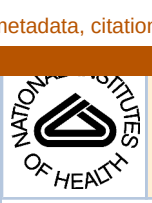

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Age-related Differences in Restricted Repetitive Behaviors in Autism Spectrum Disorders

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Abstract

Restricted repetitive behaviors (RRBs) were examined in a large group of children, adolescents and adults with ASD in order to describe age-related patterns of symptom change and association with specific contextual factors, and to examine if the patterns of change are different for the various types of RRBs. Over 700 individuals with ASD were rated on the Repetitive Behavior Scale – Revised. RRBs were less frequent and less severe among older than younger individuals, corroborating that autism symptoms abate with age. Our findings further suggest that repetitive behaviors are a heterogeneous group of behaviors, with the subtypes of RRBs having their own individual patterns across the lifespan, and in some cases, a differential association with age depending on intellectual functioning.

Keywords

ASD; repetitive behaviors; children; adolescents; adults

Symptoms of autism include social impairments, communication impairments and restricted repetitive behaviors. Current cross-sectional and longitudinal research indicates that the severity of these core features of autism among adolescents and adults tend to abate with age (Fecteau, Mottron, Berthiaume & Burack, 2003; Mawhood, Howlin & Rutter, 2000; Seltzer, Krauss, Shattuck, Orsmond, Swe & Lord, 2003; Shattuck, Seltzer, Greenberg, Orsmond, Bolt, Kring, Lounds & Lord, 2007). A greater understanding of how autism symptoms change over the life course has implications for understanding the natural course of this disorder, for developing and assessing the efficacy of appropriate interventions and supports, and for understanding the impact of this disorder on families (Seltzer, Shattuck, Abbeduto & Greenberg, 2004). In this article, we focus on one core feature of autism: restricted repetitive behaviors (RRBs). Our purpose is to examine these behaviors among a large group of children and adults with autism spectrum disorders (ASD) in order to describe age-related patterns of symptom expression, to assess whether such patterns are associated with specific contextual factors, and to examine if the age-related patterns are different for the various types of RRBs.

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Restricted repetitive behaviors are a heterogeneous group of behaviors, ranging from repetitive movements of the body to more cognitively-mediated symptoms such as intense interests or pre-occupations (American Psychiatric Association, 2000; Lewis & Bodfish, 1998). Existing research suggests that age and level of functioning are associated with variations in the manifestation of RRBs in individuals with ASD. Regarding age, in a study of children and adults with ASD, descriptive data suggest different age-related patterns for the various types of RRBs (Lam & Aman, 2007). For example, stereotyped movements and restricted interests appear to be less frequent among older individuals, self-injurious behaviors and compulsive behaviors appear comparable across age groups, and ritualistic/sameness appears to be more frequent among older individuals. Other research indicates a different pattern of age-related differences in RRBs. In a comparison of younger and older children with ASD, younger children were more likely to exhibit motor and sensory repetitive behaviors, and older children were more likely to exhibit more complex repetitive behaviors (Militerni, Bravaccio, Falco, Fico & Palermo, 2002). In another study of children with ASD who ranged in age from toddlers to 12 year olds, most RRBs, including self-injury, desire for sameness, restricted interests, and compulsions, were more frequent among the older than the younger children (Bishop, Richler & Lord, 2006). However, when taking into account nonverbal IQ, the pattern of findings changed. Some RRBs did not show age-related patterns (such as restricted interests), whereas others (such as self-injury, desire for sameness, and compulsions) were less frequent among older children. Although there are discrepancies, there is some convergence in the findings relating to age and RRBs. A trend is observed of subtypes of RRBs appearing to remain stable or becoming less frequent with age, and this depends on the age range of the sample. However, the pattern of findings across studies is not strong enough to define the age-related pattern of this aspect of the behavioral phenotype of ASD. Therefore, there is a need to examine in more detail the age-related pattern of the various types of RRBs across the lifespan.

Previous research has also suggested that the expression of RRBs may be influenced by level of functioning (Gabriels, Cuccaro, Hill, Ivers & Goldson, 2005; Le Couteur, Lord & Rutter, 2003; Turner, 1999). Repetitive behaviors are often conceptualized as having two subcategories: lower-order behaviors that are characterized by *repetition of movement* (such as stereotyped movements, repetitive manipulations of objects, and self-injurious behavior); and higher-order, more *complex behaviors* (such as object attachments, repetitive language, and circumscribed interests) (Turner, 1999). Though this classification serves as a useful shorthand method of discussing RRB, it should be used with caution as it could obscure important differences within these broad categories (Turner, 1999). Recent empirical work has suggested that there is considerable structure within the RRB domain, with as many as five different types of repetitive behavior (Lam & Aman, 2007). Previous research has suggested that certain domains of repetitive behavior are associated with the presence of intellectual disability (ID), such as motor stereotypies, and others are associated with higher levels of cognitive functioning, such as repetitive speech (Bishop et al., 2006; Militerni et al., 2002). Other forms of RRB (such as insistence on sameness or the need for routines) have not been shown to be related to level of intellectual functioning (Militerni et al., 2002). The implication is that RRBs are a heterogeneous group of behaviors, and that these behaviors may be differentially related to both age and level of functioning.

