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# Repetitive and Stereotyped Behaviors in Children with Autism Spectrum Disorders in the Second Year of Life

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## Abstract

This study examined repetitive and stereotyped behaviors (RSB) in children with autism spectrum disorders (ASD, *n*=50), developmental delays without ASD (DD; *n*=25) and typical development (TD, *n*=50) between 18 and 24 months of age. Children with ASD demonstrated significantly higher frequency and longer duration of RSB with objects, body, and sensory behaviors during a systematic behavior sample than both the DD and TD groups. RSB with objects were related to concurrent measures of symbolic capacity and social competence in the second year and predicted developmental outcomes as well as severity of autism symptoms at three years in children with communication delays. RSB in the second year appear to be important for early identification and prediction of developmental outcomes.

### Keywords

repetitive stereotyped behavior; autism spectrum disorder; second year

## Introduction

Repetitive and stereotyped patterns of behavior, interests, and activities have been considered central to autistic disorder since Kanner's (1943) original description of 11 children with autism. Kanner described a number of object and body stereotypies in his original case studies including spinning, jumping, and other rhythmic movements of the body. These observations and subsequent research have led to the inclusion of restricted repetitive and stereotyped patterns of behavior, interests, and activities as necessary features for a diagnosis of autistic disorder and Asperger syndrome, and as a possible feature in pervasive developmental disorder – not otherwise specified (PDD-NOS), according to the Diagnostic and Statistical Manual-IV-Text Revision (*DSM-IV-TR*; APA, 2000), along with social and communication impairments. Repetitive and stereotyped behaviors (RSB) therefore have strong diagnostic significance when they are observed or reported (Turner, 1999), yet far less is known about this domain of symptoms compared to the social and communication domains (Lewis & Bodfish, 1998), particularly in young children.

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## Definitions and profiles of RSB

In the literature on ASD, RSB generally refer to a broad range of behaviors including stereotypies, rituals, compulsions, obsessions, perseveration, and repetitive or stereotyped use of language. An emerging body of research now exists that attempts to understand the underlying constructs of RSB. Turner (1999) subdivided this broad range of RSB into "lower-level" behaviors characterized by repetition of movement including dyskinesias, stereotyped movements, repetitive manipulation of objects, and repetitive forms of self-injurious behavior, and "higher-level" behaviors including object attachments, insistence on sameness, repetitive language, and circumscribed interests. She proposed that the lower-level behaviors were associated with lower developmental levels, while the higher-level behaviors are likely to be observed in individuals with higher cognitive abilities.

Sensory behaviors are not formally part of the repetitive behavior diagnostic criteria on either the DSM-IV or the International Classification of Disorders (ICD) 10 classification systems. However, unusual sensory interests or behaviors are assessed on diagnostic instruments such as the Autism Diagnostic Interview - Revised (ADI-R; Lord, Rutter, & LeCouteur, 1994) and links between sensory behaviors and repetitive motor behaviors have been found in statistical examinations of the ADI-R. Cuccaro and colleagues (2003) examined the factor structure of RSB in a sample of 207 individuals with autism from 3 to 21 years of age. They found two underlying dimensions to the RSB tapped in 12 items from the ADI-R, namely, repetitive motor sensory actions (Factor 1), and resistance to change (Factor 2). They found that Factor 1 was significantly negatively correlated with level of functioning as indexed by the adaptive behavior composite of the Vineland Adaptive Behavior Scales (VABS; Sparrow, Balla, & Cicchetti, 1984), suggesting that repetitive motor sensory actions were related to adaptive developmental functioning to a greater degree than behaviors related to resistance to change. However, they stressed the need for future research to assess whether Factor 1 behaviors were associated with cognitive developmental measures to confirm this conclusion. Similarly, Honey and colleagues (in press) identified a sensory motor component in their principle components analysis of 12 items of the ADI-R, in which the repetitive use of objects, hand and finger mannerisms, complex/stereotyped movements and self-injury all clustered together with unusual sensory interests in children aged 24 – 48 months. More research is needed to determine if repetitive sensory motor behaviors can distinguish children with ASD from children with other developmental delays at more specific ages.

## Are RSB Present in Very Young Children with ASD?

There is a prevailing notion in the literature that RSB are less common in very young children with ASD and tend to emerge later than symptoms in the social or communication domains. This notion has arisen from studies that have tracked diagnostic stability of children initially diagnosed between two and three years of age and followed up after their third birthday (Lord, 1995; Stone et al., 1999; Moore & Goodson, 2003), as well as studies of children in the second year of life using parent report (Cox et al., 1999) and home videotape analyses (Werner & Dawson, 2005). Lord (1995) reported an unfolding of RSB in children with ASD from the third to the fourth year of life. In the third year, the children with ASD differed significantly from children with developmental delays (DD) on two items of the ADI-R namely, *hand and finger mannerisms* and *unusual sensory behaviors*. Stone and colleagues (1999) also found that RSB were observed with less consistency and showed more variability in children with ASD at a mean age of 31.4 months than items related to social or communication symptoms. Moore and Goodson (2003) observed a significant increase in RSB in 20 children with ASD between 2 years 10 months and 4 to 5 years of age. This was due to increases in circumscribed interests, unusual preoccupations, compulsions and rituals, hand and finger mannerisms, and repetitive use of objects, although changes in the scores of individual behaviors were not statistically significant.

Research findings on RSB in children with ASD in the second year of life are equivocal. Some studies of children in the second year have found no differences in RSB in children with ASD from those with DD or TD. Cox et al. (1999) found that ADI-R scores for RSB as measured at 20 months of age in their group with autism (*n*=8) were significantly higher than scores for the groups with language or developmental delay (LD, *n*=9) and TD (*n*=15), but not for PDD (*n*=13). However, no individual RSB items on the ADI-R distinguished the children with autism from the LD group and very few children from any of the groups showed *definite* abnormality, defined as scores of 2 or 3 on the ADI-R items. In a study of autistic regression using retrospective home videotape analyses, Werner and Dawson (2005) also found no differences in RSB at 12 or 24 months between their groups with early onset ASD (*n*=21), regressive ASD (*n*=15), and TD (*n*=20). This may reflect biases in the types of behaviors the families recorded in their home videotapes.

There are two studies that have documented significant differences in RSB in young children with ASD in the second year compared to children with DD and TD, one using retrospective parent report (Werner, Dawson, Munson, & Osterling, 2005) and the other using systematic observation (Wetherby et al., 2004). Werner and colleagues (2005) developed and used the Early Development Interview to probe retrospective parent reports of regulatory, social, communication, and RSB symptoms from birth to two years in a relatively large group of 3-to-4 year-old children with ASD (*n*=72), DD (*n*=34) and TD (*n*=39), with all groups matched on mental age and ASD and DD groups on chronological age. They found significant differences among all three groups in RSB at 16–18 months. Differences between the ASD and TD groups were observed much earlier, but it was only at these ages that the differences between the ASD and DD groups were significant. The nature of the RSB present in these young children, however, was not described.

In a prospective observational study, Wetherby and colleagues (2004) documented the presence of RSB in the second year of life in a substantial majority of children later diagnosed with ASD. Using the Systematic Observation of Red Flags of ASD (SORF; Wetherby & Woods, 2002), which employs ratings from 0 to 2 of behaviors during direct observation of a standardized behavior sample, Wetherby et al. (2004) identified 9 red flags that specifically distinguished 18 children with ASD at a mean age of 21.0 months from 18 with DD and 18 with TD. Seven of these red flags related to social and communication symptoms, but two related specifically to RSB, namely repetitive movements with objects and repetitive movements with body. They reported that 72% of the sample demonstrated repetitive movements with objects, compared to 11% in the DD group and 0% in the TD group, and 50% showed repetitive movements with body, compared to 17% in the DD group and 0% in the TD group. These findings suggest that systematic observation within a standardized behavior sample may be a sensitive measure of RSB in the second year of life. However, the scoring system was ordinal and restricted in range. More precise measures of RSB during this time period are needed in order to better characterize the frequency and nature of these behaviors and determine the feasibility of using RSB as possible early indicators of ASD.

