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Differences in the Severity and Variability of Restricted and Repetitive Behaviors in ASD Children With and Without Service Experiences

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Abstract

Background: Despite the importance of restricted and repetitive behaviors (RRBs) in diagnosing autism spectrum disorder (ASD), specific RRBs that distinguish children with ASD who are receiving services from those who have ASD but are unidentified and untreated until school age remain unclear. This study examined the differences in the severity and variability of RRBs among three groups (ASD with service experiences [ASDws], ASD without service experiences [ASDwos], and No ASD) and investigated specific RRBs predicting group membership.

Method: A total of 296 children who screened positive for ASD completed confirmative diagnostic assessments. The severity and variability scores of RRBs were obtained using 16 items of the Autism Diagnostic Interview-Revised.

Results: Both ASD groups had higher proportions of children with severe RRBs for the majority of RRBs and exhibited a greater number of RRBs than the No ASD group. However, discrepancies

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Ethical approval or Declaration of Competing Interest

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Institutional Review Boards of Yale University.

Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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between the ASDwos and the No ASD groups were not as apparent as those between the ASDws and the No ASD groups. RRBs characterized by a repetitive motor/physical component and unusual sensory responses differentiated the ASDws group from the ASDwos group. Conversely, RRBs characterized by rigid adherence to routine, and ritualistic behavior increased the odds of membership in the ASDwos group over the No ASD group.

Conclusions: Our results may improve the ability of clinicians and parents to detect ASD in the community by observing specific RRBs, especially in cognitively intact school-aged children who show significant compulsive/ritualistic behaviors and rigidity to routines/sameness RRBs, even in the absence of multiple RRBs or severe repetitive sensorimotor behaviors.

Keywords

Restricted and repetitive behavior; Autism spectrum disorder; ASD children with service experiences; ASD children without service experiences

1. Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder that is characterized by two core symptoms: deficits in social communication/interaction and restricted, repetitive patterns of behavior and interests (American Psychiatric Association [APA], 2013). There has been an upward trend in the prevalence estimates of ASD reported in most countries during the last few decades (Alshaban et al., 2019; Kim et al., 2011; Kogan et al., 2018; May et al., 2020) for a variety of reasons including advanced identification process and awareness. Early detection of ASD is particularly important as it leads to early intervention, which appears to be crucial for better long-term developmental outcomes in individuals with ASD. Previous studies have suggested early signs and symptoms of ASD that may be critical in early diagnosis such as impairments in social communication, language, visual, motor, play, and cognitive functioning (Jeans et al., 2013; Zwaigenbaum et al., 2009). While there has been progress in the early identification of those individuals at risk for ASD, there seem to be a significant number of children with ASD who remain unidentified and untreated in community settings until school age and beyond (Kim et al., 2011). Thus, there is a need to further identify reliable and valid signs and symptoms to support earlier identification of those at risk for ASD so they can be carefully assessed, appropriately diagnosed, and referred for early and timely interventions.

Much of the work, to date, has focused on social communications in ASD while the second major diagnostic criterion, “restricted and repetitive behaviors (RRBs),” has received considerably less attention. Research indicates that verbal and nonverbal communication deficits were the first area of concern in parents of children with ASD, and parents tended to notice behavior problems in their children later (Jeans et al., 2013; Kozlowski et al., 2011; Maenner et al., 2013). Moreover, when early onset social-communication impairments are noted by parents, there is a greater likelihood of both early diagnosis and early service experience. Even though early impairments in social communication more often lead to early ASD diagnosis, RRBs, the other core ASD diagnostic criterion, do not appear to be clearly associated with early diagnosis and service initiation. The few studies of parental concerns that led to early detection (Becerra-Culqui et al., 2018; Zablotsky et al., 2017)

reported that early parental concern about unusual gestures and movements resulted in early diagnosis but not early service seeking. Additionally, behavioral difficulties, including insistence on sameness and tantrums, tend to be reported later to clinicians, despite significant early parental concerns. Parental concern about behavioral difficulties as well as unusual responses to sensory stimuli were unrelated both to the ages at which children received ASD diagnosis and when they began service usage.