Past evaluations of the relationship between RRBs, age, and level of functioning have been limited by restricted age ranges. Studies have typically either focused on children younger than 12 (Bishop et al., 2006; Militerni et al., 2002; South, Ozonoff & McMahon, 2005), or have focused on adolescents and adults (Bodfish et al., 2000; Seltzer et al., 2003; Shattuck et al., 2007). There is thus a need to study the association between age and RRBs across the full lifespan in order to better understand the age-related manifestation of this domain of ASD symptoms. For example, circumscribed interests, as measured by the Autism Diagnostic Interview – Revised (ADI-R), were found to be more prevalent in older children than younger

children (Bishop et al., 2006), and to decrease with age among adolescents and adults (Seltzer et al., 2003; Shattuck et al., 2007), whereas repetitive use of objects, as measured by the ADI-R, was found to decrease with age in both children and adults (Bishop et al., 2006; Seltzer et al., 2003; Shattuck et al., 2007). We need to understand if these findings are a result of sampling for only children or only adolescents and adults in a given study, or if these are life course developmental trajectories. Only studies of the full life course have the potential to identify nonlinear trajectories across the life stages. Further, as well as examining the age-related patterns of the different RRBs across the lifespan in more detail, an examination of their association with demographic variables such as level of functioning is also warranted.

Our present analysis is unique in its ability to address the relation between age and RRBs and differences in this relationship across the various types of RRBs. By combining data from several studies of RRBs among individuals with ASD, we have a large sample size (n = 712), spanning a broad age range, from toddlers to seniors (age 2 to 62). Further, we have measured RRBs using a single instrument, the Repetitive Behavior Scale – Revised (RBS-R; Bodfish, Symons, Parker & Lewis, 2000; Lam & Aman, 2007), that has been specifically designed to measure this construct and is psychometrically sound across the lifespan (Lam & Aman, 2007). A confound of other research (Bishop et al., 2006; Shattuck et al., 2007) is that the same measure (e.g., the ADI-R) is used to diagnose ASD, and then is also used to examine age differences in symptoms of RRBs, thus potentially limiting the variability of the behaviors of interest. In addition, previous work has suggested that the ADI-R undersamples repetitive behaviors in autism (Lecavalier et al., 2006), so it is a less than ideal measure for the domain. Our methodology examines age differences in RRBs among individuals with ASD using a separate and valid instrument and then uses the ADI-R or other independent diagnostic measures to supplement prior diagnoses of ASD.

For this analysis, we address three research questions. First, to confirm past research findings, we ask whether age is associated with the severity of total repetitive behaviors in individuals with ASD. We hypothesized that total repetitive behaviors would be less frequent in older individuals than in younger individuals. In investigating the association between age and the total repetitive behaviors, we examine whether this pattern varied according to whether the individual had a comorbid diagnosis of ID, whether the individual was taking psychotropic medication, and gender. We hypothesized that individuals with ASD and a comorbid diagnosis of ID would exhibit a less pronounced age-related gradient in total repetitive behaviors as compared to individuals with ASD and average or above intelligence. Further, we hypothesized that individuals prescribed psychotropic medication would exhibit a more pronounced age-related gradient in total repetitive behaviors as compared to those not prescribed psychotropic medication, as there is evidence to suggest that such medications are prescribed more often in adults than children, which might contribute to a pattern of age-related decline in symptoms (Aman, Lam & Van Bourgondien, 2005). Although we did not expect to observe gender differences in the association between age and total repetitive behaviors (Shattuck et al., 2006), we examined this difference for descriptive and clinical purposes.

Second, we ask whether each of the five individual subscales of repetitive behaviors (i.e., stereotyped movements, self-injurious behaviors, compulsive behaviors, ritualistic behaviors, and restricted interests) shows a distinct pattern of age-related differences. Further, we examine whether these subscales have distinct associations with a comorbid diagnosis of ID, psychotropic medication use, and gender. We hypothesized that all of the individual subscales would show a pattern of fewer RRBs among older individuals as compared to younger individuals across the lifespan. Similar to our hypotheses regarding age-related patterns of differences in *total* RRBs, we hypothesized that the *subscales* of repetitive behaviors would show a less pronounced age-related gradient for individuals with a comorbid diagnosis of ID, and a more pronounced age-related gradient for individuals taking psychotropic medication.

Again, we did not expect gender differences in the association between age and the subscales of RRBs.

Third, we ask whether the pattern of age-related differences in the subscales of RRBs differ from each other. Based on previous research with children through adults with ASD (Lam & Aman, 2007), we hypothesized that the pattern of age-related differences in RRBs would be different among the five subscale measures of repetitive behaviors, with stereotyped movements and restricted interests exhibiting the most pronounced age-related differences, and self-injurious behavior and compulsive behavior exhibiting the least pronounced age-related differences.