In studying very young children, it is important to distinguish how RSB may be different from the repetitive and ritualistic behaviors observed in typically developing infants and toddlers (Thelen, 1979, 1981; Evans et al., 1997). In a recent review of studies of the early development of stereotypy not specific to children with ASD, Symons, Sperry, Dropik and Bodfish (2005) have pointed out that it is still unclear what features of early RSB are considered atypical in comparison to the repetitive behaviors observed in typically developing children. Gardenier, MacDonald and Green (2004) highlight the fact that by their very nature RSB usually occur as an episode that consists of numerous repetitions and discernable duration. This is one aspect of RSB that has not been examined in the literature as a potential early indicator of ASD. There are no studies comparing the frequency and duration of a wide variety of RSB to determine

what differences exist between children with ASD and matched children with DD and TD in the second year of life.

## How are RSB Related to Developmental Level?

RSB are known to be associated with developmental level in individuals with DD who do not have ASD, particularly in older children (Lewis & Bodfish, 1998), and therefore it is important to determine whether RSB reflect autism symptoms and/or overall developmental level. There are two approaches to examining this relationship; one is to use carefully matched control groups with DD and the second is to examine relations between RSB and developmental level within groups of individuals with ASD. As mentioned, both Wetherby et al. (2004) and Werner and Dawson (2005) included matched control groups of children with DD and found significant group differences in RSB, suggesting that even in the second year, RSB are not explained by developmental level alone.

There are conflicting findings in the literature in studies examining relations between RSB and developmental level within children with ASD. For example, Mooney, Gray, and Tonge (2006) recently examined RSB in 40 children with ASD with a mean age of 36.8 months compared to 15 matched children with DD. RSB were measured using parent report with the Developmental Behaviour Checklist- Primary Carer Version (Einfeld & Tonge, 2002) and the ADI-R. While the scores on the ADI-R algorithm were significantly positively associated with the probability of receiving a diagnosis of autism, RSB were not associated with developmental level in the children with ASD measured with the Psychoeducational Profile-Revised (PEP-R; Schopler, Reichler, Bashford, Lansing, & Marcus, 1990). They suggested that the lack of association may have been related to the limited range of developmental functioning in their sample. Similarly, Lord and Pickles (1996) found that neither language stage nor mental age were related to overall RSB as measured on the ADI-R in 51 three-to-five-year-olds with ASD and 43 three-to-five-year-olds with language impairments who did not have ASD. Only one item, *hand and finger mannerisms* was related to mental age in the ASD group, while the item *unusual sensory interests* was significantly related to language stage in the ASD group. In contrast, Honey et al. (in press) found that RSB on the ADI-R and functioning on language and adaptive behavior measures were significantly correlated at a mean age of 37.05 months (*SD*=6.08) in 104 children with autism, ASD, and speech/language delays and again at a mean of 50.15 months (*SD*=6.71). Although the measures of RSB and ages of the children in the two studies are similar, different measures of language and developmental level were used. Furthermore, the studies also differed in that Lord and Pickles (1996) examined the relationship between RSB and ability using individual items from the ADI-R and also kept diagnostic groups separate whereas Honey et al. (in press) used total ADI-R scores and examined this relationship in their total sample of children with ASD and other developmental disorders.

The potential significance of the differences in age of the participants in particular is highlighted by the results of Bishop, Richler, and Lord (2006) who examined RSB in 830 children with ASD with a mean age of 58 months (*SD*=29 months), ranging from 15 months to 11 years 11 months. Using the ADI-R as a measure of RSB, they found that developmental level, in particular, NVIQ, became more strongly negatively correlated with the presence of a number of RSB as the children got older, in particular *resistance to change in the environment, compulsions/rituals, repetitive use of objects, unusual attachments, stereotyped speech,* and *self-injury.* The relationship between severity of *repetitive use of objects* and NVIQ also increased with increasing age. In discussing these findings, the authors hypothesized that younger children with ASD may have more limited play options than older children and therefore may be likely to engage in similar types of activities or RSB regardless of their level of functioning. They stress the need for future studies to obtain data through direct observation in order to corroborate their findings.

Conflicting evidence also exists regarding the relationship between early RSB and later developmental outcomes. On the one hand, early RSB have been shown to have a significant impact on the acquisition of a number of skills during intervention (Bopp, Mirenda & Smith, 2005, November). These authors found that not only did preschool children with fewer RSB at the onset of intervention show more progress in social skills over two years, but also that children who showed improvements in RSB in the first six months to a year of intervention showed greater gains in language, daily living skills, and IQ skills over two years. They concluded that "stereotypic behaviours may be considered more 'pivotal' to language and social outcomes than previously believed" (p.7). In contrast, Charman and colleagues (2005) reported the results of a prospective longitudinal study of a group of 26 young children with ASD assessed at 2, 3, and 7 years of age with a variety of standard measures of cognition and language. RSB was measured using parent report (ADI-R). Predictive relations showed no relationship between RSB at two years and NVIQ or language outcomes at three or seven years of age. Similarly, RSB at three years did not predict any measure of functioning at seven years of age. In light of these contrasting findings, further research in this area using more precise observational measures of RSB in the early years is essential. If individual differences in RSB from the second year of life have a discernable impact on developmental outcomes later in the preschool years, it could be hypothesized that prolonged engagement in RSB across the crucial developmental period of the second and third years of life may interfere with learning opportunities and thus have a cumulative detrimental impact on developmental outcomes over time.

### How are RSB Related to the Social Symptoms of ASD?

The question of how RSB is related to the severity of other core autism symptoms has intriguing implications for our theoretical understanding of ASD. Studies of the relationship among symptom domains from the earliest stages of their emergence are important for our understanding of the dependence among these domains and the pathogenesis of ASD (Charman & Swettenham, 2001). Research with adults and older children with ASD has consistently found a close concurrent relationship among RSB and social and communication symptoms (Bodfish, Symons, Parker, & Lewis, 2000). In younger children, Mundy, Sigman, and Kasari (1994) examined the relations among joint attention and other symptoms of ASD in 30 preschoolers with ASD. They found no correlation between joint attention skills and symptoms involving sensory behaviors or stereotypies as measured on the Autism Behavior Checklist (Krug, Arick, & Almond, 1979) based on parent interview. There are no studies examining the relations between RSB and social symptoms, particularly using direct observation, in children with ASD under two years of age. Similarly very few studies have examined predictive relations among symptom domains in very young children. In the study mentioned earlier, Charman and colleagues (2005) found no significant correlations between early RSB at 2 and later symptoms in other domains at 3 or 7 years of age in 26 children with ASD. In contrast, RSB at 7 years of age were significantly predicted by social and communication symptoms as measured on the ADI-R at 3. Further studies using direct observation are needed to elucidate these relationships.

The purpose of this study was to examine RSB in children between 18 and 24 months of age who were later diagnosed with ASD, and matched groups of children with DD and TD. The specific research objectives and corresponding hypotheses were: (1) to describe the duration, frequency, and types of RSB displayed by children with ASD, DD, and TD between 18 and 24 months of age during systematic observation and to examine group differences. It was hypothesized that the group with ASD would show both higher frequency and longer duration of RSB than both the DD and TD groups; (2) to examine concurrent and predictive relationships between RSB in the second year and developmental level, specifically verbal (second and fourth year) and nonverbal developmental level and adaptive behavior (fourth year). It was

hypothesized that RSB would be negatively correlated with developmental level both concurrently and predictively; and (3) to examine concurrent and predictive relationships between RSB in the second year and social symptoms in the second and fourth years. It was hypothesized that higher frequency and duration of RSB in the second year would correlate positively with social symptoms both concurrently and predictively.

