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Repetitive and Stereotyped Movements in Children with Autism Spectrum Disorders Late in the Second Year of Life

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Abstract

Objectives—The purpose of this study was to examine group differences and relationships with later developmental level and autism symptoms using a new clinical tool developed to measure repetitive and stereotyped movements (RSM) in young children.

Method—Videotaped behavior samples using the Communication and Symbolic Behavior Scales Developmental Profile (CSBS; Wetherby & Prizant, 2002) were coded for 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.

Results—Children with ASD demonstrated significantly higher rate and larger inventory of RSM with objects and body during a systematic behavior sample than both the DD and TD groups. Measures of RSM were related to concurrent measures of social communication and predicted developmental outcomes and autism symptoms in the fourth year for the ASD group. None of the correlations between RSM and autism symptoms remained significant when controlling for CSBS Symbolic level. RSM with objects predicted unique variance in the severity of autism symptoms in the fourth year beyond that predicted by social communication measures alone.

Conclusions—This study provides support for the diagnostic significance of RSM in children under 24 months of age and documents the utility of this RSM measurement tool as a companion to the CSBS.

Introduction

The third diagnostic domain of autism spectrum disorders (ASD) is restricted repetitive and stereotyped patterns of behavior, interests, and activities (American Psychiatric Association, 2000). While a growing body of literature has examined the construct of repetitive behaviors, very few studies have addressed repetitive behaviors in children under 24 months of age. Turner (1999) first introduced the notion of two primary categories of repetitive behavior including “lower order” behaviors characterized by repetitive movements with objects and body and “higher order” behaviors characterized by object attachments, insistence on sameness, circumscribed interests, and repetitive language. Turner hypothesized that lower order repetitive behaviors were related to lower developmental levels whereas higher order behaviors are associated with higher cognitive levels and some may be specific to ASD in terms of their prevalence and severity.

Presence of Repetitive Behavior in Young Children

Social communication deficits have been identified as reliable and distinguishing characteristics of ASD in very young children (Stone et al., 1999; Wetherby et al., 2007). In

contrast, extant research has suggested that repetitive behaviors may not be present or fully developed until at least three years of age (Lord, 1995; Moore & Goodson, 2003; Stone et al., 1999). A number of studies have utilized retrospective parent report from the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, LeCouteur, 1994) to provide preliminary clues as to the development of repetitive movements and whether these behaviors distinguish young children with ASD. Parent report studies have indicated that repetitive behaviors generally increase from age two to four (Cox et al., 1999; Moore & Goodson, 2003; Stone et al., 1999). Cox et al. (1999) reported on ADI-R results for 21 children with ASD at 20 months of age and found that none of the Restricted, Repetitive Behaviors (RRB) items on the ADI distinguished the children with ASD from children with language delays or TD at this young age. Werner and colleagues (2005) utilized retrospective parent report to investigate the emergence of behaviors in the three domains from birth to two years in 3- to 4-year-old children with ASD ($n=72$), DD ($n=34$), and TD ($n=39$). Compared to the DD and TD groups, children with ASD had significantly higher social symptoms at 13–15 months, repetitive behavior at 16–18 months, and communication symptoms at 19–21 months. These discrepancies indicate a need to further characterize repetitive behavior in young children. Richler et al. (2007) also utilized the ADI-R to examine prevalence and severity of RRB in 192 children with ASD compared to children with DD and TD at age two. They reported that children with ASD presented with significantly more repetitive behavior and with a greater level of severity than both children with DD and TD. Watson et al. (2007) utilized the *First Year Inventory – Retrospective Version (FYI-R)* to estimate characteristics of ASD at 12 months in children ranging in age from 14 to 73 months. Out of 11 items related to repetitive behavior, differences in 3-year-old children with ASD ($n=38$) were detected on 8 items compared to TD ($n=40$) but differences between the ASD and DD ($n=15$) group were detected on only two items, repetition of a simple activity and interest in playing with a part of a toy. The discrepancies in findings based on parent report indicate the need to obtain measures of repetitive behavior through direct observation, particularly for children under 24 months of age.

Studies using home videotapes as a primary data source have provided little indication that repetitive behavior is an important discriminating variable in children under two. In a retrospective study using home videos of children 9–12 months of age, Baranek (1999) did not find object or body stereotypies to distinguish 11 children with ASD from children with developmental delay (DD) or typical development (TD), with the exception of excessive mouthing. Osterling, Dawson, & Munson (2002) examined home videotapes of first birthday parties of 20 children with ASD and found differences in repetitive behavior between ASD and TD groups but not between ASD and DD groups. In a study of home videotapes of first and second birthday parties with 21 children with ASD, Werner and Dawson (2005) did not find significant group differences in duration of repetitive behavior compared to toddlers with typical development at either age.