Methods

Study Design

Participants were selected from six previously conducted studies in which children, adolescents and adults with ASD were rated using the RBS-R. These studies included a survey of the members of the South Carolina Autism Society (Lam & Aman, 2007), a study in North Carolina of the development of repetitive behaviors in preschool-age children with ASD (Lam, Holtzclaw & Bodfish, 2005b; Lam, Holtzclaw, Turner-Brown, Boyd, Baranek & Bodfish, submitted), a study in Rhode Island of repetitive behaviors in school-age children with ASD (Lam, Aman, Parker, Woodard, Lewis & Bodfish, 2005a), two studies in North Carolina of adolescents and adults with ASD in state hospitals (Bodfish et al., 2000), and a study of adolescents and adults with ASD and their families in Wisconsin and Massachusetts (Seltzer et al., 2003; Shattuck et al., 2007). Studies were conducted between 1998 and 2005. Data from these studies were combined for the current analysis resulting in a modified cross-sectional design. No new data were collected.

For inclusion in the present analyses, all participants in the studies were required to have a prior clinical diagnosis of ASD, independent of the research. Supplementary information on ASD diagnoses was available from most of the studies. The diagnosis of ASD was confirmed with the Social Communication Questionnaire (SCQ; Rutter, Bailey, & Lord, 2003) in the study of pre-schoolers, the ADI-R in the Wisconsin/Massachusetts study, and a DSM-IV Checklist and the Childhood Autism Rating Scale (CARS; Schopler, Reichler, & Renner, 1993) in the North Carolina studies in state hospitals. The CARS was used in the latter studies as the individuals rated had comorbid diagnoses of ID. In the study of school-age children the diagnosis of ASD was confirmed with the SCQ, CARS and either the ADI-R or Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore & Risi, 1999). No supplementary confirmation of ASD diagnosis was obtained in the South Carolina survey.

The informant completing the RBS-R was typically a parent, teacher, or caregiver. In the study of school-age children, the informants were teachers, and in the two studies of adolescents and adults in North Carolina, the informants were the treating psychologists at the state hospital. The RBS-R was completed as either a mailed questionnaire (Lam et al., 2005b; Lam & Aman, 2007), a questionnaire completed at work (Bodfish et al., 2000), or as part of an in-person interview and completion of self-administered measures (Seltzer et al., 2003).

Sample

The sample contained 712 individuals with ASD, of whom four-fifths were male (79.8%). Many were prescribed at least one psychotropic medication (40.3%). Most were Caucasian (67.3%), and had a comorbid diagnosis of ID (62.2%). The sample ranged in age from 2 to 62 years (M = 19.6, SD = 12.0), with a fairly even distribution between children (ages 2−13;

33.8%), adolescents (ages 14−21; 30.9%) and adults (ages 22 and older; 35.3%). Demographic characteristics of each study and of the entire sample are presented in Table 1.

Comparisons between the six groups of participants revealed significant differences with respect to gender, comorbid diagnosis of ID, medication and ethnicity. While males constituted over 70% of the sample in all studies, there were significant differences found with the Wisconsin/Massachusetts study including fewer males (72.5%) than the other studies (76.7% −88.8%), $\chi^2(5) = 13.87$, $p < .05$. Significant differences in level of functioning were also found, with the South Carolina survey having more individuals with ASD only, and the North Carolina and Rhode Island studies having more individuals with ASD and a comorbid diagnosis of ID, $\chi^2(5) = 115.12$, $p < .01$. Medication use was not assessed in two studies: the Rhode Island study of school-age children and one of the North Carolina studies of adolescents and adults. However, significant differences were found for whether individuals were prescribed any psychotropic medication in the remaining four studies, $\chi^2(3) = 66.02$, $p < .01$. Fewer children in the North Carolina pre-school study and more adults in the Wisconsin/Massachusetts and North Carolina studies were prescribed psychotropic medication. Ethnicity was not documented for the two studies of adolescents and adults in North Carolina. However, significant differences were found in ethnicity in the remaining four studies, with more African-Americans in the South Carolina survey and fewer African-Americans in the Wisconsin/Massachusetts study, $\chi^2(12) = 75.60$, $p < .01$.

Many of these differences are due to the designs of the various studies and their locations, and therefore are not unexpected. As such, the six samples were combined for the present study. This combined sample provides a large and more representative sample that better captures the natural variability in the population of individuals with ASD across the lifespan than any single study can provide.

Measures

The common measure of repetitive behaviors across all six studies was the Repetitive Behavior Scale – Revised (RBS-R; Bodfish et al., 2000). The RBS-R is a 43-item measure with items rated on a four-point Likert-type scale ranging from (0) behavior does not occur, to (3) behavior occurs and is a severe problem. The original RBS-R had six *conceptually* derived subscales. The current scoring for the RBS-R recommends using five *empirically* derived subscales based on 38 of the 43 items (Lam & Aman, 2007). The empirically derived subscales include: (a) Stereotyped Behavior (movements with no obvious purpose that are repeated in a similar manner); (b) Self-injurious Behavior (actions that cause or have the potential to cause redness, bruising, or other injury to the body); (c) Compulsive Behavior (behavior that is repeated and performed according to a rule or involves things being done “just so”); (d) Ritualistic/Sameness Behavior (performing activities of daily living in a similar manner; resistance to change, insisting that things stay the same); and (e) Restricted Interests (limited range of focus, interest, or activity). Internal consistency for the subscales ranges from .78 to .91 (Lam & Aman, 2007). Interrater reliability for the subscales ranges from .57 to .73 when administered for children and adolescents (Lam & Aman, 2007).