## Method

### Participants

Three groups of children, all in the second year of life, participated in this study, one with ASD ($n$ = 50), one with DD in which ASD was ruled out ($n$ = 25), and one with TD ($n$ = 50). The participants were recruited prospectively through the FIRST WORDS® Project. This Project conducts screening on a general population sample of children recruited from healthcare and childcare agencies to identify children in the first two years of life with communication delays using the Communication and Symbolic Behavior Scales Developmental Profile (CSBS; Wetherby & Prizant, 2002). All children recruited for this study met the following selection criteria: (1) a CSBS Infant-Toddler Checklist was completed by the family when the child was under 24 months of age; (2) a CSBS Behavior Sample was videotaped when the child was over 18 months of age; and (3) a follow-up developmental evaluation was conducted over 24 months of age, which included administration of the Mullen Scales of Early Learning (MSEL; Mullen, 1995) as a measure of verbal and nonverbal developmental level.

The 50 children with ASD in this study are the same cohort as those reported on by Wetherby, Watt, Morgan and Shumway (2007), where the recruitment process and selection criteria for each group have been described in detail. Briefly, children in the ASD and DD groups were drawn from a pool of children with a communication delay during the second year of life based on performance in the bottom 10th percentile on one or more composites of the Behavior Sample. The children with a communication delay were divided into two groups, ASD and DD, based on a follow-up evaluation completed by a multidisciplinary team when the child was at least 30 months of age to make a best estimate diagnosis of ASD or DD without ASD. This diagnosis was made on the basis of a battery of tests including the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 1999) to provide a standardized assessment of communication, social interaction, and play or imaginative use of materials for the diagnosis of ASD. Children were assigned to the ASD group if they received a diagnosis of Autistic Disorder or PDD-NOS and their communication and social interaction total on the ADOS fell at or above the cutoff for autism spectrum; otherwise they were assigned to the DD group. There was only one child whose ADOS scores fell above the autism spectrum cut-off but did not receive a PDD-NOS diagnosis because the team felt that his heightened scores were due to the severity of his developmental delay. The ADOS could not be completed for two children because they lived at a distance and families could not return for the evaluation. Both of these children received a diagnosis of ASD at 30 months of age or older by a pediatric neurologist, and therefore, were assigned to the ASD group. Of the 75 children with a communication delay, 50 were assigned to the ASD group and 25 to the DD group, which is two more than the number of DD children recruited for Wetherby et al. (2007). Children in the TD group were drawn from a pool of children who displayed performance above the 25th percentile on all three composites of the Behavior Sample during the second year and within normal limits on the MSEL at three years. Additionally, none of the TD children were suspected of having ASD by the parent or clinician during the follow-up evaluation.

The DD group was matched group-wise to the ASD group on the symbolic composite of the CSBS in the second year. Thus, the DD group formed a comparison group at the same age and developmental level as the children with ASD. It is important to note that the DD group included a mixture of children with global developmental delay and with specific language, speech, and/

or motor delay, in order to match the variation in cognitive level of the ASD group. The TD group was matched individually to the ASD group on sex and chronological age at the time of the Behavior Sample.

The demographic characteristics of the three groups are presented in Table 1 and these indicate that all 3 groups were well-matched on mother's and father's education and mother's age, using the criterion *p*-value of > .50 on tests of group differences for the purposes of matching (Mervis & Klein-Tasman, 2004). This suggests that the groups were comparable on socioeconomic status. The ASD group had slightly more children who were Hispanic and Asian and the DD group had slightly more children who were African American.

Participant developmental characteristics are provided in Table 2. The children ranged in age from 18.24 to 26.86 months at the Behavior Sample and there were no significant group differences in age between the ASD and DD or between the ASD and TD groups. The ASD group scored significantly lower than the TD group on the Symbolic Composite of the CSBS, but was well matched with the DD group on the Symbolic Composite, indicating they were matched on development level in the 2$^{nd}$ year. There were no significant differences between groups in age at the MSEL during the follow-up evaluation. The ASD and DD groups showed a wide range of cognitive functioning in verbal and nonverbal MSEL developmental quotients (DQ). As expected, the ASD group was significantly different than the TD group on nonverbal and verbal DQ. There were no significant differences between the ASD and DD group on verbal or nonverbal DQ, although the *p*-values for these differences did not reach the optimal value of .50 for the purposes of group matching. More than half of the ASD group was relatively higher functioning (nonverbal DQ > 70) and 38% had a nonverbal DQ below 70. The DD group was comprised of 28% who had a nonverbal DQ below 70, 28% with specific language delay, and 36% with speech and/or fine motor delay. On the Vineland Adaptive Behavior Scales (VABS; Sparrow et al., 1984) presented in Table 2, the ASD group was matched with the DD group on only the motor domain, with significant differences on the communication, daily living, and social domains.

The mean age at assessment of the ADOS was 44.18 months (*SD*=14.09) for the ASD group and 47.33 months (*SD*=14.51) for the DD group. The revised algorithm scores for the ADOS were used to calculate severity of symptoms in the fourth year (Gotham, Risi, Pickles, & Lord, 2007). According to the revised algorithm scores for the ADOS, the mean ADOS Social Affect (SA) + Restricted, Repetitive Behaviors (RRB) total algorithm score was 15.04 (*SD*=5.48) for the ASD group and 3.54 (*SD*=3.30) for the DD group, which was significantly different, $F = 121.22$, $p < .000$. There were 27 children in the ASD group (54%) who received a best estimate diagnosis of autistic disorder and 23 (46%) who received a diagnosis of PDD-NOS.

## Second Year Measures

**CSBS Behavior Sample—**All measures in the second half of the second year were obtained from the videotaped Behavior Sample of the CSBS. The Behavior Sample employs a standard but flexible format for sampling behavior of very young children. It uses a variety of communication temptations designed to encourage spontaneous communication behavior, such as a wind-up toy, bubbles, a jar of cheerios, and a bag of toys. Other activities include book sharing, language comprehension probes, and opportunities for symbolic and constructive play. This instrument has been normed on a national sample and the standard scoring has been shown to have good internal consistency and test-retest stability (Wetherby & Prizant, 2002) as well as good predictive validity with language outcome scores at two and three years of age (Wetherby, Allen, Cleary, Kublin & Goldstein, 2002; Wetherby, Goldstein, Cleary, Allen & Kublin, 2003). While standard in the materials and steps of administration, the Behavior Sample may take differing lengths of time for different children. Potential implications of this are addressed in the data analyses and preliminary results sections.

**RSB—**RSB were coded from the Behavior Sample videotapes using the Noldus Pro Observer® software version 5. This software allows the scoring and timing of operationally defined behaviors in digitized video media files by different observers. It provides a precise temporal tagging of each behavior, allowing for measures of frequency and duration to be calculated. Three categories of RSB were coded: RSB with objects, RSB with body, and sensory behaviors. These behaviors were all "low-level" motor and stereotyped behaviors (Turner, 1999) or repetitive sensory motor behaviors (Cuccaro et al., 2003; Honey et al., in press). The reason for this was practical in nature. These were the behaviors most likely to be observed with the objects and opportunities presented to children in the semi-structured standardized Behavior Sample setting. They were also the behaviors more likely to be seen by direct observation as opposed to detailed parental interview, which might probe behaviors such as resistance to change in routines. Finally, they were also deemed to be the most likely behaviors to be observed in children under two years of age.