Relative ambiguity in how RRBs contribute to an early diagnosis of ASD can be accounted for certain characteristics of RRBs. The Diagnostic and Statistical Manual of Mental Disorders-5 (DSM-5; APA, 2013) defines restricted and repetitive patterns of behavior and interests as involving a broad range of idiosyncratic responses classified into four behavior categories: stereotyped motor movement or speech, insistence on sameness and rituals, circumscribed interests, and hyper- or hypo-reactivity to sensory stimuli. Some RRBs frequently occur in early development irrespective of presence or risk for developmental disorders; they may even be developmentally functional for children without disabilities (Arnott et al., 2010; Thelen, 1979). Moreover, some RRBs, especially insistence on sameness and circumscribed interests, are manifested later in development while others, such as stereotyped motor movements, are observed as early as infancy (Bishop et al., 2006; Schertz et al., 2016). Since RRBs are common in both typical and atypical development, they may not be primary concerns that lead parents to request early assessments and interventions by clinicians, especially when the child has no significant intellectual and adaptive impairments.

There is accumulating evidence suggesting that RRBs are of diagnostic significance. In general, it has been reported that children with ASD displayed more severe, frequent, and numerous RRBs than children with other disabilities or typically developing children (Bodfish et al., 2000; Harrop et al., 2014; Kim & Lord, 2010; Richler et al., 2007; Watt et al., 2008). Past research indicates that diagnostic group differences vary by the type of RRBs. For instance, Richler et al. (2007) reported that children with ASD had more repetitive sensorimotor behaviors (RSM) than those with other disabilities and those without disabilities. However, insistence on sameness (IS) tended to remain consistent across groups. Although the prevalence of RRBs did not significantly differentiate individuals with autism from those with PDD-NOS groups, Kim and Lord (2010) reported that children with autism exhibited more severe RRBs than those with PDD-NOS. This indicates the need to consider not only the presence of RRBs but also other RRB measures, including severity and variability, in order to gain a clearer understanding of RRBs in children with ASD.

The dearth of evidence on the specificity or predictive validity for RRBs in ASD diagnosis may be due to the fact that current RRB research on individuals with ASD has predominantly been conducted using only clinic-referred samples. Such data included children with an ASD diagnosis who were receiving services (i.e., ASD with service experiences group; ASDws), but not those with ASD who were previously unidentified and untreated in the community (i.e., ASD with service experiences group; ASDwos). Although there has been no attempt to compare RRBs of children with ASD from the two different ASD populations, a few studies lend some support to an assumption that ASDws and ASDwos populations would differ in the severity and topographies of RRBs. Bishop et al.

(2006) reported that some RRBs (e.g., hand and finger mannerisms, repetitive use of objects, unusual sensory interests) were more common in children with low-functioning ASD, while other RRBs (e.g., circumscribed interests, compulsion/ritual) were more prevalent in children with high-functioning ASD. Similarly, children with autistic disorder exhibited more severe repetitive sensory and motor behaviors and engaged in more symptoms than those with PDD-NOS or Asperger's disorder (Georgiades et al., 2007; Kim & Lord, 2010; Richler et al., 2007). Given that high-functioning children with ASD are less likely to be referred for clinical and/or special education services (Kim et al., 2011), it can be assumed that the severity and variability of RRBs in the ASDwos group would be distinct from those in the ASDws group. Such characteristics of RRB in the ASDwos group, when identified, can promote the earlier identification of and intervention for children with ASD through public awareness programs.

The current study primarily aimed to contrast RRBs in two different ASD groups, "ASD with service experiences (ASDws)" and "ASD without service experiences (ASDwos)," using a community-based epidemiological sample. We also included another comparison group, the "No ASD group," to clarify the diagnostic significance of specific RRBs observed in children without ASD. Age, gender, intellectual functioning, language level, and symptom severity that prior research reported to be related to RRBs (Antezanae et al., 2019; Harrop et al., 2014; Kim & Lord, 2010; Ray-Subramanian & Weismer, 2012; Schertz et al., 2016; Szatmari et al., 2011) were included in the analysis as control variables.

The current study addressed the following research questions.

Question 1: Does the severity of each RRB differ across groups (ASDws, ASDwos, and No ASD)?

Question 2: Does the variability of RRBs differ across the three groups?

Question 3: Which types of RRBs can predict group membership in the three groups?

2. Methods

2.1. Participants

The study participants were drawn from a total population prevalence study (Kim et al., 2011). It includes 22,394 children born from 1994~1999 (ages 7 to 12-years-old at the time of screening) in a suburb in metropolitan Seoul, South Korea. All children who were in regular and special education schools, as well as those listed in the Disability Registry for the study area were invited to participate in the study. Informed consent was obtained from the parents of the research participants. Confirmative diagnostic assessments were performed with the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2001), Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003), Korean-Wechsler Intelligence Scale for Children-III (K-WISC-III; Kwak, Park, & Kim, 2001), and Leiter International Performance Scale-Revised (Leiter-R; Roid & Miller, 1997) in screen positive children (Teacher-Autism Spectrum Screening Questionnaire (ASSQ) 10 and/or Parent-ASSQ 14) [see Kim et al. (2011) for the details of the case identification processes].