Several studies have documented significant differences in repetitive behavior using systematic observation in young children with ASD compared to children with DD and TD in the second year. These studies have examined repetitive behavior as a subset of behaviors in this domain that include repetitive movements with objects reflecting an intense focus, restricted interest, difficulty changing activities, or preoccupation with a part of an object, as well as stereotyped and repetitive motor mannerisms. For this discussion and the purposes of the present study we will refer to these repetitive behaviors as repetitive and stereotyped movements (RSM). In a recent pilot study, Loh et al. (2007) examined RSM using standardized observational assessments at 12 and 18 months in 8 infant siblings of children with ASD, compared to 9 nondiagnosed siblings, and 15 TD controls. They found that the ASD group showed more arm waving than the TD group at 12 months and both the TD and DD groups at 18 months. In addition, the ASD group showed more putting hands to ears than the TD group at 12 and 18 months. Overall, they found considerable overlap in the repertoires of RSM in these groups at

this young age, however these data should be viewed with caution due to the small sample size. Utilizing a prospective observational design, Wetherby and colleagues (2004) documented the presence of RSM in the second year in the majority of 18 children later diagnosed with ASD, compared to 18 with DD and 18 with TD. Using the Systematic Observation of Red Flags of ASD (SORF) which employs ordinal ratings of behaviors from 0 to 2, Wetherby et al. (2004) found two red flags related specifically to RSM, repetitive movements with objects and repetitive movements with body, which distinguished children with ASD from both DD and TD.

Watt and colleagues (Watt, 2006; Watt et al., 2007) confirmed and extended these findings in a larger sample of children with ASD ($n=50$), DD ($n=25$), and TD ($n=50$) between 18–24 months of age, which included the 18 children with ASD studied by Wetherby et al. (2004). CSBS behavior samples were coded using the Noldus Pro Observer[®] software which allowed for precise temporal tagging to examine frequency and duration of RSM. Watt investigated specific forms of RSM within three categories. Children with ASD demonstrated significantly higher rates and duration of RSM with objects, RSM with body, and sensory behaviors than both TD and DD groups. RSM with objects revealed the largest effect sizes.

RSM and Relations with Diagnostic Outcome and Developmental Level

Because it has been established that RSM may reliably discriminate young children with ASD using systematic observation, it is important to investigate the relationship between RSM and diagnostic outcome. Mooney, Gray, and Tonge (2006) studied 40 children with ASD ranging from 22 to 51 months of age compared to 15 children with DD. They found that repetitive behaviors measured concurrently were significantly positively associated with the probability of receiving a diagnosis of autism and were not associated with overall developmental level. This finding is supported by a recent report by Lord et al. (2006) indicating that scores on the repetitive behavior items of the ADI-R at age two significantly predicted diagnostic outcome at age 9. Charman and colleagues (2005) studied prospectively a group of children with ASD who were assessed at 2, 3, and 7 years of age. Parent report of RSM at two years of age showed no relationship to developmental outcome at three or seven years.

Because parent report studies have indicated that RSM generally increase from age two to four (Cox et al., 1999; Moore & Goodson, 2003; Stone et al., 1999), it is important to examine how the associations between RSM and developmental level may change with chronological age. Using the ADI-R, Bishop, Richler, and Lord (2006) studied a sample of 830 children with ASD, with 236 of the children ranging from 15 to 36 months and the rest over 36 months. Consistent with Mooney et al., they found that RRB were not associated with overall developmental level in children less than 36 months of age. It is noteworthy that the relationship between nonverbal IQ and RSM became more pronounced with age and was strongly related in older children. Although relationships between RSM and developmental level have been reported in children who are older than 36 months, this relationship has been indicated in younger children with ASD in one study to date. In the prospective observational study mentioned previously, Watt et al. (2007) reported significant moderate correlations between RSM with objects in the second year and developmental level in the fourth year for a group of children with ASD and a combined group of children with ASD and DD. These correlations did not remain significant when controlling for developmental level. RSM with objects in the second year were also correlated with autism symptoms in the fourth year.

Turner (1999) proposed that RSM are closely related to developmental level and described categories of repetitive behavior in which to examine this relationship. This association has been demonstrated in several studies of RSM utilizing parent report. For individuals ranging from 3 to 21 years of age ($N=292$), Cucarro et al. (2003) conducted a principal components analysis and found that lower order RSM were related to adaptive behavior scores. In contrast,

the higher order repetitive behaviors were less clearly associated with adaptive functioning. Bishop et al. (2006) also used parent report to provide further support for classes of repetitive behaviors in children under 12 years of age. They reported that prevalence of most lower order behaviors was negatively associated with nonverbal IQ whereas certain behaviors, such as circumscribed interests, showed a positive correlation with nonverbal IQ. Moore and Goodson (2003) reported that two- and three-year-old children with ASD presented greater severity with respect to lower order repetitive behaviors including hand mannerisms and repetitive use of objects. Higher order repetitive behaviors such as compulsions, rituals, and unusual preoccupations were infrequent according to parent report. Richler and colleagues (2007) recently reported that behaviors loading on a repetitive sensorimotor factor were more common and severe in children with ASD than compared to children with DD and TD under three years of age. The factor representing insistence on sameness (i.e. higher order behaviors) were less prevalent and did not differentiate diagnostic groups. These studies have provided consistent information about the negative relation of lower order RSM to developmental level in children over three years of age. This relation has not been examined in children under two.