Unless otherwise stated, repetitive behaviors were defined as behaviors that were repetitive (3 or more repetitions or occurred with 3 or more objects) and were not used communicatively (e.g., were not communicative gestures such as waving "bye", or signing "more"). Stereotyped behaviors were specifically defined and were coded every time they occurred. Specific onset and offset criteria were defined for each behavior. In general, onset occurred at the moment the particular movement started and offset occurred the moment the child ceased that behavior, engaged in a different action or behavior with the same object or a different object, or paused between bouts of repetitive behavior, with a pause defined as a period longer than the duration of the first three repetitions, or 2 seconds, whichever was longer. Different RSB could not be coded simultaneously. The operational definitions of each category of RSB are presented in Table 3.

**Symbolic capacity and social competence—**Two measures using the standard scoring procedures of the CSBS Behavior Sample were included in this study, the symbolic composite as a measure of developmental level and the social composite as a measure of social competence in the second half of the second year. The symbolic composite consists of measures of verbal comprehension, as well as functional, symbolic, and constructive play. Verbal comprehension is a measure of symbolic capacity to understand single words without gestural cues. Probes were presented during which the adult said "give me" or "show me" up to 3 different object names, 2 different person names, and 3 different body parts and the child identified each by touching, showing, or making a clear change in direction of gaze. The symbolic play measure consists of the inventory of different action schemes a child used with the set of feeding and cooking toys, the number of action schemes used toward others (e.g., the doll or adults), and the number of two or more sequenced action schemes (e.g., scoop and feed). Constructive play is a measure of how many blocks the child was able to stack. Wetherby et al. (2002) reported large correlations between the symbolic composite at 22–24 months and verbal developmental level as measured on the combined receptive and expressive scales of the MSEL ($r$ =.76 for receptive and .66 for expressive) at a mean age of 25.1 months in a sample of 243 children, suggesting that this composite is a good indicator of verbal developmental level. The social composite was used as a measure of social competence. The composite score consists of 9 items related to the use of emotion and eye gaze (gaze shifts, shared positive affect, and gaze/point following), communication (rate of communicating, acts for behavior regulation, social interaction, and joint attention), and gestures (inventory of conventional gestures, and use of distal gestures).

**Interobserver agreement—**Interobserver agreement for frequency and duration of episodes of RSB was calculated using Cohen's kappa (Cohen, 1960). Cohen's kappa assesses the reliability of a categorical scale while correcting for chance agreement (Bakeman & Gottman, 1997) and has values ranging from 0 to 1. Values from .60 to .75 are regarded as

good and values over .75 as excellent (Fleiss, 1981), although additional factors such as baserate of the behaviors coded should also be taken into account when interpreting kappa scores (Bruckner & Yoder, 2006). Interobserver agreement was calculated on 26% of the data using 32 randomly selected samples from all three groups, 14 from the ASD, 6 from the DD, and 12 from the TD groups respectively. Primary coders were blind to which study samples were being coded for reliability. A 2-second tolerance window was permitted (i.e., if the two observers coded the same behavior within 2 seconds of each other, it was counted as an agreement).

Initially, two-by-two contingency tables were constructed to determine agreement regarding the presence of any RSB versus no RSB. For this decision, a kappa of .73 was obtained for frequency indicating good agreement. A kappa of .53 was obtained for duration of RSB. Taking into account the low baserate of duration of RSB in relation to the total duration of the behavior samples (.04), this kappa reflects an estimated observer accuracy of between .9 and .95 indicating good agreement overall for duration of RSB (Bruckner & Yoder, 2006).

Next, kappas for the decision regarding type of RSB when both coders coded a behavior, were calculated. A kappa of .94 was obtained for both frequency and duration of RSB indicating excellent agreement on type of RSB. The following kappas were calculated for frequency and duration respectively of individual categories of RSB: .96 and .98 for RSB with objects, .99 and .99 for RSB with body, and .66 and .97 for sensory. This indicates good agreement overall with lowest agreement for sensory, which can be attributed in part to their low frequency. Results regarding sensory behaviors must therefore be viewed with caution.

Interobserver agreement for the social and symbolic composites was also assessed as the Behavior Sample requires that raters make judgments about the occurrence or non-occurrence of behaviors during ongoing interaction. Agreement was calculated using *g* coefficients by comparing the scores for pairs of four independent raters using randomly selected samples for at least 20% of the samples scored by each rater. The *g* coefficient is a measure of the source and magnitude of variance accounted for by the subjects and the raters and has been used in similar research (e.g., McCathren, Yoder & Warren, 2000; McWilliam & Ware, 1994; Wetherby et al., 2002). A *g* coefficient approaches 1 as the variance accounted for by the subjects is large in comparison with the variance accounted for by raters (Bakeman & Gottman, 1997). *G* coefficients of .6 or greater are considered acceptable for demonstrating inter-rater reliability (Mitchell, 1979). The *g* coefficients ranged from .90–.97 for the Social Composite and .95–.98 for the Symbolic Composite, which indicate that the CSBS raters exhibited high interobserver reliability for these measures.

## Fourth Year Measures

As indicated in Table 2, developmental level and adaptive behavior outcomes were assessed in the fourth year using the MSEL nonverbal and verbal DQ and the VABS adaptive behavior composite. Autism symptoms were also measured in the fourth year of life for the ASD and DD groups using the ADOS. The RRB and SA algorithm scores were calculated according to the revised algorithms (Gotham et al., 2007).

## Data Analyses

Data analyses began with preliminary analyses to determine if the raw duration and frequency measures could be used or whether proportion and rate measures needed to be derived from the data due to potentially differing sample lengths (see results of these preliminary analyses in the results section below). Thereafter, means and standard deviations for all discrete RSB coded were calculated and explored. Following this, composite RSB measures were derived and used in a priori one tailed *t*-tests to test for group differences in RSB. Effect sizes for all

differences were calculated using Cohen's *d*, which is calculated as the difference in means divided by the average pooled *SD*, where $d \geq .20$ is considered small, .50 medium, and .80 large (Cohen, 1988). Pearson product moment correlations were calculated in order to determine concurrent and predictive relations among RSB in the second year and other indices of functioning. Despite the fairly narrow age range of children in the study (18–24 months), all correlations controlled for age to eliminate this as a confounding factor. Where appropriate, partial correlations were also calculated in order to control for confounding factors such as concurrent developmental level. Effect sizes for the correlations were classified according to the benchmark values of .1 is small, .3 medium, and .5 is large (Cohen, 1988).

## Results

### Preliminary analyses

In order to determine whether the frequency and duration measures could be used for analyses or whether rate and proportion of RSB needed to be derived as a function of the length of the samples, the mean lengths of the samples across groups were compared. The mean lengths (and standard deviations) of the Behavior Samples in minutes for the three groups were as follows: ASD: 21.5 (5.3); DD: 21.4 (3.4); and TD: 21.9 (3.9). No differences in sample length were found between any groups (ASD-DD: $p<.94$; ASD-TD: $p<.59$; DD-TD: $p< .61$). As a final check, rate (frequency/sample length) and proportion (duration/sample length) measures were calculated for the composite RSB measures (see below) and subjected to ANOVA comparisons. There were no differences in the pattern of results obtained from the frequency and duration measures. Therefore, the raw frequency and duration data were used for all analyses.

### RSB in the Second Year

A summary of the means, standard deviations, and effect sizes of group differences for each RSB coded in the study is provided in Table 4 for frequency measures and Table 5 for duration. All RSB included in the coding system were demonstrated by some children, except for covering ears in response to a sensory stimulus, which no children demonstrated. In addition, the ASD group did not demonstrate lining up or stacking objects, or sniffs/smells in the sensory category and no one in the TD group demonstrated rolling objects, or sniffs/smells. It is evident in Tables 4 and 5, that most group differences were in the expected direction (i.e., the ASD group had larger mean scores), with the exception of two behaviors. Specifically, both the DD and TD groups demonstrated lining up or stacking of objects, while the ASD group did not. In addition, only one child in the DD group demonstrated one instance of sniffing/smelling. In light of these results, a subset of behaviors that showed differences in the expected direction for both groups (i.e., effect sizes with a positive value) with small effect sizes ($d$=.20), or with a medium effect size ($d$=.50) with one group was selected and a composite RSB score was calculated for each category of RSB. For RSB with objects, this included the following behaviors: bang/taps, rocks/flips, swipes, spins/wobbles, rolls, moves/places, and clutches. RSB with body included bangs surface, rubs body, and stiffens, and the sensory composite included feels/touches, fixates, and sucks fingers.