Clinical best estimate diagnoses were made based on DSM-5 criteria using all available clinical information.

A total of 296 screen positive children with confirmative diagnostic assessments were included in analyses of this study. The ASDws group ($n = 104$) consisted of children who were confirmed to have ASD and received clinical/educational interventions, whereas children in the ASDwos group ($n = 84$) were confirmed to have ASD, but had never received any services. The No ASD group ($n = 108$) comprised of children who were screen-positive, but were confirmed not to have ASD. In the No ASD group, 74 had other psychiatric diagnoses (including attention deficit hyperactivity disorders, anxiety disorders, learning disorder, intellectual disability, externalizing and/or internalizing problems, depression, tic disorders, and disruptive behavior disorder) and 34 had no psychiatric diagnoses.

2.2. Measures

2.2.1. Restrictive and Repetitive Behaviors—Sixteen RRB items were selected from the ADI-R (Lord et al., 1994): Items 33 (*stereotyped utterances*), 36 (*inappropriate questions/statements*), 37 (*pronominal reversal*), 38 (neologisms/idiosyncratic language), 39 (verbal rituals), 67 (unusual preoccupations), 68 (circumscribed interests), 69 (repetitive use of objects), 70 (compulsion and rituals), 71 (unusual sensory interests), 72 (*undue general sensitivity to noise*), 73 (*abnormal idiosyncratic response to sensory stimuli*), 74 (*difficulties with minor changes in routines*), 75 (*resistance to trivial changes*), 77 (*hand and finger mannerisms*), and 78 (*other complex mannerisms*). Although the RRB algorithm of the ADI-R consists of eight items (i.e., Items 39, 67, 68, 69, 70, 71, 77, and 78), we included Items 33, 36, 37, 38, 72, 73, 74, and 75 (stereotyped or repetitive speech, ritualized patterns of verbal behavior, and unusual reactivity to sensory stimuli) in RRB according to the DSM-5 criteria (APA, 2013). Each item was coded between 0 (no RRB), 1 (not sufficient in severity or frequency of RRB to meet “2”) and 2 (definite RRB), with 3 (extreme severity of RRB). Due to the sample size, scores of 3 were converted to 2 for the purpose of these analyses. Two aspects of RRBs were then examined: severity of individual RRB and variability of types of RRBs. Severity of individual RRB was based on parental report, ranging from 0 to 2. Variability of types of RRB was computed by tallying the number of RRB items scored 2 (definite RRB), yielding a total score ranging from 0 to 16. The ADI-R was conducted by the research staff, who achieved research reliability.

2.2.2. Cognitive Functioning—The Leiter-R (Roid & Miller, 1997) standardized for Korean edition (Shin & Cho, 2009) was administered to assess the intellectual functioning of the participants. To minimize the influence of language capacity (Dethorne & Watkins, 2006), performance IQ was used to represent cognitive function in the current study.

2.2.3. Overall Language Level—Caregivers’ responses to Item 30 (how much speech their child had) from the ADI-R (Lord et al., 1994) were used as a measure of the overall level of language of the participants. A score of 0 indicates that the child uses functional language, including comprehensible three-word phrases or more, while scores of 1 (*no functional use of three-word phrases, but use at least five words*) and 2 (*fewer than five words or no speech*) indicate no use of functional speech. Scores of 2 were collapsed with 1

when the language measure was used as a control variable in the analyses, as there were no participants who scored 1 or 2 in the ASDws and only one in the No ASD groups.

2.2.4. ASD Symptom Severity—Calibrated severity scores (CSS) were computed from the ADOS (Gotham et al., 2009; Hus et al., 2014). CSS is a standardized continuous measure of overall severity of ASD symptoms (CSS). The SA-CSS reflects severity of social-affective function whereas the RRB-CSS indicates severity of restricted and repetitive behaviors. CSS scores range from 1 (no or little symptoms) to 10 (most severe symptoms).

