotyped/repetitive motor mannerisms	4.64	3.99	0.22	1.16	0.26
Preoccupation with parts of objects	1.30	4.09	0.06	0.32	0.75
Sensory Interests	-6.88	4.32	-0.29	-1.59	0.12
Self-Injurious behaviors	0.04	3.78	0.00	0.01	0.99
Mullen ELC and RRBs at Age 3-5					
Mullen ELC[a]	0.14	0.15	0.20	0.98	0.34
Preoccupation with abnormal intensity/focus	-2.78	5.16	-0.10	-0.54	0.60
Adherence to routines/rituals	1.84	3.28	0.10	0.56	0.58
Stereotyped/repetitive motor mannerisms	-5.90	4.24	-0.25	-1.39	0.18
Preoccupation with parts of objects	-4.14	4.41	-0.19	-0.94	0.36
Sensory Interests	-5.25	4.29	-0.22	-1.23	0.23
Self-Injurious behaviors	-1.73	4.44	-0.07	-0.39	0.70

Note. The table reports hierarchical multiple regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). [a]Cognitive and language ability was measured using the Early Learning Composite on the *Mullen Scales of Early Learning* (Mullen ELC). Adaptive functioning was measured by the Adaptive Behavior Composite score of the *Vineland Adaptive Behavior Scales, Second Edition*.

Table 13: Mullen ELC and RRBs at Age 1-2 as Predictors of ASD Symptomatology at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: ADOS					
Mullen ELC[a]	-0.09	0.06	-0.32	-1.64	0.11
Preoccupation with abnormal intensity/focus	-0.38	0.95	-0.08	-0.40	0.69
Adherence to routines/rituals	0.53	0.86	0.12	0.62	0.54
Stereotyped/repetitive motor mannerisms	0.15	0.75	0.04	0.20	0.84
Preoccupation with parts of objects	0.12	0.77	0.03	0.15	0.88
Sensory Interests	0.57	0.81	0.14	0.69	0.49
Self-Injurious behaviors	-0.35	0.71	-0.10	-0.49	0.63
Outcome Measure at Age 8-10: CARS					
Mullen ELC[a]	-0.29	0.14	-0.38	-2.09	**0.047**
Preoccupation with abnormal intensity/focus	1.83	2.34	0.15	0.78	0.44
Adherence to routines/rituals	1.42	2.13	0.12	0.67	0.51
Stereotyped/repetitive motor mannerisms	-1.90	1.86	-0.20	-1.02	0.32
Preoccupation with parts of objects	-0.25	1.90	-0.03	-0.13	0.90
Sensory Interests	2.55	2.01	0.24	1.27	0.22
Self-Injurious behaviors	-0.06	1.76	-0.01	-0.04	0.97

Note. The table reports hierarchical multiple regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). [a]Cognitive and language ability at age 1-2 was measured by the Early Learning Composite on the *Mullen Scales of Early Learning* (Mullen ELC). Symptom severity was measured by the *Autism Diagnostic Observation Schedule* (ADOS) Calibrated Severity Score and the *Child Autism Rating Scale* (CARS) Total Score.

Table 14: Mullen ELC and RRBs at Age 3-5 as Predictors of ASD Symptomatology at Age 8-10

Source	***B***	***SE B***	***β***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: ADOS					
Mullen ELC[a]	-0.01	0.03	-0.11	-0.52	0.61
Preoccupation with abnormal intensity/focus	1.18	0.93	0.24	1.27	0.22
Adherence to routines/rituals	-0.49	0.59	-0.15	-0.83	0.42
Stereotyped/repetitive motor mannerisms	0.19	0.77	0.05	0.25	0.81
Preoccupation with parts of objects	1.08	0.80	0.28	1.36	0.19
Sensory Interests	0.84	0.78	0.20	1.09	0.29
Self-Injurious behaviors	-1.18	0.80	-0.27	-1.47	0.15
Outcome Measure at Age 8-10: CARS					
Mullen ELC[a]	-0.13	0.06	-0.38	-2.09	**0.047**
Preoccupation with abnormal intensity/focus	1.21	2.13	0.09	0.57	0.57
Adherence to routines/rituals	-1.27	1.35	-0.14	-0.94	0.36
Stereotyped/repetitive motor mannerisms	2.04	1.75	0.19	1.17	0.25
Preoccupation with parts of objects	0.54	1.82	0.05	0.30	0.77
Sensory Interests	3.42	1.77	0.31	1.93	0.06
Self-Injurious behaviors	0.38	1.83	0.03	0.21	0.84

Note. The table reports hierarchical multiple regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*β*). [a]Cognitive and language ability at age 3-5 was measured by the Early Learning Composite on the *Mullen Scales of Early Learning* (Mullen ELC). Symptom severity was measured by the *Autism Diagnostic Observation Schedule* (ADOS) Calibrated Severity Score and the *Child Autism Rating Scale* (CARS) Total Score.