A priori one-tailed contrasts were then calculated between the ASD and TD and ASD and DD groups to determine whether the ASD group demonstrated more RSB than the DD and TD groups on the composite measures of RSB with objects, RSB with body and sensory behaviors. Levene's test of homogeneity of variance was significant for all categories of RSB; therefore contrasts were calculated without assuming equal variance. The results are presented in Table 6. Using the subset of behaviors included in the composites, children with ASD demonstrated significantly higher frequency and duration of RSB with objects, RSB with body, and sensory behaviors than both the TD and the DD groups. The effect sizes of the differences were

moderate and large for the RSB with objects and RSB with body categories, and small for the sensory behaviors. The means and standard deviations for the sensory behaviors indicate many children had no or very low sensory behaviors causing the distribution of the data to be skewed. Where sensory behaviors were observed, the large *SD* in relation to the mean suggests variability among the children in all groups, which may have masked group differences. Group differences in sensory behaviors must therefore be viewed with caution, and sensory behaviors were not included in any further analyses. In addition, it should be noted that because the patterns for frequency and duration measures of RSB were very similar in this analysis, only the frequency data were used in the remaining analyses.

### Concurrent Relationships with other Second Year Measures

Concurrent relations between RSB frequency measures and other second year measures were examined in the ASD group alone, as well as in the ASD and DD groups combined in order to explore the relationship between RSB and other second year measures in children with ASD specifically, as well as in the combined group of children with communication delays in the second year. Correlations are presented in Table 7. Significant correlations were observed between RSB with objects and developmental level on the symbolic composite that were moderate in the ASD group alone, and small in the ASD and DD groups combined. Significant moderate correlations were observed between RSB with objects and the social composite in both the ASD group and the ASD and DD groups combined, while small correlations were observed between RSB with body and the social composite that were only significant in the combined group. In light of the relationship between RSB and the symbolic composite, these correlations were recalculated controlling for developmental level. Only the relationship between RSB with objects and the social composite in the ASD and DD groups combined remained significant, with a small effect ($pr$=.26; $p$<.05).

### Predictive Relationships with Fourth Year Outcome Measures

To examine predictive relations between early RSB and developmental outcomes, bivariate correlations controlling for age between the RSB measures in the second year and verbal and nonverbal scores on the MSEL and the adaptive behavior composite of the VABS were computed. To examine predictive relations between early RSB and autism symptoms at 3 years, bivariate correlations controlling for age were examined between frequency of RSB in the second year and severity of autism symptoms based on the ADOS algorithm scores for repetitive and restricted behaviors (RRB) and social affect (SA) at three years. Results are presented in Table 7.

In the children with ASD, significant moderate correlations were observed between RSB with objects in the second year and verbal and nonverbal DQ on the MSEL at three years. These were no longer significant when controlling for developmental level on the symbolic composite in the second year. There were no significant correlations between early RSB and outcome on the VABS, or autism symptoms on the ADOS in the ASD group. Similar patterns between early RSB with objects and outcome on the MSEL were noted in the combined ASD and DD groups. The relationship between RSB with objects and nonverbal DQ remained significant ($pr$=.25; $p$<.05) even when controlling for developmental level on the symbolic composite. In the combined ASD and DD groups, small to moderate significant correlations were observed between RSB with objects in the second year and RRB and SA symptoms in the fourth year, as well as a significant moderate correlation between RSB with body in the second year and RRB on the ADOS in the fourth year. When controlling for developmental level on the symbolic composite, correlations remained significant between RSB with objects and SA on the ADOS ($pr$=.35; $p$<.01) and between RSB with body and RRB on the ADOS ($pr$=.31; $p$<.01). The correlation between RSB with objects and RRB was no longer significant ($pr$=.19) and the correlation between RSB with body and SA symptoms remained largely unchanged

(*pr*=.15). No significant correlations were observed between RSB with objects or body and the VABS adaptive behavior composite in the combined group of children with communication delays.

## Discussion

The purpose of this study was to examine RSB in children with ASD between 18 and 24 months of age compared to children with TD matched individually on age and gender, and children with DD matched groupwise on age and developmental level, as well as the concurrent and predictive relations between RSB and indices of developmental and social functioning. Frequency and duration of three categories of RSB were examined: RSB with objects, RSB with body, and sensory behaviors.

### RSB in the Second Half of the Second Year of Life

The findings of this study indicated that children with ASD demonstrated significantly higher frequency and longer duration of RSB with objects and RSB with body with moderate to large effect sizes, and of sensory behaviors with small effects, compared to children in both the TD and DD groups. These findings confirm and extend the findings of previous studies (Wetherby et al., 2004; Werner et al., 2005; Mooney et al., 2006; Honey et al., in press) by documenting group differences in RSB in children with ASD in a larger sample under two years of age using more precise measures of RSB based on direct observation. The findings contrast with those of previous studies using the ADI-R at 20-months of age (Cox et al., 1999) and analysis of home videotapes of 24-month-olds (Werner & Dawson, 2005). The contrasting findings could be due to the larger sample size, more precise observational measures, and the systematic sampling procedures used in this study.

Examination of group means for individual behaviors revealed a subset of RSB with objects that appeared to distinguish the ASD group from that of the DD or TD groups. These included repetitively banging or tapping objects on a surface, rocking or flipping objects back and forth, swiping objects away repetitively, spinning, wobbling, or rolling objects, moving or placing objects in a stereotypical manner or place, and clutching objects for longer than expected. RSB with body that distinguished the ASD group included more repetitive banging of the table surface, rubbing the body, and stiffening or posturing of the hands and fingers. These findings suggest that these particular RSB in children between 18 and 24 months displayed in a structured observation such as the CSBS Behavior Sample may be important early red flags of ASD. These findings have important implications for the utility of using measures of RSB as early indicators of ASD along with social and communication impairments. However, the precise measures of RSB afforded by the Observer© coding software in this study do not translate easily into a clinical tool. Further efforts are needed to develop and validate a tool that could capture the behaviors measured in this study in a more efficient and clinically feasible way.

The findings of this study suggest that in this sample of children, sensory behaviors were not clearly related to repetitive behaviors with objects or body. This is in contrast to studies measuring RSB using parent report such as the ADI, where performance on the item *unusual sensory interests* tends to cluster with items related to repetitive use of objects and body even in children as young as 24 months (Honey et al., in press). There are a variety of possible reasons this relationship may not have been observed in this study, including the fact that sensory behaviors were low in frequency and posed some difficulties for reliable coding. It is possible that the sampling context did not lend itself to the occurrence of many sensory behaviors and so this aspect is worthy of future research using alternative sampling methods. It is also possible that sensory behaviors may not occur in children this young with sufficient

frequency for analysis as compared to children older than 24 months. Sensory behaviors therefore remain an important area for future investigations.