2.3. Data Analysis

One-way analyses of variance (ANOVAs) and the Chi square (χ^2) test were performed to determine group differences in gender, age, non-verbal IQ, overall language level, CSS, SA-CSS, and RRB-CSS. A series of Chi-square test were then used to examine the differences in score distribution of individual RRB items across the groups. In addition, a one-way analysis of covariance (ANCOVAs) was conducted to examine differences in the variability of types of RRBs among the three groups with a variability score as a dependent variable, group membership as an independent variable, and age, gender, performance IQ, overall language level, and the SA-CSS as covariates. Scheffe's post-hoc test was conducted to determine which group(s) significantly differed from the other(s). We also tested the linearity of the logit using binary regressions with the continuous predictor variables for three pairs of the group membership (i.e., ASDws vs. ASDwos, ASDwos vs. No ASD, and ASDws vs. No ASD). All the interaction terms yielded p values greater than 0.05, confirming the assumption of a linear relationship between log odds and predictors. Therefore, we conducted a multinomial logistic regression analysis to determine individual RRBs that predict group membership, with severity scores of 16 RRB items as independent variables and age, gender, performance IQ, overall language level, and the SA-CSS as covariates. As Items 32–41 of the ADI-R are for children who are verbal, only 272 verbal children were included in analyses for five items (i.e., *stereotyped utterances*, *inappropriate questions/statements*, *pronominal reversal*, *neologisms/idiosyncratic language*, and *verbal rituals*).

3. Results

3.1. Sample Characteristics

The characteristics of the participants are summarized in Table 1. The proportion of boys (83.65%) was highest in the ASDws group ($\chi^2 = 11.61$, $df = 2$, $p < .01$), although boys outnumbered girls in all three groups. There were no significant group differences for age. Mean performance IQ (73.33) of the ASDws group was the lowest among the three groups, while there was no difference between the ASDwos (97.77) and No ASD groups (98.44) ($F = 39.92$, $p < .001$). More than 20% of the children in the ASDws group did not use functional language, while all participants in the ASDwos (100.00%) and all except one in the No ASD (99.10%) groups were reported to have the functional use of spontaneous, echoed, or stereotyped language, including at least three-word phrases, on a daily basis ($\chi^2 = 40.74$, $df = 2$, $p < .001$). The difference in the overall CSS ($F = 81.97$, $p < .001$) and RRB-CSS ($F = 35.50$, $p < .001$) for all the three groups was statistically significant: ASDws (7.70

and 6.55) > ASDwos (6.81 and 5.02) > No ASD (3.67 and 3.53). The SA-CSS ($F = 76.06$, $p < .001$) for the ASDws and ASDwos groups (7.98 and 7.33) were significantly higher than that of the No ASD group (4.11), but there were no significant differences between the ASD groups.

3.2. Group Differences in the Severity of Individual RRB

Significant differences in the scores of 14 out of 16 ADI-R items were noted across the three groups (See Table 2 and Figure 1). The largest proportion of children with ADI-R-based RRBs coded as 2 was in the ASDws group followed by the ASDwos and No ASD groups ($\chi^2 = 11.57\text{--}68.35$, $p < .05$), except Items 33 (*stereotyped utterances/delayed echolalia*) and 68 (*circumscribed interests*). The percentage of children coded as 2 on Item 33 (*stereotyped utterances/delayed echolalia*) was the highest in the ASDws group, followed by the No ASD and ASDwos groups, while the ASDwos group recorded the highest proportion of definite RRBs for Item 68 (*circumscribed interests*) followed by the ASDws and No ASD groups. There were no significant differences among the groups in Items 38 (*neologisms/ idiosyncratic language*) and 39 (*verbal rituals*).

3.3. Group Differences in the Variability of Types of RRBs

After controlling for gender, age, performance IQ, overall language level, and SA-CSS, the differences in RRB variability scores among the three groups were statistically significant ($F = 27.98$, $p < .001$; Table 3). The post-hoc test showed that the three groups significantly differed, indicating that the ASDws group exhibited the greatest number of RRBs (4.35), followed by the ASDwos group (2.20) and then the No ASD group (1.03). Among the five covariates, being male and having lower performance IQ were significantly associated with higher RRB variability scores, whereas age, overall level of language, and SA-CSS were not.

3.4. RRBs and Group Membership

Multinomial regression analyses, with group membership as the dependent variable and RRB item scores as predictors, revealed several RRB items that significantly predicted group membership. The models were adjusted by gender, age, performance IQ, overall language level, and SA-CSS. Identical multinomial regression analyses were repeated with different reference levels for each dependent variable—Model 1 with the ASDwos group and Model 2 with the No ASD group as reference groups. The likelihood ratio tests revealed 12 RRBs items that significantly contributed to predicting group membership after controlling for five control variables. Four RRBs did not report significant contributions: *inappropriate questions/statements* (Item 36), *neologisms/idiosyncratic language* (Item 38), *verbal rituals* (Item 39), and *abnormal response to sensory stimuli* (Item 73).