For the purposes of this manuscript, the *total score* is defined as the sum of the ratings of each repetitive behavior across all 38 items. The total score is used to assess the relationship between age and the severity of total repetitive behaviors in individuals with ASD. To assess the subscales of RRBs, we use the subscale item mean score rather than the subscale total score because the five subscales of the RBS-R have differing numbers of items. To facilitate comparisons across subscales, the mean item score for each subscale ranging from 0 to 3, referred to as the *subscale score*, is used to assess the relationship between age and the severity of subscales of repetitive behaviors, and age-related differences between the subscales of repetitive behaviors.

Method of Data Analysis

Bivariate correlations were used to explore the relation between RBS-R scores and age. To further examine this association while controlling for gender, presence of ID, and psychotropic medication use, multiple regression analyses were used. Psychotropic medication was included in the analysis as older individuals in the sample were more likely to be prescribed medication than younger individuals, $r = .32$, $p < .01$. In these regression models, gender (0 = male, 1 = female), a comorbid diagnosis of ID (0 = ASD only, 1 = comorbid diagnosis of ID) and psychotropic medication (0 = no medication, 1 = at least one psychotropic medication) were entered in the first step of six regression equations predicting each of the five RBS-R subscales and the total RBS-R score. Age was entered in the second step of the regression models. The interactions between age and the covariates were then entered in the third step of the regression equations. Missing demographic data reduced the sample size in these regression analyses to 581. The reduced sample of 581 individuals did not differ systematically from the total sample in any way.

Multiple hierarchical regression was again used to test the third research question which investigated whether the pattern of age-related differences in repetitive behaviors differed between the five RBS-R subscales. In these regression analyses, dummy coding was used to investigate the differences in the slope of each repetitive behavior relative to the other four repetitive behaviors. In total, four regression analyses with dummy coding were performed in order to make all possible comparisons of the slope and intercept among the RBS-R subscales.

Results

Internal consistency of the RBS-R (.93) and its subscales was high and ranged from .74 to .89 (see Table 2). Internal consistency estimates were comparable when examined for males and females, when examined for prescribed psychotropic medication or not, and when examined for individuals with ASD only and individuals with ASD and a comorbid diagnosis of ID. The mean total score on the RBS-R was 26.48 ($SD = 18.05$, range 0−96). All subscales of the RBS-R were significantly correlated with each other, $p < .01$, although the strength of the correlation varied considerably, from .27 between restricted interests and self-injury to .66 between restricted interests and ritualistic/sameness (see Table 3).

Relationship between Repetitive Behaviors (Total Score) and Age

For our first research question, we asked whether there is an association between age and severity of repetitive behaviors. Age was significantly correlated with repetitive behaviors, as measured by the RBS-R total score, $r = -.21$, $p < .01$. Total scores on the RBS-R for different age groups are presented in Table 4 (first column). Adults displayed fewer repetitive behaviors than did children. When controlling for gender, a comorbid diagnosis of ID and a prescription for psychotropic medication, age continued to be associated with repetitive behaviors, $\beta = -.26$, $p < .01$. Having a comorbid diagnosis of ID was also associated with repetitive behaviors, $\beta = .15$, $p < .01$, with individuals diagnosed with ID exhibiting more repetitive behaviors than individuals with ASD only. Neither gender, $\beta = .05$, $p = .20$, nor psychotropic medication, $\beta = -.01$, $p = .86$, was associated with the total score of repetitive behaviors. No significant interactions were observed.

The above analysis was conducted on a smaller sample (n=581) due to missing demographic data, primarily missing data about psychotropic drug use in two of the studies. We repeated this analysis with the full sample, excluding the psychotropic medication variable from the regression model, and the same pattern of findings was found (data available from the first author).

Thus, regarding our first research question, the data indicated that older individuals with ASD tend to exhibit fewer repetitive behaviors than younger individuals with ASD, consistent with our hypothesis. When taking gender into account, whether the individual with ASD had a diagnosis of ID or was taking psychotropic medication, individuals with ASD continued to show a pattern where older individuals displayed fewer repetitive behaviors than did younger individuals.

Relationship between Repetitive Behaviors (Subscale Scores) and Age

For our second research question, we examined the relation between age and severity of the different forms of RRB as measured by the RBS-R subscale scores. Age was significantly correlated with all five of the repetitive behavior subscales, including stereotyped movements ($r = -.26$, $p < .01$), self-injurious behaviors ($r = -.13$, $p < .01$), compulsive behaviors ($r = -.09$, $p < .05$), ritualistic/sameness behaviors ($r = -.12$, $p < .01$), and restricted interests ($r = -.24$, $p < .01$). Older individuals displayed fewer repetitive behaviors than did younger individuals on all of these subscales. Mean RSB-R subscale scores for different age groups are presented in Table 4 (2^{nd} to 6^{th} columns).