Table 15: Relationship between RRBs at Age 8-10 and Cognitive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 38					
Outcome Measure at Age 8-10: Verbal IQ					
Stereotyped Behaviors	-3.25	2.30	-0.34	-1.41	0.17
Self-Injurious Behaviors	-0.14	1.37	-0.02	-0.10	0.92
Compulsive Behaviors	-0.84	2.22	-0.11	-0.38	0.71
Ritualistic Behaviors	3.34	2.54	0.48	1.31	0.20
Sameness Behaviors	-2.91	1.56	-0.53	-1.87	0.07
Restricted Behaviors	0.30	3.02	0.02	0.10	0.92
Outcome Measure at Age 8-10: Nonverbal IQ					
Stereotyped Behaviors	0.56	2.07	0.07	0.27	0.79
Self-Injurious Behaviors	-1.28	1.24	-0.26	-1.04	0.31
Compulsive Behaviors	-1.98	2.01	-0.29	-0.99	0.33
Ritualistic Behaviors	4.85	2.30	0.80	2.11	**0.04**
Sameness Behaviors	-3.32	1.41	-0.70	-2.35	**0.03**
Restricted Behaviors	0.23	2.72	0.02	0.08	0.93

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). IQ was measured by the *Differential Ability Scales, Second Edition* or *Stanford-Binet Intelligence Scales for Early Childhood, Fifth Edition*. RRBs at age 8-10 were measured by the *Repetitive Behaviors Scale, Revised* Total Score.

Table 16: Relationship between RRBs at Age 8-10 and Adaptive Functioning at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 40					
Stereotyped Behaviors	-2.27	0.87	-0.53	-2.62	**0.01**
Self-Injurious Behaviors	-0.04	0.52	-0.01	-0.07	0.95
Compulsive Behaviors	0.13	0.84	0.04	0.15	0.88
Ritualistic Behaviors	1.19	0.96	0.38	1.24	0.23
Sameness Behaviors	-1.13	0.59	-0.47	-1.92	0.07
Restricted Behaviors	-0.21	1.14	-0.04	-0.19	0.85

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). Adaptive functioning was measured by the Adaptive Behavior Composite score of the *Vineland Adaptive Behavior Scales, Second Edition*. RRBs at age 8-10 were measured by the Total Score of the *Repetitive Behaviors Scale, Revised.*

Table 17: Relationship between RRBs at Age 8-10 and ASD Symptom Severity at Age 8-10

Source	***B***	***SE B***	***ß***	***t***	***p***
N = 40					
Outcome Measure at Age 8-10: ADOS					
Stereotyped Behaviors	0.28	0.18	0.38	1.56	0.13
Self-Injurious Behaviors	-0.19	0.11	-0.44	-1.76	0.09
Compulsive Behaviors	0.15	0.18	0.24	0.83	0.41
Ritualistic Behaviors	-0.22	0.20	-0.40	-1.07	0.29
Sameness Behaviors	0.11	0.12	0.27	0.91	0.37
Restricted Behaviors	-0.17	0.24	-0.16	-0.70	0.49
Outcome Measure at Age 8-10: CARS					
Stereotyped Behaviors	1.63	0.41	0.83	3.98	**<0.001**
Self-Injurious Behaviors	-0.17	0.24	-0.15	-0.68	0.50
Compulsive Behaviors	0.04	0.40	0.02	0.09	0.93
Ritualistic Behaviors	-0.48	0.45	-0.34	-1.06	0.30
Sameness Behaviors	0.11	0.28	0.10	0.38	0.71
Restricted Behaviors	-0.16	0.54	-0.06	-0.30	0.77

Note. The table reports the results of regressions, including the unstandardized beta (*B*), the standard error of the unstandardized beta (*SE B*) and the standardized beta (*ß*). Symptom severity was measured by the *Autism Diagnostic Observation Schedule* (ADOS) Calibrated Severity Score and the *Child Autism Rating Scale* (CARS) Total Score. RRBs at age 8-10 were measured by the *Repetitive Behaviors Scale, Revised* Total Score.

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