While there were significant group differences in RSB, it is noteworthy that children with TD also demonstrated many of the behaviors coded in the study, albeit with lower frequency and duration. The presence of RSB in the group of TD children extends existing descriptions of rhythmic motor behaviors in typically developing infants in the first year (Thelen, 1979) as well as repetitive behaviors in typically developing preschoolers based on parent report (Evans et al., 1997). A clear trend in Thelen's longitudinal data was that while the overall frequency of stereotyped behavior decreased after 42 weeks of age, the number of different stereotypies continued to increase over the first year (Thelen, 1979). In addition, she noted that "in the second half of the first year the presence of an object in the infant's hand was a potent releaser of bouts of rhythmical arm movements" (p. 7). The findings in the present study suggest that this statement is still true to some extent even at the end of the second year of life in TD children, evident particularly in the shaking and banging of objects in this standardized semi-structured clinical setting. The mean frequencies and durations provide precise quantitative data regarding RSB in TD children to which behaviors in clinical populations can be compared in the context of the CSBS Behavior Sample.

### Relationship with Developmental Level and Social Symptoms

With regard to the relationship between RSB and developmental level, clear patterns were observed in this sample. RSB with objects but not body were significantly negatively correlated with developmental level both concurrently in the second year as well as predictively with developmental outcomes at three years of age. This is in contrast to numerous previous studies (Mooney et al., 2006; Lord & Pickles, 1996; Bishop et al., 2006; Charman et al., 2005) but supports the recent findings of Honey et al. (in press). Although these correlations were small to medium in size in this study, the potential implications of these relations are important to consider. It is possible, as Bishop et al. (2006) suggested that overall developmental level may drive the appearance of RSB initially. However, over time, it is possible that the prolonged engagement with RSB across the crucial developmental period of the second and third years of life may interfere with learning opportunities and thus have a cumulative detrimental impact on developmental outcomes. This could have important intervention implications for children with ASD. Depending on the possible functions of RSB in young children with ASD, increasing appropriate play with objects to replace RSB may be a critical intervention target to optimize developmental outcomes. Potential functions of RSB have not been considered in this study, though theoretically they range from soothing anxiety to communication (Turner, 1999). To date, no research has examined specific RSB triggers in young children with ASD and comparison groups. This is an important direction for future research as it may hold valuable implications for intervention targets.

Changes in the relationship between symptom domains with age is an important issue to consider in light of limited knowledge and theories on the ontogeny of core deficits in very young children with ASD. With regard to the concurrent relations between RSB and social symptoms of ASD, again RSB with objects showed significant correlations with social skills in the second year; however, this relationship was not observed when controlling for concurrent developmental level. Therefore, the relationship between RSB and social skills appeared to be mediated by developmental level in this group of children. However, the predictive relationship between early RSB with objects and social symptoms on the ADOS at three was significant even controlling for developmental level in the second year. Similar to the potential impact of early RSB on developmental outcomes, it is possible that prolonged repetitive engagement with objects may hinder the already compromised development of social skills over the third

year of life. This is consistent with Bopp et al.'s (2005) observation that children with fewer RSB at the onset of intervention showed more progress in social skills over two years.

Both the findings related to group differences and concurrent and predictive relations between RSB and other domains support the utility of measuring RSB in very young children at risk for ASD and underscores the importance of clinical diagnostic tools that measure RSB for children in the second year of life. While a strength of this study is the precise nature of the measures of RSB, they do not translate easily into clinical measures. As mentioned therefore, future research is needed to develop clinical tools to capture this information in a practical yet reliable way. These findings suggest that measures of frequency may be sufficient to detect group differences and that duration measures are fairly consistent with frequency measures of RSB in children at this young age.

### Strengths, Limitations, and Conclusions

Methodological strengths of the study included careful matching of all groups on chronological age, as well as on developmental level for the ASD and DD groups. In addition, systematic sampling procedures appropriate for young children with and without developmental delays were used to avoid confounds associated with the use of home videotapes and parent report to measure RSB. The use of direct and independent measures of RSB rather than scores which have contributed to diagnosis or group membership, such as the ADI-R is also a strength of this study. However, the results of this study need to be considered in light of a number of limitations. One limitation was the small size of the DD group in relation to the ASD and TD groups. In addition, due to the exploratory nature of this study, the potential for Type 1 error was not controlled for in the study. Therefore some spurious results may have been present simply due to the number of statistical analyses. However, it is unlikely that relationships were missed due to lack of power. Low baserate of behaviors led to some difficulties in reliability of coding, mainly in the sensory category and these results need to be considered with caution. In addition, the method of construction of the composite RSB scores admittedly may have capitalized on chance findings in this sample of children. Therefore replication is critical.

Frequency and duration of RSB with objects, RSB with body, and sensory behaviors were significantly greater in children with ASD between 18 and 24 months compared to matched DD and TD groups. RSB with objects was related to developmental level concurrently and predictively to three years of age in both children with ASD and the combined group of children with communication delays. In this larger group, early RSB also predicted severity of autism symptoms at three years of age. These findings provide evidence that the RSB domain is a core deficit of ASD by late in the second year of life and is an important diagnostic feature to consider at this young age. They also add small pieces to the puzzle of characterizing the ontogeny of autism symptoms and their developmental relationships in very young children.

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**Table 1**

Summary of Participant Demographics

| Demographic | ASD (*n* =50) | | DD (*n* =25) | | TD (*n* =50) | | *F* value | Pairwise *p*-value | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | ASD-DD | ASD-TD |
| Parent's education in years completed | | | | | | | | | |
| Mother (*M, SD*) | $15.48_a$ | 2.08 | $15.22_a$ | 2.47 | $15.19_a$ | 2.25 | 0.24 | .959 | .883 |
| Father (*M, SD*) | $15.73_a$ | 2.52 | $15.52_a$ | 2.71 | $15.40_a$ | 2.57 | 0.22 | .986 | .883 |
| Parent's age at child's birth in years | | | | | | | | | |
| Mother (*M, SD*) | $31.19_a$ | 4.93 | $31.94_a$ | 6.37 | $31.24_a$ | 5.56 | 0.13 | .943 | .999 |
| Father (*M, SD*) | $32.99_a$ | 6.82 | $35.91_a$ | 5.50 | $33.71_a$ | 6.04 | 1.95 | .162 | .929 |
| Males (%) | 86.0 | | 76.0 | | 86.0 | | | | |
| First born (%) | 44.0 | | 36.0 | | 38.0 | | | | |
| Ethnicity (%) | | | | | | | | | |
| Caucasian | 72.0 | | 68.0 | | 84.0 | | | | |
| African American | 16.0 | | 20.0 | | 14.0 | | | | |
| Hispanic | 8.0 | | 8.0 | | 2.0 | | | | |
| Asian | 4.0 | | 4.0 | | 0.0 | | | | |

*Note:* Means in the same row with different subscripts differ significantly at $p < .05$ on the post-hoc Dunnet *T3* comparison. *F*-values are Welch corrected when necessary for violation of homogeneity of variance as assessed by Levene's test.