Table 4 depicts the odds ratios of the 12 RRBs that predicted group membership in comparison to a reference. Compared to the ASDwos group, odds of being in the ASDws group were higher among children who had ever exhibited (i.e., coded as 1 or 2) *stereotyped utterances/delayed echolalia* (Item 33), *pronominal reversal* (Item 37), *unusual preoccupations* (Item 67), *repetitive use of objects* (Item 69), *unusual sensory interests* (Item 71), *difficulties with minor changes in routines* (Item 74), *hand and finger mannerisms* (Item

77), and *other complex mannerisms* (Item 78) than those who did not exhibit these RRBs (i.e., coded as 0) (Model 1). Compared to the ASDws group, odds of being in the No ASD group were higher among children who had never exhibited *circumscribed interests* (Item 68), *repetitive use of objects* (Item 69), *compulsion/rituals* (Item 70), *difficulties with minor changes in routines* (Item 74), *resistance to trivial changes* (Item 75), and *other complex mannerisms* (Item 78) than those who exhibited these RRBs (Model 1). Furthermore, odds of membership in the ASDws group over membership in the No ASD group were higher among children who exhibited all 12 RRBs than those who did not (Model 2).

4. Discussion

Our results show that the percentage of children who engaged in definite RRBs (i.e., RRB items coded as 2) was higher in the ASD groups than in the No ASD group for the majority of RRBs, as expected, although the No ASD group also exhibited some RRBs. This confirms previous findings that children with ASD displayed greater severity of RRBs than those without ASD (Bodfish et al., 2000; Kim & Lord, 2010). Richler et al. (2007) reported that the severity of RRBs related to RSM factor, including the repetitive use of objects, unusual sensory interests, and hand/finger/other complex mannerisms, differed in children with and without ASD, but the severity of IS rarely differed. The authors suggested this lack of differential capacity for IS could be partially explained by the young age of their study participants (under age 3) as IS behaviors are not common during infancy. In our school-aged children, we found differences in both RSM and IS behaviors between the ASD and No ASD groups, supporting the findings of Richler et al. (2007).

Further, the outcomes also support the clinical validity of including RRBs in the DSM-5 ASD diagnostic criteria. In particular, the DSM-5 extended the category of RRBs by including sensory issues that the DSM-IV did not contain. Indeed, our findings demonstrated the utility of sensory symptoms in distinguishing children with ASD from those without ASD, given differential score distributions of all three RRB sensory symptoms—*unusual sensory interests*, *undue general sensitivity to noise*, and *abnormal response to sensory stimuli*—across the three groups. Generally, the percentage of children that depicted severe sensory symptom RRBs (to the extent that they interrupted the child and/or family functioning) was the highest in the ASDws group and lowest in the No ASD group.

With respect to score distributions of RRB-related speech, there were no differences in *neologisms/idiosyncratic language* and *verbal rituals* across three groups. This may be because *neologisms/idiosyncratic language* and *verbal rituals* are less likely to occur in children who mostly emit brief utterances (Volden & Lord, 1991). Considering the lower levels of intellectual functioning in the ASDws group compared to the other two groups, it is plausible that this group did not exhibit significant *neologisms/idiosyncratic language* or *verbal rituals* due to their limited language capacity. Our finding that no group differences were found in the distribution of severity scores in these RRB items (i.e., *neologisms/idiosyncratic language* and *verbal rituals*) should be interpreted with caution, as it might be due to low occurrences of these symptoms across groups (hence, inadequate power). Independent studies including a sufficient number of participants exhibiting *neologisms/idiosyncratic language* and *verbal rituals* are needed. Further examination of group

differences in the percentage of children with definite RRBs uncovered discrepancies between the ASDwos and the No ASD groups that were not as apparent as those between the ASDws and the No ASD groups for the other RRBs-related speech (i.e., *stereotyped utterances/delayed echolalia, inappropriate questions/statements, and pronominal reversal*). In other words, it may be relatively difficult to distinguish children in the ASDwos group from those without ASD with respect to language-based RRBs.