Use of the CSBS in the Study of RSM

The CSBS behavior sample employs a standard but flexible interactive context. The CSBS is comprised of 14 measures of social communication organized into three composites: social, speech, and symbolic. This measure has been standardized and normed on a national sample with good internal consistency and test-retest stability (Wetherby & Prizant, 2002) as well as good predictive validity with language outcomes at two and three years (Wetherby, Allen, Cleary, Kublin & Goldstein, 2002; Wetherby, Goldstein, Cleary, Allen & Kublin, 2003). The CSBS provides norm-referenced standard scores profiling performance on a collection of typical social communication skills. Wetherby et al. (2007) reported on the CSBS measures of social communication for the same sample of children in the present study. Children with ASD differed significantly from the TD group on all 8 of the items included in the social composite and differed significantly from the DD group on 5 items including: gaze shifts, gaze point/follow, rate of communicating, acts for joint attention, and inventory of gestures. Given the standardization of the CSBS, the findings from both Wetherby et al. (2004) using the SORF scoring and Watt et al. (2007) using the Noldus Observer, the CSBS behavior sample may be well suited for evaluating RSM in young children. Further, the recent report by Watt et al. (2007) of significant moderate correlations between RSM and the social and symbolic composites of the CSBS, indicate that the CSBS may provide a viable context to examine relations among domains of ASD in children under two years of age.

In contrast to the research of Watt et al. (2007) that utilized precise techniques with digital video to measure frequency and duration of RSM, the present study sought to examine RSM in the second year of life utilizing a clinical tool developed as a companion to the CSBS. The coding procedures used in the present study also differ from that of Watt and colleagues in regard to the set of behaviors coded and the use of a scaled measure with a narrower score range. The method of scoring for RSM is simplified in order to enable the coder to make determinations of rate and inventory of behavior on-line or very quickly from a videotape as a clinically feasible tool adapted from the CSBS. The rate measure includes six sampling opportunities during the behavior sample to score the presence of three RSM with body or three with objects for a possible total of 18 for each category, similar to the scoring of rate of communication in the CSBS. The inventory measure is an index of the variety of different RSM that are present during the CSBS. Parallel scoring in the CSBS includes inventories of gestures, sounds, words, and actions.

The purpose of the present study was to examine clinical ratings of RSM in CSBS behavior samples of children 18 to 24 months of age. The specific research objectives were: (1) to

compare the rates and inventories of RSM in children with ASD, DD, and TD using a companion tool to rate RSM from the CSBS; (2) to examine concurrent relations between RSM in the second year and the CSBS social, speech, and symbolic composites of children with ASD; and (3) to examine predictive relations between measures of RSM in the second year, and developmental level and autism symptoms in the fourth year for children with ASD.

Method

Participant Recruitment

Three groups of children 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 ASD group consists of consecutive cases diagnosed from consecutive screens and as noted, was the same as those reported in Watt et al. (2007) and Wetherby et al. (2007). The children reported in Wetherby et al. (2004) are also included in the present sample. The participants were recruited prospectively through the FIRST WORDS® Project screening of a general population sample of children recruited from healthcare and childcare agencies to identify children under two with communication delays using the CSBS (Wetherby & Prizant, 2002). Informed consent was appropriately obtained from all participant parents. All children met the following selection criteria: (1) a CSBS behavior sample was videotaped in the second year of life and (2) a follow-up developmental evaluation was conducted over 24 months of age.

Children with communication delay as determined by the CSBS in the second year were assigned to either the ASD or DD group based on a follow-up evaluation. A follow-up diagnostic evaluation was completed for all children with a communication delay when they were at least 30 months of age by an interdisciplinary team consisting of a licensed speech-language pathologist and psychologist. The team made a *best estimate* diagnosis based on the following measures: a) the *Mullen Scales of Early Learning* (MSEL; Mullen, 1995) to determine nonverbal and verbal developmental level; b) the *Vineland Adaptive Behavior Scales* (VABS; Survey Interview Form; Sparrow, Balla, & Cicchetti, 1984) to provide an index of adaptive behavior; c) a developmental history; d) 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; and e) the *Social Communication Questionnaire* (SCQ; Lifetime Version; Rutter, Bailey, Berument, Lord, & Pickles, 2001) to provide parent report of symptoms of ASD. Earlier CSBS scores were available to the diagnostic team; however they were blind to ratings of RSM.

The team made a *best estimate diagnosis* of Autistic Disorder, Pervasive Developmental Disorder- Not Otherwise Specified (PDD-NOS), or nonspectrum based on the DSM-IV diagnostic criteria (APA, 2000). A diagnosis of Asperger Disorder was not made or ruled out due to the young age of these children. 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 cut-off for autism spectrum; otherwise they were assigned to the DD group. There was only one child who's ADOS scores fell above the autism spectrum cutoff 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.

The DD group was matched group-wise to the ASD group on the CSBS symbolic composite and included a mixture of children with global DD and with specific language, speech, and/or motor delay, in order to match the cognitive level of the ASD group. The TD group was drawn from a pool of children who displayed normal performance on the CSBS during the second

year and on the MSEL during the third year. Additionally, none were suspected of having ASD by the parent or clinician when the MSEL was completed. The TD group was matched individually to the ASD group on sex and chronological age at the time of the behavior sample.

Demographic and Developmental Characteristics

The demographic and developmental characteristics of the three groups are presented in Table 1. All 3 groups were well-matched on mother's and father's education and mother's age, suggesting that groups were comparable on socioeconomic status. There were no significant group differences in age. The ASD group scored significantly lower than the TD group but was well matched with the DD group on the symbolic composite. As expected, the ASD group was significantly different than the TD group on the MSEL nonverbal developmental quotient (NVDQ) and verbal developmental quotient (VDQ). There were no significant differences between the ASD and DD group on NVDQ or VDQ. More than half of the group with ASD was relatively higher functioning (NVDQ > 70) and 38% had a NVDQ below 70. The DD group was comprised of 28% who had a NVDQ below 70, 26% with specific language delay, and 35% with speech and/or fine motor delay.