**Table 2**

Summary of Developmental Characteristics on second and fourth year measures

| Characteristic | ASD (*n*=50) | | DD (*n*=25) | | TD (*n*=50) | | | Pairwise *p*-value | |
|---|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *F* value | ASD-DD | ASD-TD |
| CSBS DP behavior sample[d] in the second year | | | | | | | | | |
| Age in months | $21.29_a$ | 1.92 | $20.64_a$ | 1.56 | $21.07_a$ | 1.75 | 1.23 | .321 | .911 |
| Social composite | $5.00_a$ | 2.36 | $7.92_b$ | 3.21 | $11.38_c$ | 2.57 | $82.77^{***}$ | .001 | .000 |
| Speech composite | $5.82_a$ | 2.62 | $7.16_a$ | 2.59 | $10.26_b$ | 2.43 | $39.86^{***}$ | .116 | .000 |
| Symbolic composite | $5.82_a$ | 3.07 | $6.52_a$ | 2.60 | $10.96_b$ | 2.56 | $48.77^{***}$ | .661 | .000 |
| Total | $73.88_a$ | 12.62 | $81.64_b$ | 11.86 | $102.54_c$ | 11.26 | $75.77^{***}$ | .035 | .000 |
| Mullen scales of early learning[e] in the fourth year | | | | | | | | | |
| Age in months | $38.98_a$ | 9.83 | $35.85_a$ | 6.11 | $35.45_a$ | 5.42 | 1.23 | .258 | .085 |
| Nonverbal DQ | $76.00_a$ | 25.81 | $84.48_a$ | 20.12 | $114.08_b$ | 17.48 | $44.45^{***}$ | .325 | .000 |
| Verbal DQ | $68.00_a$ | 31.11 | $77.26_a$ | 21.04 | $108.93_b$ | 15.52 | $46.96^{***}$ | .345 | .000 |
| Vineland adaptive behavior scales[f] in the fourth year | | | | | | | | | |
| Age in months | $43.18_a$ | 14.48 | $47.04_a$ | 14.48 | | | 1.28 | .284 | |
| Communication | $75.88_a$ | 19.25 | $81.88_b$ | 16.99 | | | $4.49^{*}$ | .015 | |
| Daily living | $73.00_a$ | 12.86 | $83.08_b$ | 20.13 | | | $4.30^{*}$ | .017 | |
| Social | $74.79_a$ | 16.47 | $84.72_b$ | 17.12 | | | $3.77^{*}$ | .028 | |
| Motor | $78.96_a$ | 13.76 | $79.20_a$ | 26.28 | | | 0.27 | .765 | |
| Adaptive Behavior | $71.00_a$ | 14.02 | $79.08_b$ | 20.08 | | | $3.99^{*}$ | .023 | |

*Note:* Means in the same row with different subscripts differ significantly at $p < .05$ on the post-hoc Dunnet *T3* comparison; *F*-values are Welch corrected when necessary for violation of homogeneity of variance as assessed by Levene's test.

[d] Standard Scores based on a *M* of 10 and *SD* of 3 for the Composite and *M* of 100 and *SD* of 15 for the Total.

[e] Developmental Quotients (DQ) based on age equivalent divided by chronological age multiplied by 100

[f] Standard Scores based on a *M* of 100 and *SD* of 15.

$^{*}p < .05$

$^{**}p < .01$

*** $p < .001$

**Table 3**

Operational Definitions of Repetitive and Stereotyped Behaviors (RSB)

| Category of RSB | Operational Definitions |
|---|---|
| ***RSB with Objects*** | |
| Bangs/Taps | makes contact between one object with another object or between an object and a surface |
| Rocks/Flips | tilts the vertical axis of an object back and forth in a trajectory of at least 30° or rotates the vertical axis 180° or 360° at least 3 consecutive times |
| Swipes | strikes an object or group of objects in a back and forth motion in an effort to move the object(s) 3 consecutive times with no interceding action |
| Rubs/Squeezes | manipulates an object by rubbing or squeezing it or part of the object 3 consecutive times or moves the object back and forth on the table in a rubbing or pushing motion at least 3 consecutive times |
| Lines up/Stacks | moves at least 3 objects consecutively into a line or stack with no other actions interceding |
| Collects | holds or gathers 3 or more objects at one time for at least 3 seconds, in one or both hands, under the arm, in a pile, or collecting them in a container such as the bowl, cup, or jar |
| Spins/Wobbles | rotates or turns an object around a vertical axis |
| Rolls | knocks an object over or sets it down and rotates it around a horizontal axis so that it rolls; |
| Moves/Places | moves or deliberately places an object to the same side or unique location on the table, floor, or in the lap in the same way repeatedly three or more times across the entire sample |
| Clutches | holds onto an object from the previous activity and does not release the object easily with either offer of a new object or an attempt by an adult to remove the object |
| ***RSB with Body*** | |
| Bangs Surface | bangs or taps hand/arm against a surface, such as the table or body, while not holding an object |
| Pats Body | pats, taps, or smacks with a clear up-and-down movement releasing and contacting the body with one or more fingers of one or both hands or in a flicking motion away from the body |
| Rocks/Swivels | moves the trunk back and forth or swivels the body from left to right or vice versa in the seat in the same way 3 consecutive times |
| Flaps | moves the hand, wrist, or arm up-and-down at least 3 consecutive times while not holding any object; may be oriented horizontally or vertically |
| Rubs Body | rubs hands on any part of the body back and forth three times or 3 rubs in one direction in which the hand or finger(s) is lifted between rubs |
| Stiffens | postures or stiffens the fingers, hand, or arm, usually with the fingers spread or fist clenched |
| ***Sensory Behaviors*** | |
| Licks | moves the tongue toward an object or surface (including the body) with visible contact |
| Sniffs/Smells | lifts an object to the nose to sniff it, or bends the head to a surface or object to sniff it |
| Feels/Touches | places any part of the skin other than the hand against an object to feel it e.g., picks up an object and rubs it against the cheek |
| Fixates Gaze | fixates gaze on, or visually examines an object held to the side or held very close to the eyes |
| Covers Ears | holds both hands over the ears in response to an environmental sound or potential for sound, such as when watching the balloon being inflated |
| Sucks Fingers | puts one or more fingers or thumb in the mouth for any period of 5 seconds or longer |

**Table 4**

Mean Frequencies of Individual Repetitive and Stereotyped Behaviors Across Groups

| RSB Item | ASD (*n*=50) | | DD (*n*=25) | | TD (*n*=50) | | Pairwise effect size (*d*)[a] | |
|---|---|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* | ASD-TD | ASD-DD |
| ***RSB with objects*** | | | | | | | | |
| Bang/Taps | 3.90 | 5.20 | 1.80 | 1.78 | 2.54 | 2.97 | 0.33 | 0.60 |
| Rocks/Flips | 0.74 | 1.19 | 0.36 | 0.57 | 0.20 | 0.54 | 0.62 | 0.43 |
| Shakes | 1.84 | 2.97 | 2.24 | 2.91 | 1.3 | 1.84 | 0.22 | −0.14 |
| Swipes | 0.52 | 1.28 | 0.12 | 0.44 | 0.02 | 0.14 | 0.70 | 0.47 |
| Rubs/Squeezes | 0.32 | 0.77 | 0.24 | 0.52 | 0.16 | 0.42 | 0.27 | 0.12 |
| Linesup/Stacks | 0.00 | 0.00 | 0.08 | 0.28 | 0.08 | 0.44 | −0.36 | −0.57 |
| Collects | 0.28 | 0.83 | 0.12 | 0.44 | 0.20 | 0.57 | 0.11 | 0.25 |
| Spins/Wobbles | 0.98 | 2.75 | 0.04 | 0.20 | 0.08 | 0.34 | 0.58 | 0.64 |
| Rolls | 0.22 | 0.68 | 0.24 | 1.20 | 0.00 | 0.00 | 0.65 | −0.02 |
| Moves/Places | 0.42 | 1.26 | 0.32 | 1.15 | 0.02 | 0.14 | 0.57 | 0.08 |
| Clutches | 1.26 | 2.63 | 0.20 | 0.71 | 0.48 | 1.33 | 0.39 | 0.63 |
| ***RSB with body*** | | | | | | | | |
| Bangs Surface | 1.88 | 3.81 | 0.52 | 1.19 | 0.28 | 0.83 | 0.69 | 0.54 |
| Pats Body | 0.10 | 0.30 | 0.08 | 0.28 | 0.02 | 0.14 | 0.36 | 0.07 |
| Rocks/Swivels | 0.10 | 0.42 | 0.04 | 0.20 | 0.10 | 0.46 | 0.00 | 0.19 |
| Flaps | 0.70 | 1.72 | 1.12 | 2.65 | 0.40 | 1.47 | 0.19 | −0.19 |
| Rubs Body | 0.50 | 1.45 | 0.04 | 0.20 | 0.24 | 0.48 | 0.27 | 0.56 |
| Stiffens | 0.78 | 2.02 | 0.12 | 0.44 | 0.18 | 0.56 | 0.47 | 0.54 |
| ***Sensory Behaviors*** | | | | | | | | |
| Licks | 0.08 | 0.27 | 0.20 | 0.58 | 0.02 | 0.14 | 0.29 | −0.28 |
| Sniffs/Smells | 0.00 | 0.00 | 0.04 | 0.20 | 0.00 | 0.00 | 0.00 | −0.40 |
| Feels/Touches | 0.18 | 0.77 | 0.04 | 0.20 | 0.02 | 0.14 | 0.35 | 0.29 |
| Fixates | 0.12 | 0.44 | 0.04 | 0.20 | 0.02 | 0.14 | 0.34 | 0.25 |
| Covers Ears | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sucks Fingers | 0.64 | 2.21 | 0.12 | 0.33 | 0.20 | 0.76 | 0.30 | 0.41 |