For all subscales, after controlling for gender, presence of ID, and psychotropic medication use, older age remained significantly related to lower levels of repetitive behaviors (stereotyped movements, $\beta = -.29$, $p < .01$; self-injurious behaviors, $\beta = -.22$, $p < .01$; compulsive behaviors, $\beta = -.12$, $p < .01$; ritualistic/sameness behaviors, $\beta = -.17$, $p < .01$; restricted interests, $\beta = -.24$, $p < .01$). Having a comorbid diagnosis of ID was associated with more severe stereotyped movements, $\beta = .19$, $p < .01$, and more self-injurious behaviors, $\beta = .26$, $p < .01$, but was not related to the expression of ritualistic/sameness behaviors, compulsions, or restricted interests. Being female was associated with more severe self-injurious behaviors, $\beta = .10$, $p < .05$, and taking psychotropic medication was associated with more severe stereotyped movements, $\beta = .09$, $p < .05$.

We were also interested in whether the covariates of gender, ID and psychotropic medication would interact with age in predicting severity of repetitive behavior subscales. Only one significant interaction was found. In predicting stereotyped movements, there was a significant interaction between age and ID, $\beta = .27$, $p < .05$. Individuals with ASD and a comorbid diagnosis of ID exhibit a less pronounced pattern of age-related differences in stereotyped movements with age than do individuals with ASD only (see Figure 1).

Thus, with respect to our second research question, older individuals with ASD exhibited fewer repetitive behaviors, as measured by each of the individual subscales, than younger sample members. These patterns support our predictions and persisted after controlling for covariates of gender, ID, and psychotropic medication. Further, these age-related patterns of severity of repetitive behaviors are minimally dependent on the covariates. Only for stereotyped movements is there a divergent age-related pattern based on whether the individual has ID. For both individuals with and without ID, older individuals exhibit fewer stereotyped movements than younger individuals. However, individuals who are lower functioning show a less pronounced pattern of age-related differences in stereotyped movements than individuals who are higher functioning.

Differences among Repetitive Behaviors in their Association between Age and Severity

Our third research question asked whether the pattern of age-related differences in severity of repetitive behaviors differed among the five different RBS-R subscales of repetitive behaviors. This question was investigated by comparing the slopes of the pattern of age-related differences for each RBS-R subscale to each other.

The slopes for each RBS-R subscale are presented on the diagonal, within parentheses, in Table 5, and are all significantly different from a flat slope, suggesting age-related attenuation of RRBs. Above the diagonal are indicators of whether the RBS-R subscale slopes are significantly different from each other. Restricted interests have the steepest slope, reflecting the greatest attenuation of the frequency of RRBs between older and younger individuals. The slope of restricted interests is significantly steeper than the slope of self-injurious behaviors ($\beta = -.17$, $p < .01$), compulsive behaviors ($\beta = -.19$, $p < .01$), and ritualistic/sameness behaviors ($\beta = -.16$, $p < .01$). Restricted interests exhibited a trend of a steeper slope than stereotyped movements ($\beta = -.07$, $p = .09$). Stereotyped movements exhibited the second steepest slope, and its slope was also significantly steeper than that of self-injurious ($\beta = .10$, $p < .01$), compulsive ($\beta = .12$, $p < .01$), and ritualistic/sameness behaviors ($\beta = .09$, $p < .05$). There were no significant differences in the slopes among self-injurious behaviors, compulsive behaviors and ritualistic/sameness behaviors. Figure 2 displays the slopes, or patterns of age-related differences of the five subscales of the RBS-R.

The intercept (mean score when age = 0) of each RBS-R subscale is also presented on the diagonal in Table 5. Below the diagonal are indicators of whether the intercepts were significantly different from each other. All intercepts were significantly different from each other with the exception of the intercepts for stereotyped repetitive behaviors and the ritualistic/sameness repetitive behaviors, $\beta = -.06$, $p = .09$. As ASD is not typically diagnosed until a child is age 2, it is unwise to interpret the rank order of the intercepts which indicate the mean score when an individual is age 0. The intercepts are better viewed as a by-product of obtaining the most accurate slope estimate.

We repeated the analyses controlling for gender, presence of ID, and psychotropic medication use. A similar pattern of findings was found with this smaller sample (smaller sample due to missing data on medication use; data available from the first author). The differences in the findings were that the slopes of stereotyped movements and restricted interests were not significantly different and the intercepts of stereotyped movements and ritualistic/sameness behavior were not significantly different. All other significant findings remained.

Thus, with respect to our third research question, the pattern of age-related differences in repetitive behaviors differs among the five subscales of the RBS-R. The slopes or pattern of age-related attenuation of restricted interests and stereotyped movements are the steepest, and significantly different from the other measures of repetitive behaviors, whereas pattern of age-related attenuation of self-injurious behaviors, compulsive behaviors and ritualistic/sameness behaviors did not differ from each other.