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 (Gotham, Risi, & Lord, in press). The mean ADOS Social-Affect + Restricted Repetitive Behavior (SA+RRB) 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—The behavior sample employs a standard but flexible interactive structure between the child, clinician, and the child's caregiver. The sample takes approximately 20 minutes to administer and uses communication temptations designed to encourage spontaneous communication, 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. As noted this instrument is norm-referenced and has good internal consistency and test-retest stability (Wetherby & Prizant, 2002) as well as good predictive validity (Watt, Wetherby, & Shumway, 2006; Wetherby et al., 2002; 2003). Internal consistency estimates range from .86 to .89 for the clusters and composite scores respectively, and .90 for the total (Wetherby & Prizant, 2002). The sample was videotaped and scored using the standard procedures by trained examiners blind to diagnosis. Standard scores included the social, speech, and symbolic composites.

Measures of RSM—RSM were coded from the behavior sample videotapes using scoring definitions from the *Repetitive and Stereotyped Movement Scales: Companion to the CSBS* (RSMS; Wetherby & Morgan, 2007). The RSMS was developed as a companion tool to code RSM during the CSBS behavior sample. Definitions of RSM are presented in Table 2. RSM were defined as behaviors that were repetitive (3 or more repetitions or occurred with 3 or more objects) and were not imitations of an adult movement or were not used communicatively (i.e., were not conventional communicative signals such as waving "bye", or signing "more"). These behaviors were selected from a more comprehensive list of possible movements based on preliminary studies documenting the presence of the behaviors and acceptable levels of reliability.

The RSMS differs from the coding system employed by Watt et al. (2007) in several aspects. As mentioned previously, Watt and colleagues utilized the Noldus Observer© technology to calculate total rates and durations for each behavior coded. The RSMS was designed as a clinical tool that can be scored quickly on-line or via videotape. As a result, measures of RSM consisted of rate and inventory, described in detail below. The behaviors coded using the RSMS differ somewhat from those reported by Watt. For example, we did not include RSM with objects such as bang/taps and shakes.

Categories of RSM were organized into two clusters: RSM with body and RSM with objects. These categories were selected based on observations from the SORF as reported in Wetherby et al., 2004. RSM with objects included two sets of behaviors, *Restricted* which reflected a preoccupation in intensity or focus with a restricted interest, and *Sameness* which reflected an insistence on sameness or difficulty with change in activity with respect to objects. Previous studies using the ADI-R have separated out repetitive sensory motor (RSM) behaviors from *insistence on sameness* (Cuccaro et al., 2003; Szatmari et al., 2006). Studies of young children utilizing these factors suggest that RSM behaviors may be more common than *insistence on sameness* behaviors in young children with ASD (Bishop et al., 2006; Richler et al., 2007). Whereas the ADI-R is a comprehensive parent interview aimed at gathering information on all of the features of autism, the brief and structured sampling context of the CSBS imposes some limitations in the likelihood of sampling the full range of RSM, particularly that of the *insistence on sameness* factor. Nonetheless, it is likely that the categories of the RSMS overlap in function with the factors identified by Cuccaro et al., 2003. Consistent with the RSM factor, the cluster RSM with body and the *Restricted* set of RSM with objects may exist for the function of self-stimulation. Likewise, *sameness* in RSM with objects may reflect an aspect of *resistance to change* as reported by Cuccaro wherein the child is attempts to impose order in their environment.

Both rate and inventory of RSM were scored for each behavior. Rate of RSM is measured by documenting the number of RSM up to three per sampling opportunity. The CSBS includes six sampling opportunities to score the presence of up to three RSM with body and/or three RSM with objects for a possible total of 18 for each category. The inventory measure is used to score the variety of different RSM that are present during the CSBS. These measures of RSM were designed and scaled like the social communication measures of the CSBS to be used as a companion tool.

Interobserver agreement

Interobserver agreement was calculated using generalizability (*g*) intraclass correlation coefficients (Bakeman & Gottman, 1997). *G* coefficients have been used as a meaningful indicator of reliability in clinical scoring systems that utilize judgments about of behavior within ongoing interaction (McCathren et al., 2007; Mundy et al., 2003; Stone, 2004; Wetherby et al., 2002). *G* coefficients provide a measure of the source and magnitude variance accounted for by scorer rating and child behavior. *G* coefficients of .6 or greater are considered acceptable for demonstrating interrater reliability (Mitchell, 1979).

Interobserver agreement was calculated on 32 randomly selected samples from all three groups by raters blind to diagnostic classification. Compared to an expert rater, two independent raters demonstrated *g* coefficients of .96 and .93 for rate of RSM body and .94 and .78 for inventory. Coefficients were .95 and .92 for rate of RSM Objects and .81 and .77 for inventory.

Outcome Measures in the Fourth Year

Developmental outcomes were assessed using the MSEL Nonverbal Developmental Quotient (NVDQ) and Verbal Developmental Quotient (VDQ) at 3 years of age. Autism symptoms were

assessed in the fourth year using the ADOS for the ASD and DD groups. The Social Affect (SA)+ RRB revised algorithm scores were calculated (Gotham et al., in press).