[a] Effect size based on Cohen's $d \geq .20$ is small, .50 is medium, and .80 is large

**Table 5**

Mean Duration in Seconds of Individual Repetitive and Stereotyped Behaviors across Groups

| RSB Item | ASD (*n*=50) | | DD (*n*=25) | | TD (*n*=50) | | Pairwise effect size (*d*)[a] | |
|---|---|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* | ASD-TD | ASD-DD |
| ***RSB with objects*** | | | | | | | | |
| Bang/Taps | 12.21 | 16.43 | 4.12 | 4.46 | 6.39 | 8.92 | 0.46 | 0.77 |
| Rocks/Flips | 5.01 | 10.29 | 3.13 | 6.68 | 0.78 | 2.26 | 0.67 | 0.22 |
| Shakes | 10.68 | 41.18 | 5.06 | 7.58 | 2.67 | 4.04 | 0.35 | 0.23 |
| Swipes | 1.91 | 5.48 | 0.43 | 1.89 | 0.22 | 1.58 | 0.48 | 0.40 |
| Rubs/Squeezes | 2.91 | 10.79 | 2.12 | 6.90 | 0.66 | 2.01 | 0.35 | 0.09 |
| Linesup/Stacks | 0.00 | 0.00 | 0.44 | 1.74 | 0.47 | 3.01 | −0.31 | −0.51 |
| Collects | 2.88 | 7.86 | 0.55 | 1.97 | 1.80 | 6.54 | 0.15 | 0.47 |
| Spins/Wobbles | 5.57 | 18.53 | 0.41 | 2.05 | 0.35 | 1.83 | 0.51 | 0.50 |
| Rolls | 1.61 | 4.70 | 0.37 | 1.87 | 0.00 | 0.00 | 0.69 | 0.38 |
| Moves/Places | 0.74 | 2.32 | 0.71 | 3.24 | 0.04 | 0.28 | 0.54 | 0.01 |
| Clutches | 13.86 | 31.30 | 1.16 | 5.30 | 7.87 | 22.00 | 0.22 | 0.69 |
| ***RSB with body*** | | | | | | | | |
| Bangs Surface | 4.03 | 8.33 | 1.02 | 2.47 | 0.63 | 1.97 | 0.66 | 0.56 |
| Pats Body | 0.22 | 0.72 | 0.23 | 0.80 | 0.03 | 0.18 | 0.42 | −0.01 |
| Rocks/Swivels | 0.49 | 2.05 | 0.10 | 0.49 | 0.43 | 2.51 | 0.03 | 0.31 |
| Flaps | 1.44 | 3.40 | 3.35 | 9.83 | 1.16 | 4.28 | 0.07 | −0.29 |
| Rubs Body | 2.71 | 7.74 | 0.50 | 2.48 | 1.76 | 4.32 | 0.16 | 0.43 |
| Stiffens | 2.17 | 5.02 | 1.62 | 7.71 | 0.36 | 1.39 | 0.56 | 0.09 |
| ***Sensory behaviors*** | | | | | | | | |
| Licks | 0.10 | 0.37 | 0.46 | 1.84 | 0.02 | 0.15 | 0.31 | −0.33 |
| Sniffs/Smells | 0.00 | 0.00 | 0.10 | 0.52 | 0.00 | 0.00 | 0.00 | −0.38 |
| Feels/Touches | 0.49 | 2.10 | 0.13 | 0.66 | 0.05 | 0.34 | 0.36 | 0.26 |
| Fixates | 0.28 | 1.05 | 0.07 | 0.34 | 0.04 | 0.28 | 0.36 | 0.30 |
| Covers Ears | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Sucks Fingers | 7.47 | 23.81 | 1.39 | 4.23 | 1.71 | 7.27 | 0.37 | 0.43 |

[a] Effect size based on Cohen's $d \geq .20$ is small, .50 is medium, and .80 is large

**Table 6**

Frequency and Duration of Repetitive and Stereotyped Behaviors Across Groups

| | ASD (*n*=50) | | DD (*n*=25) | | TD (*n*=50) | | One-tailed contrasts | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASD-TD | | ASD-DD | |
| **RSB Measure** | **Mean** | ***SD*** | **Mean** | ***SD*** | **Mean** | ***SD*** | ***p*** | ***d*** [a] | ***p*** | ***d*** [a] |
| RSB with objects | | | | | | | | | | |
| Frequency | 8.04 | 6.18 | 3.08 | 2.61 | 3.34 | 3.18 | .000 | 1.00 | .000 | 1.13 |
| Duration (s) | 40.90 | 39.88 | 10.32 | 11.31 | 15.65 | 23.72 | .000 | 0.79 | .000 | 1.19 |
| RSB with body | | | | | | | | | | |
| Frequency | 3.16 | 4.64 | 0.68 | 1.22 | 0.70 | 1.23 | .001 | 0.84 | .001 | 0.85 |
| Duration (s) | 8.91 | 12.18 | 3.14 | 8.10 | 2.75 | 5.18 | .001 | 0.71 | .009 | 0.57 |
| Sensory Behaviors | | | | | | | | | | |
| Frequency | 0.94 | 2.55 | 0.20 | 0.50 | 0.24 | 0.77 | .034 | 0.42 | .027 | 0.49 |
| Duration (s) | 8.23 | 24.34 | 1.59 | 4.47 | 1.80 | 7.26 | .040 | 0.41 | .033 | 0.46 |

Note. *p* -values reflect planned one-tailed contrasts between the ASD group and the other two groups respectively

[a] Effect size based on Cohen's $d \geq .20$ is small, .50 is medium, and .80 is large

**Table 7**

Correlations between Repetitive and Stereotyped Behaviors in the Second Year and Second and Fourth Year Measures

| | Second Year Concurrent Measures | | Fourth Year Outcome Measures | | | | |
|---|---|---|---|---|---|---|---|
| | CSBS Composite | | MSEL | | VABS | | ADOS |
| | Symbolic | Social | NVDQ[a] | VDQ[b] | ABC[c] | RRB[d] | Social Affect |
| **Second year measures** | **ASD group (*n* = 50)** | | | | **ASD group (*n*= 46)** | | |
| RSB with objects | −.31* | −.31* | −.38* | −.33* | −.03 | .03 | .19 |
| RSB with body | −.23 | −.21 | −.20 | −.09 | .05 | .28 | .04 |
| | ASD and DD groups (*n* =75) | | | | ASD and DD groups (*n* =71) | | |
| RSB with objects | −.24* | −.35** | −.34** | −.30* | −.12 | .26* | .41*** |
| RSB with body | −.20 | −.23* | −.21 | −.10 | −.05 | .36** | .19 |

Note: Correlations are Pearson partial correlation coefficients controlling for age

[a] Nonverbal developmental quotient;

[b] Verbal developmental quotient;

[c] Adaptive Behavior Composite;

[d] Restricted Repetitive Behaviors

* $p < .05$,

** $p < .01$,

*** $p < .001$