Discussion

We examined the age-related pattern of RRBs for individuals with ASD. Our analyses suggest that repetitive behaviors are less frequent and less severe among older individuals than among younger individuals, regardless of whether examining total display of RRBs, or whether examining each of the various subtypes of RRBs, such as stereotyped movements or restricted interests. This finding corroborates other research findings using both cross-sectional and longitudinal methods that autism symptoms are less severe among older than younger individuals with ASD (Seltzer et al., 2003; Shattuck et al., 2007) and extends past research by including individuals ranging in age from toddlers to seniors in the same analysis.

Secondly, we found that, in general, the age-related pattern of symptom abatement in RRBs is not dependent upon gender, a comorbid diagnosis of ID, or taking psychotropic medication. This finding suggests that the pattern of age-related differences in RRBs applies to a heterogeneous group of people with ASD, and that these clinical factors do not influence the

manifestation of RRBs across the life course. The exception is with stereotyped movements. While older individuals with ASD exhibit fewer motor stereotypies than do younger individuals with ASD, these behaviors appear more persistent in individuals with ID. An examination of the raw data suggests that both children and adolescents with a comorbid diagnosis of ID exhibit more stereotyped repetitive behaviors than adults with a comorbid diagnosis of ID. In contrast, adolescents with ASD "only" exhibit fewer stereotyped movements than children with ASD "only," and a comparable level of stereotyped movements as adults with ASD "only." This pattern is similar to what is observed in comparisons of toddlers and older children (Bishop et al., 2006).

Our findings provide support for the concept that discrete types of RRBs may have unique age-related patterns. For example, restricted interests are the most prevalent RRB across most ages, although they are markedly less prevalent among older individuals with ASD than younger individuals with ASD in these cohort comparisons and show the steepest slope of age-related differences. Self-injurious repetitive behaviors are the least prevalent RRB across all ages. Stereotyped movements are common among young children with ASD, more so than rituals and compulsions, but become less prevalent than these other RRBs in adulthood. These unique patterns of age-related differences suggest that RRBs are a heterogeneous group of behaviors, and further confirm the dimensional structure reported in Lam and Aman (2007).

Our findings also have potential implications for the diagnosis and treatment of individuals with ASD. It has been documented that individuals who met criteria for ASD at a younger age may not meet criteria when they are older (Seltzer et al., 2003). Whether this implies that they no longer have autism is a topic for future research and is well beyond the scope of the present paper. We prefer to interpret these present findings in the context of Piven's observation that "autism may perhaps be best viewed as a lifelong disorder whose features change with development" (Piven, Harper, Palmer & Arndt, 1996). Although our data suggest that RRBs do lessen in severity across the lifespan, they are still present, even in the oldest individuals with autism, and are likely still severe relative to typical development.

The primary limitation of this analysis is that is it based on modified cross-sectional data. The findings could be interpreted to suggest symptom abatement within individuals, but could also reflect cohort differences and not developmental patterns. As such, we are unable to draw firm conclusions about symptom changes for individuals. Longitudinal data are needed to augment the current analyses. In addition, our data were compiled from several different research studies. As a result, varying diagnostic measures (ADI-R, SCQ, CARS) were used to confirm ASD diagnoses; ideally the same method would have been employed. Also, the different research studies, in addition to providing a heterogeneous sample, may have introduced systematic bias that contributed to the pattern of findings. Further, our findings are also limited as the results are based primarily on parental report of RRBs. It is possible that parents of younger children with ASD are more sensitive to RRBs and more likely to report them, whereas parents of older individuals with ASD may be accustomed to these behaviors and less likely to report them. Also, psychologist-, teacher- and parent-raters may differentially rate RRBs (Achenbach & Edelbrock, 1981).

Despite these limitations, the study contributes to the understanding of RRBs. Our findings suggest that repetitive behaviors are a heterogeneous group of behaviors, with the discrete types of RRBs having relatively distinct age-related profiles and, in the case of stereotyped movements, a differential association with age depending on ID. Our modified cross-sectional study provides suggestions for understanding the development of repetitive behaviors across the life course by corroborating past findings of symptom abatement among individuals with ASD. The next step to better understanding symptom abatement in repetitive behaviors is to

collect longitudinal data. The better we understand age-related patterns of change in symptoms of ASD, the more able we will be to diagnoses and treat individuals with ASD.