Results

Group Differences in RSM Late in the Second Year

A series of one-way analyses of variance (ANOVA) were conducted to evaluate group differences in clusters using a Welch correction and are presented in Table 3. The Welch correction was used to control for violation of the assumption of homogeneity of variance across these groups. Children with ASD demonstrated significantly higher rates and inventories of RSM with body and objects than the TD group and significantly higher inventory of RSM with body and rate and inventory of RSM with objects than the DD group. Medium effect sizes for all measures of RSM with body were detected. Large effect sizes were found for all measures of RSM with objects with the exception of a medium effect for the sameness inventory in the ASD and TD comparison.

The means, standard deviations, and effect sizes of group differences based on Cohen's *d* for the inventory of each RSM item are presented in Table 3. All of the RSM included in the coding system were demonstrated by children in the ASD group; the DD group demonstrated all except rolls, collects, and moves/places, and the TD group demonstrated all except pats body, rolls, and moves/places. Group differences in RSM items based on effect sizes ranged from small to large in the expected direction (i.e., the ASD group had larger mean scores) with a few exceptions. The ASD and DD groups had negligible differences in the use of pats body, swipes, and lines up/stacks. The ASD and TD groups differed on everything except collects. Most of these items were those that were rarely exhibited by children in the study, therefore the lack of detectable differences may be due to a floor effect. For all three groups, RSM with objects were present at a higher rate and with a larger inventory than RSM with body. Interquartile ranges of RSM are presented and indicate a broader dispersion of scores within ASD group for all categories.

Concurrent Relationships between Second Year Measures

Concurrent bivariate correlations between measures of RSM and CSBS composites in the second year were examined for the ASD group alone ($n = 50$) and the ASD and DD groups combined ($n = 75$) allowing for observation of relations specific to children with ASD as well as for the combined group of children with communication delays. First relations among measures of RSM were inspected to evaluate the construct validity of our measures of RSM. No significant correlations were observed between object and body measures of RSM for the ASD group. Small significant correlations were observed between the body inventory and both the sameness inventory ($r = .24$; $df = 72$) and the object cluster ($r = .25$; $df = 72$) for the combined group. Similarly a small significant correlation of $.25$ ($df = 72$) was observed between the intense and sameness object inventories for the ASD and DD group combined.

Concurrent correlations between measures of RSM and CSBS composites are presented in Table 4. Moderate to small significant correlations were observed between CSBS composites and the overall RSM composite for both the ASD group and the ASD and DD groups combined with the strongest negative with the social composite and the weakest with the symbolic. Measures of RSM with body showed several small significant correlations with CSBS composites with two primary patterns of note. First, relations were slightly stronger for the ASD group alone compared to the combined ASD and DD groups. Second, the symbolic composite was the most strongly related measure to RSM with body in both groups. Small to moderate relationships were observed between the CSBS composites and measures of RSM with objects for both the ASD and the combined groups. In contrast to the pattern observed for

RSM with body, relationships between CSBS composites and RSM with objects were slightly weaker for the ASD group alone when compared to the ASD and DD group combined.

Predictive Correlations with Outcome Measures

To examine predictive relations between early RSM and developmental outcomes, bivariate correlations between RSM measures in the second year and NVDQ and VDQ were computed and are presented in Table 5. No significant correlations were found between RSM with body and NVDQ and VDQ in the ASD group alone and the ASD and DD groups combined. Significant small correlations in the negative direction were observed between RSM object cluster and NVDQ and VDQ for the ASD and DD groups combined. The items in the Restricted inventory likely contributed to this relationship, since a small correlation was found between this inventory and both NVDQ and VDQ for the ASD and DD groups combined. For the ASD and DD groups combined, significant correlations between RSM with body and the SA domain of the ADOS was a correlation of .32 ($df=68$) and .26 ($df=68$) for the inventory and cluster respectively. ($df = 44$). Moderate significant correlations were observed between measures of RSM with objects and the SA domain of the ADOS for the ASD and DD groups combined. Small significant correlations were observed between rate of RSM with body, RSM with body cluster, the Restricted inventory of objects, and the RSM composite with the RRB domain of the ADOS for the ASD group only. Small and moderate significant correlations were observed between all measures of RSM and the RRB domain of the ADOS for the ASD and DD groups combined. None of the correlations between the RSMS and the ADOS remained significant when controlling for the CSBS Symbolic standard score.

Prediction of Autism Symptoms at Age 3

A multiple regression analysis was conducted with the ASD and DD groups combined to examine whether CSBS composites and RSM in children with communication delays in the second year contribute significantly to the prediction of ASD symptoms at age 3 and is presented in Table 6. Raw scores were used in this analysis with behavior sample age entered into the model first to control for age. The ADOS SA + RRB score was used as the outcome variable. In each regression the changes in R^2 were calculated at each step. The model with the CSBS composites predicted 32% of the variance in autism symptoms at age 3, which is a medium effect size. The semi-partial correlation squared (sr^2) showed that only the social composite contributed unique significant variance (16%). In the second model, the two RSM clusters were added and found to contribute an additional 13% of variance to the prediction of autism symptoms, which was a significant R^2 change. When the sr^2 was examined with this model, the CSBS social composite and RSM with objects contributed significant unique variance.