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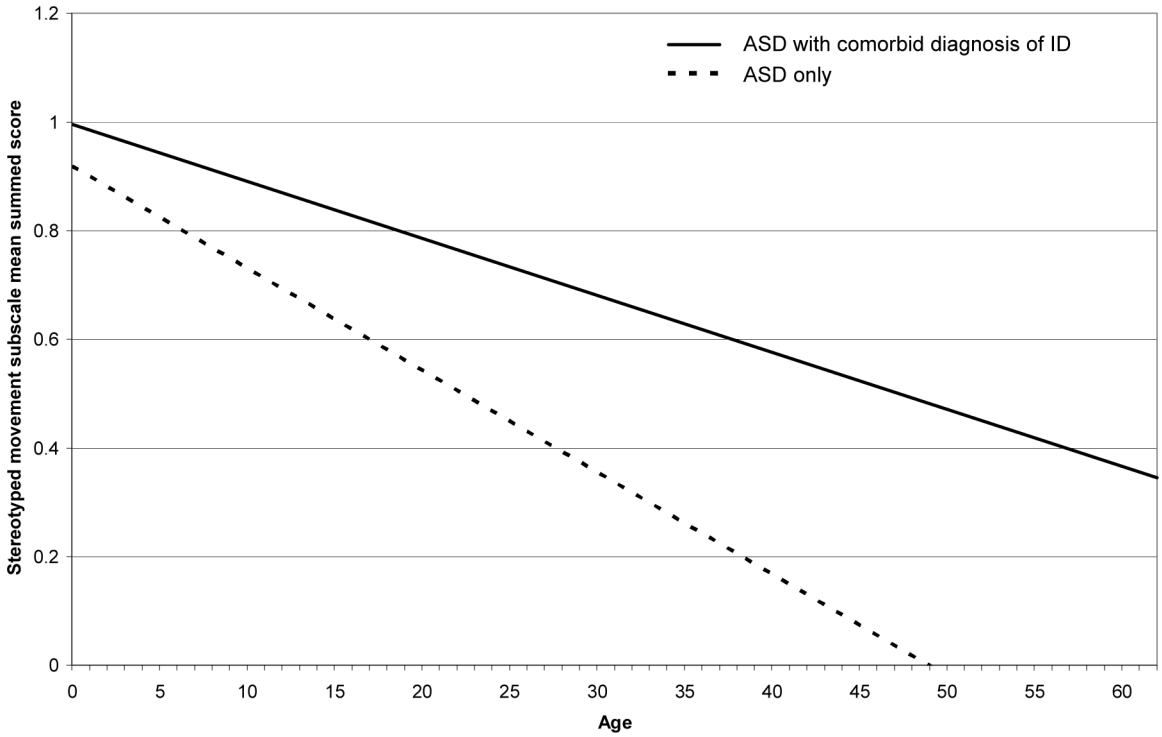

Figure 1.
Pattern of age-related differences on the stereotyped movement subscale of the RBS-R among individuals with ASD, with or without a comborbid diagnosis of ID.

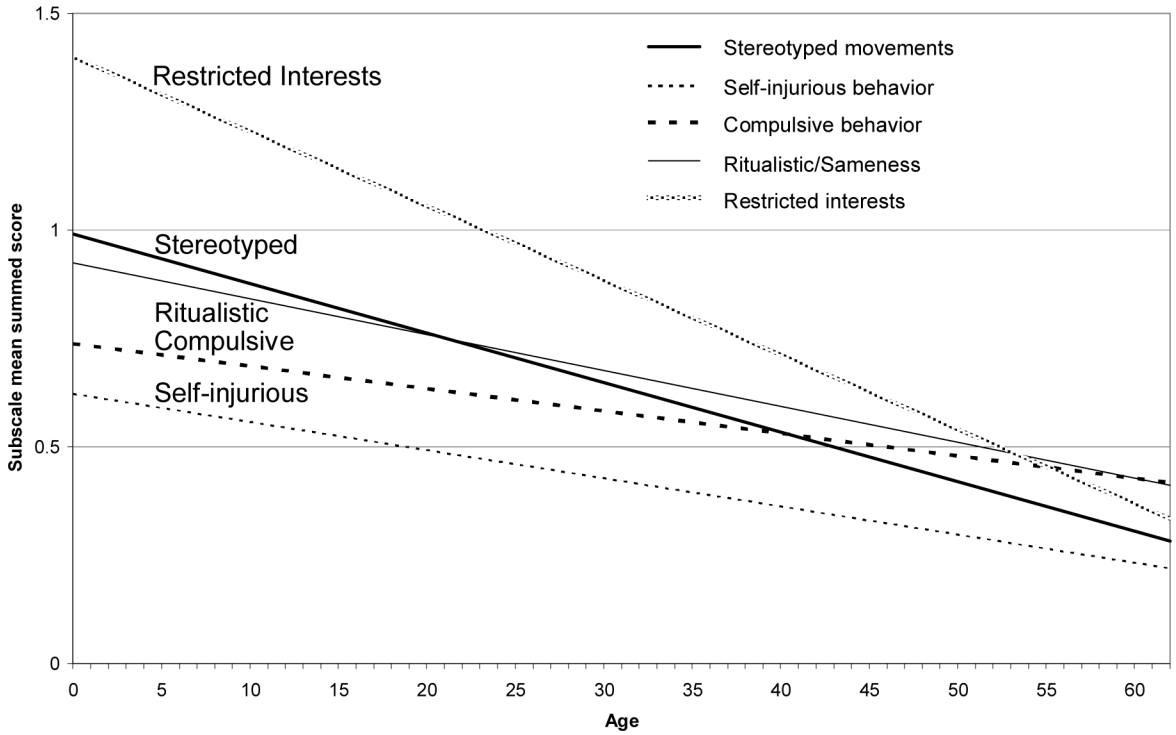

Figure 2.
Pattern of age-related differences on each of the RBS-R subscales for the entire sample.

Table 1

Demographics of sample.