Discussion

The purpose of this study was to compare RSM in children with ASD, DD, and TD between 18 and 24 months of age, as well as to examine concurrent and predictive relations between RSM and indices of developmental and social functioning. Inventory and rate of two clusters of RSM were examined: RSM with body and RSM with objects. RSM with objects were further analyzed by examining inventories of behaviors that reflect both restricted interests and insistence on sameness, potentially overlapping in function with factors identified by Cucarro and colleagues (2003). It has been reported that lower order RSM are more prevalent in young children (Bishop et al., 2006; Richler et al., 2007). Although this observation may be accurate, it has also been posited that higher level RRB are associated with higher cognitive levels and that some may be specific to ASD (Turner, 1999) and that these RRB may not differentiate children with autism prior to age three (Rutter et al., 2003; Stone et al., 1999). Therefore it would be informative to examine whether precursors of higher level RRB are present in young

children. We examined the categories of restricted interests and insistence on sameness through the lens of RSM with objects.

Group Differences in RSM in the Second Year of Life

The findings of this study indicated that children with ASD demonstrated significantly higher rates and inventories of RSM with body and objects than children with TD and DD, which supports the validity of the RSMS as a clinical tool to distinguish children with ASD. These results extend the findings of Wetherby et al. (2004), Werner et al. (2005), and Mooney et al. (2006) by documenting group differences in RSM in a larger sample of children with ASD between 18 and 24 months based on systematic observation. The results contrast with the findings of previous studies using the ADI-R at 20 months of age (Cox et al., 1999) and analysis of home videotapes at 24 months (Werner & Dawson, 2005). The contrasting findings may be due to the larger sample size, more precise observational measures, and the systematic sampling methods used. The consistency of these results with the recent findings of Watt et al. (2007), which used even more precise measures of RSM, support the criterion-related concurrent validity of this clinical tool.

Concurrent Relationships between RSM and CSBS Composites

Concurrent bivariate correlations revealed no significant relations among measures of RSM for children with ASD. This provides support for the independence of categories of RSM as measured by the RSMS and gives preliminary evidence as to the construct validity of this measure. Moderate to small significant correlations were observed between RSM with body and objects and concurrent measures of social communication. These effect sizes are consistent with recent findings reported by Watt et al. (2007) utilizing the same sample but more precise coding levels and analyses. An interesting contrast between RSM measures of body and objects were noted in that relations between measures of social communication and RSM with body were slightly stronger for the ASD group whereas relations between social communication and RSM with objects were slightly stronger for the ASD and DD groups combined. Overall the social composite was the most strongly related measure to RSM with body and objects in both groups. For both groups the restricted object inventory displayed the most consistent relationship to the CSBS composite measures. The modest but significant moderate correlations observed in the second year raise questions as to how these social and repetitive behavior domains influence one another in the course of development.

Predictive Relationships between RSM in the Second Year and Outcomes in the Fourth Year

Consistent with the findings reported by Watt et al. (2007), RSM with objects in the second year significantly predicted NVDQ and VDQ in the fourth year for the ASD and DD groups combined. Specifically the rate and the restricted inventory of RSM with objects were negatively correlated with NVDQ and VDQ. These findings should be considered in light of evidence presented by Mooney et al. (2005) in preschoolers and Bishop et al. (2006) in children under 36 months ($n=236$) indicating no association between RSM and developmental level. These contrasts may be explained by differences in measurement and the different relationship that RRB may have with developmental level at different ages. There is evidence to suggest that the relationship between RSM and nonverbal IQ begins at three years and becomes more pronounced with age (Bishop et al., 2006).

In addition, RSM with body in the second year significantly predicted SA and RRB measured on the ADOS in the fourth year. This relation did not remain significant, however when controlling for cognitive level suggesting that the relationship between these domains is mediated by developmental level. The relation between the RSM with objects cluster and SA on the ADOS provides further support for a developmental interaction between the domains

of repetitive behavior and social communication. That is, greater levels of RSM with objects in the second year may be negatively associated with the development of skills in SA domain.

The multiple regression analysis revealed that RSM with objects contributed unique variance to the prediction of autism symptoms in the fourth year, beyond that which is predicted by measures of social communication alone, for a total of 45% predicted variance. This analysis supports the clinical utility of the RSMS as a companion to the CSBS. Although modest in size, the association between social communication and RSM appears to begin early. Therefore, it is important to consider whether RSM may play a contributing role in the development of later social deficits.

Conclusion

The results of this study provide confirmation of the presence of RSM in children with ASD less than 24 months of age. Further, the presence of such behaviors reliably differentiates children with ASD from those with TD and DD within the context of the CSBS behavior sample. The presence of RSM, in addition to delays in social communication, is an important early red flag of ASD in the second year. It is likely that this information, when applied in a clinical context, will add important information to the diagnostic process and improve early identification efforts for children less than 24 months of age.

In addition to contributing to early identification, this measure may provide clues regarding the ontogeny of autism symptoms when examined in relation to other symptom domains. Charman and Swettenham (2001) emphasized the importance of examining clues about the critical role of these domains in the diagnosis of ASD. The concurrent correlations presented in this study reveal moderate negative relations between RSM and social communication measured with the CSBS. This finding, along with predictive relationships between RSM and later autism symptoms, suggests a link between these domains that requires further investigation.

Finally, this study supports the predictive value of this measure of RSM. RSM with objects uniquely predicted autism symptoms beyond that which was predicted by social communication features alone. This highlights the importance of longitudinal examination of RSM in larger samples and extending younger than 18 months to reveal how the combination of these features may provide important prognostic indicators of outcome.

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Table 1

Summary of Participant Characteristics

Characteristic	ASD (<i>n</i> =50)	DD (<i>n</i> =25)	TD (<i>n</i> =50)	<i>F</i> value	p-value of pairwise differences	
					DD-ASD	TD-ASD
Parent's education in years completed						
Mother (<i>M, SD</i>)	15.48 _a	15.22 _a	15.19 _a	2.25	.959	.883
Father (<i>M, SD</i>)	15.73 _a	15.52 _a	15.40 _a	2.57	.986	.883
Parent's age at child's birth in years						
Mother (<i>M, SD</i>)	31.19 _a	31.94 _a	31.24 _a	5.56	.943	.999
Father (<i>M, SD</i>)	32.99 _a	35.91 _a	33.71 _a	6.04	.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			
CSBS DP behavior sample ^d						
Age in months (<i>M, SD</i>)	21.29 _a	20.64 _a	21.07 _a	1.75	.321	.911
Social composite (<i>M, SD</i>)	5.00 _a	7.92 _b	11.38 _c	82.77***	.001	.000
Speech composite (<i>M, SD</i>)	5.82 _a	7.16 _a	10.26 _b	39.86***	.116	.000
Symbolic composite (<i>M, SD</i>)	5.82 _a	6.52 _a	10.96 _b	48.77***	.661	.000
Total	73.88 _a	81.64 _b	102.54 _c	75.77***	.035	.000
Mullen scales of early learning ^e						
Age in months	38.98 _a	35.85 _a	35.45 _a	5.42	.258	.085
NVDQ	76.00 _a	84.48 _a	114.08 _b	44.45***	.325	.000
VDQ	68.00 _a	77.26 _a	108.93 _b	46.96***	.345	.000

Note: Means in the same row with different subscripts differ significantly at $p < .05$ on the post-hoc Dunnett T3 comparison.

^dStandard 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.

^eNonverbal and verbal developmental quotients based on age equivalent divided by chronological age multiplied by 100.

* $p < .05$
** $p < .01$
*** $p < .001$

Table 2
Definitions of Repetitive and Stereotyped Movements (RSM)

Category	Definitions
RSM with Body	
Flaps ^a	moves the hand or arm up-and-down while not holding an object
Rubs Body ^a	rubs hands on any part of the body back and forth or in one direction
Pats Body ^a	pats, taps, or smacks with a clear up-and-down movement releasing and contacting the body with one or more fingers or in a flicking motion away from the body
Stiffens	postures or stiffens the fingers, hand, or arm, usually with the fingers spread or fist clenched
RSM with Objects	
Restricted	Preoccupation in intensity or focus with restricted interest
Swipes ^a	swipes an object or group of objects in a back and forth motion in an effort to move the object(s)
Rubs/Squeezes ^a	rubs or squeezes an object or part of the object or moves the object back and forth on the table in a rubbing or pushing motion
Rolls/Knocks Over ^b	knocks an object over or sets it down and rotates it around a horizontal axis so that it rolls
Rocks/Flips ^a	tilts vertical axis back and forth in a trajectory of at least 30° or rotates vertical axis 360°
Spins/Wobbles ^b	rotates or turns an object around a vertical axis
Sameness	Insistence on sameness or difficulty with change in activity
Collects	holds or gathers 3 or more objects at one time for at least 3 seconds, in the hand, under the arm, in a pile, or in a container
Moves/Places ^b	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
Lines up/Stacks ^a	moves at least 3 objects into a line or stack
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

^a movement must occur at least 3 consecutive times

^b movement occurs at least 3 times across the sample

Table 3

Comparison of RSM across Groups

Measure	ASD (<i>n</i> =50)			DD (<i>n</i> =25)			TD (<i>n</i> =50)			Pairwise group differences				
	Mean	SD	$Q_3-Q_1^a$	Mean	SD	$Q_3-Q_1^a$	Mean	SD	$Q_3-Q_1^a$	ASD-DD		ASD-TD		
										<i>p</i>	<i>d^b</i>	<i>p</i>	<i>d^b</i>	
RSM with body														
Rate	2.16	2.65	3.25	.92	2.00	1.00	.70	1.40	1.00	.079	0.53	.003	0.72	0.72
Inventory	.92	.90	1.00	.40	.65	1.00	.44	.68	1.00	.017	0.67	.010	0.61	0.61
Flaps	.32	.47		.20	.41		.16	.37			0.27		0.38	0.38
Rubs Body	.24	.43		.04	.20		.10	.30			0.63		0.38	0.38
Pats Body	.04	.20		.04	.20		.00	.00			0.00		0.40	0.40
Stiffens	.32	.47		.08	.28		.14	.35			0.64		0.44	0.44
Body Cluster	1.64	1.67	2.67	.71	1.25	1.33	.67	1.02	1.33	.025	0.64	.002	0.72	0.72
RSM with objects														
Rate	4.96	3.61	5.00	1.44	1.92	2.50	1.34	1.66	2.00	.000	1.27	.000	1.37	1.37
Inventory														
Restricted	1.62	1.10	1.00	.72	.89	1.00	.42	.61	1.00	.001	0.90	.000	1.40	1.40
Swipes	.18	.39		.12	.33		.04	.20			0.17		0.47	0.47
Rubs	.34	.48		.08	.28		.16	.37			0.68		0.42	0.42
Squeezes														
Rocks	.62	.49		.40	.50		.14	.35			0.44		1.14	1.14
Flips														
Spins	.32	.47		.12	.33		.08	.27			0.50		0.65	0.65
Wobbles														
Rolls	.16	.37		.00	.00		.00	.00			0.86		0.86	0.86
Sameness	.80	.70	1.00	.16	.37	.00	.38	.53	1.00	.000	1.20	.003	0.68	0.68
Lines up	.12	.33		.12	.33		.02	.14			0.00		0.43	0.43
Stacks														
Collects	.20	.41		.00	.00		.20	.40			0.98		0.00	0.00
Moves	.22	.42		.00	.00		.00	.00			1.05		1.05	1.05
Places														
Clutches	.26	.44		.04	.20		.16	.37			0.69		0.25	0.25
Object Cluster	4.07	2.35	3.75	1.36	1.54	2.83	1.27	1.31	2.00	.000	1.39	.000	1.43	1.43