	NC preschool (n=60)	RI school-age (n=45)	SC (n=301)	WI/MA (n=233)	NC 1 (n=30)	NC 2 (n=43)	Total (n=712)
Gender							
Male	85.0%	88.8%	82.7%	72.5%	76.7%	83.7%	79.8%
Missing	-	-	0.7%	-	-	-	0.3%
Level of functioning							
ID	75.0%	100%	40.2%	68.7%	100%	97.7%	62.2%
Missing	13.3%	-	14.0%	-	-	2.3%	7.2%
Psychotropic meds							
Any psychotropic	6.7%	-	39.2%	60.1%	-	58.1%	40.3%
Missing	-	100%	-	1.3%	100%	-	11.0%
Ethnicity							
African-American	8.3%	8.9%	22.9%	1.3%	-	-	10.8%
Asian-American	0.0%	0.0%	2.7%	2.1%	-	-	1.8%
Caucasian	83.3%	75.6%	69.1%	94.8%	-	-	67.3%
Hispanic	3.3%	4.4%	1.3%	0.4%	-	-	1.0%
Other	5.0%	6.7%	2.7%	1.3%	-	-	2.0%
Missing	-	4.4%	1.3%	-	100%	100%	17.1%
Age							
2−4	91.7%	-	6.3%	-	-	-	10.4%
5−9	8.3%	8.9%	25.9%	-	-	-	12.2%
10−13	-	40.0%	20.6%	-	-	-	11.2%
14−21	-	51.1%	26.2%	48.5%	3.3%	9.3%	30.9%
22−30	-	-	10.6%	31.8%	33.3%	14.0%	17.1%
31−40	-	-	8.3%	10.7%	50.0%	27.9%	10.8%
41−50	-	-	2.0%	6.4%	13.3%	37.2%	5.8%
51+	-	-	-	2.6%	-	11.6%	1.5%
M (SD)	3.7 (0.7)	14.4 (3.7)	15.4 (9.6)	25.1 (9.0)	32.9 (7.3)	37.7 (11.1)	19.6 (12.0)
range	2−5	7−20	3−48	14−53	15−49	16−62	2−62

Table 2

Internal consistency and descriptives of RBS-R subscales (n=712).

	Internal Consistency	Mean (SD)[a]	Range
Stereotyped	.83	.74 (.60)	0−2.75
Self-Injurious	.77	.47 (.51)	0−3
Compulsive	.75	.63 (.60)	0−3
Ritualistic/Sameness	.89	.76 (.62)	0−3
Restricted Interests	.74	1.06 (.89)	0−3

[a] Mean of the mean summed subscale score.

Table 3

Intercorrelations of RBS-R subscales

	Stereotyped	Self-Injurious	Compulsive	Ritualistic/Sameness
Self-Injurious	.52	-	-	-
Compulsive	.48	.31	-	-
Ritualistic/Sameness	.54	.39	.60	-
Restricted Interests	.50	.27	.50	.66

All correlations: $p < .01$

Table 4

Summed total and mean item subscale scores on the RBS-R by age groups

Age Group (n)	Total	Stereotyped	Self-Injurious	Compulsive	Ritualistic/Sameness	Restricted Interests
2−4 (n=74)	30.92 (17.75)	.94 (.52)	.69 (.60)	.70 (.54)	.79 (.62)	1.11 (.82)
5−9 (n=87)	31.32 (20.06)	.97 (.63)	.44 (.57)	.70 (.62)	.88 (.70)	1.43 (.87)
10−13 (n=80)	28.82 (17.68)	.92 (.62)	.51 (.51)	.66 (.63)	.76 (.58)	1.15 (.90)
14−21 (n=220)	26.91 (19.25)	.73 (.64)	.46 (.53)	.63 (.66)	.79 (.63)	1.17 (.93)
22−30 (n=122)	23.98 (16.58)	.59 (.54)	.43 (.44)	.61 (.57)	.73 (.63)	.95 (.87)
31−40 (n=77)	21.60 (12.73)	.56 (.42)	.46 (.46)	.55 (.50)	.65 (.60)	.64 (.65)
41−50 (n=41)	21.02 (17.65)	.57 (.51)	.37 (.38)	.60 (.60)	.62 (.57)	.67 (.79)
51+ (n=11)	14.91 (8.55)	.33 (.19)	.18 (.16)	.52 (.50)	.45 (.39)	.67 (.92)

Table 5

Differences in intercept and slope of repetitive behaviors[a]

	Stereotyped	Self-Injurious	Compulsive	Ritualistic/Sameness	Restricted Interests
Stereotyped	.997 (−.013)	**	**	*	+
Self-Injurious	**	.580 (−.005)	ns	ns	**
Compulsive	**	*	.719 (−.004)	ns	**
Ritualistic/Sameness	+	**	*	.886 (−.007)	**
Restricted Interests	**	**	**	**	1.408 (−.018)

+ $p < .10$

* $p < .05$

** $p < .01$

[a] Intercept (and slope) presented on diagonal. Significant differences among intercepts presented below diagonal. Significant differences among slopes presented above diagonal.