Pairwise group differences											
Measure	ASD (n=50)			DD (n=25)			TD (n=50)			ASD-DD	
	Mean	SD	$Q_3-Q_1^a$	Mean	SD	$Q_3-Q_1^a$	Mean	SD	$Q_3-Q_1^a$	p	d^b
RSM Composite	5.71	2.91	4.67	2.10	2.21	3.17	2.00	1.95	3.08	.000	1.42
											1.53

^aInterquartile range

^bEffect size based on Cohen's $d \geq .20$ is small, .50 is medium, and .80 is large

Table 4
Concurrent Correlations Between RSM and CSBS Composites in the Second Year

	RSM with Body			RSM with Objects			
	Rate	Inventory	Body Cluster	Rate	Restricted Inventory	Sameness Inventory	Objects Cluster
CSBS Composite							
ASD group (<i>n</i> = 50)							
Social	-.36*	-.19	-.30*	-.35*	-.34*	-.34*	-.44**
Speech	-.30*	-.30*	-.33*	-.29*	-.36*	-.15	-.36*
Symbolic	-.29*	-.12	-.22	-.16	-.31*	-.03	-.23
ASD and DD groups (<i>n</i> = 75)							
Social	-.27*	-.22	-.26*	-.45***	-.41***	-.38**	-.51***
Speech	-.27*	-.30**	-.30**	-.29*	-.31*	-.16	-.32*
Symbolic	-.18	-.10	-.15	-.19	-.33*	.03	-.23
RSM Composite							
Social							-.52***
Speech							-.47***
Symbolic							-.31*
Social							-.52***
Speech							-.40***
Symbolic							-.25*

Table 5
Predictive Correlations Between RSM and Developmental Outcome and Autism Symptoms on the ADOS in the Fourth Year

	RSM with Body			RSM with Objects				RSM Composite
	Rate	Inventory	Body Cluster	Rate	Restricted Inventory	Sameness Inventory	Objects Cluster	
4th Year Outcomes								
ASD group (<i>n</i> = 46)								
MSEL								
NVDQ ^a	-.17	-.10	-.14	-.30 [*]	-.37 [*]	-.14	-.36 [*]	-.37 ^{**}
VDQ ^b	-.17	-.17	-.18	-.20	-.26	-.13	-.27	-.32 [*]
ADOS								
Social Affect	.07	.09	.09	.28	.23	.14	.29 [*]	.28
RRB ^c	.37 [*]	.26	.33 [*]	.11	.36 [*]	.09	.26	.40 ^{***}
ASD and DD groups (<i>n</i> = 71)								
MSEL								
NVDQ ^a	-.16	-.13	-.16	-.29 [*]	-.35 ^{**}	-.09	-.32 [*]	-.32 ^{**}
VDQ ^b	-.17	-.19	-.19	-.21	-.26 [*]	-.10	-.24 [*]	-.28 [*]
ADOS								
Social Affect	.19	.29 [*]	.26 [*]	.55 ^{***}	.48 ^{***}	.39 ^{**}	.58 ^{***}	.58 ^{***}
RRB ^c	.36 ^{***}	.33 [*]	.36 ^{***}	.37 ^{***}	.50 ^{***}	.32 [*]	.49 ^{***}	.60 ^{***}

^aNonverbal developmental quotient;

^bVerbal developmental quotient;

^cRestricted Repetitive Behaviors

* $p < .05$;

** $p < .01$,

*** $p < .001$

Table 6
Regression Analysis for CSBS Measures and Autism Symptoms in the Fourth Year (n = 71)

Regression Model	R	R ²	R ² Change	F Change	sr ²
Model 1: CSBS Composites	.64	.40	.32	11.78***	.16***
Social Composite					.00
Speech Composite					.00
Symbolic Composite					.00
Model 2: CSBS & RSM	.73	.54	.13	9.23***	.04*
Social Composite					.00
Speech Composite					.00
Symbolic Composite					.02
RSM with Body					.10***
RSM with Objects					

* p<.05,
** p<.01,
*** p<.001