When comparing the two ASD groups, it was interesting that the ASDws group reported a significantly higher RRB-CSS and a greater percentage of children exhibiting severe RRBs than did the ASDwos group for all RRB types, except *circumscribed interest*, while no difference was observed in SA-CSS between the two groups. These findings imply that the severity of RRBs may significantly have influenced parents' decision to seek support services for their children, hence forming the ASDws group. This may be because RRBs are more observable by parents, and/or cause more challenges in everyday life, than are the social-communication deficits of their children (Leekam et al., 2011). Unlike other RRBs, definite or extremely *circumscribed interests* were more prevalent in the ASDwos group than in the ASDws group. Our result is consistent with the work of Bishop et al. (2007). They reported that *circumscribed interests* were more prevalent in children with a higher nonverbal IQ than in those with a lower nonverbal IQ, while other RRBs were more prevalent in children with a lower nonverbal IQ. This was even more the case for children ages 6–12. The authors postulated that it was because *circumscribed interests* require adequate intellectual functioning and being old enough to have access to different topics and activities. Children in the ASDwos group in our study were 6–12-years-old with an average IQ. Therefore, our findings suggest that ASD is a possible diagnosis for cognitively intact school-aged children with *circumscribed interests* and social-communication deficits.

We also observed that children with ASD engaged in a greater number of definite or severe RRBs than those without ASD, after controlling for age, gender, intellectual functioning, overall language level, and autism symptom severity (measured by the SA-CSS), supporting prior findings (Kim & Lord, 2010; Richler et al., 2007). While the DSM-5 stipulates that children must have RRBs to meet the diagnostic criteria for ASD, it does not specify the variability of RRBs. In our additional ANCOVA analyses, including the covariate RRB-CSS that indicates severity of RRB, group differences still remained significant despite a decrease in the F value (ASDws > ASDwos > No ASD, $F = 21.88$, $p < .001$). Therefore, a greater number of RRBs exhibited may increase the probability of a child being diagnosed with ASD early and exposed to services, independent of the RRB severity. Specifically, children in the ASDws group exhibited more types of RRBs than those in the ASDwos group. This suggests that the greater number of RRBs increases the likelihood that a child will be referred to clinical/educational services. As in the RRB severity, however, the difference in the RRBs variability was not evident between the ASDwos and No ASD groups. Taken together, these findings indicate the importance of considering a diagnosis of ASD in older children with intact cognitive functioning, a few RRBs, and severely circumscribed interests.

Our finding also revealed that specific RRBs predicted group membership. As expected, the majority of RRBs predicted membership in the ASDws group over the No ASD group, indicating the significance of individual RRBs in the clinical diagnosis of ASD. Notably,

RRBs predicting membership in the ASDwos group over the ASDws group were different from those that predicted membership in the ASDwos group over the No ASD group. In general, RRBs related to RMS, which are characterized by a repetitive motor/physical component and unusual sensory responses (e.g., *stereotyped utterances/delayed echolalia, repetitive use of objects, unusual sensory interests, and hand and finger mannerisms*), differentiated children in the ASDws group from those in the ASDwos group. These RRBs have several characteristics: (a) They tend to emerge during infancy and worsen in children with ASD (Arnott et al., 2010; Schertz et al., 2016); (b) RRBs involving a motor component are easily identified by families; and, (c) adaptive skills are negatively related to RSM behaviors (Cuccaro et al., 2003; Szatmari et al., 2006). Such characteristics appear to increase the probability of children being referred earlier for ASD diagnosis or intervention.

Conversely, RRBs related to IS, which are characterized by higher intellectual functioning, rigid adherence to routine, and ritualistic behavior (e.g., *circumscribed interests, compulsion/rituals, difficulties with minor changes in routines, and resistance to trivial changes*) increased the odds of membership in the ASDwos group over the No ASD group. This finding suggests that children in the ASDwos group are less likely to exhibit repetitive movements and unusual sensory behaviors than those in the ASDws group and more likely to engage in insistent on sameness and fixated interests compared to those in the No ASD group. These RRBs exhibited by children with intact cognitive functions may be misinterpreted as oppositionality, selfishness, rigidity, stubbornness, or being gifted/smart rather than RRB symptoms in ASD (Barrio et al., 2019).

Our results show that four RRBs (i.e., *inappropriate questions/statement, neologisms, verbal rituals, and abnormal response to sensory stimuli*) did not predict group membership. There are two plausible explanations: 1) the low occurrence of symptoms in Items 38 (*neologisms/ idiosyncratic language*) and 39 (*verbal rituals*) across groups may have obviated their ability to predict group membership due to inadequate statistical power, and 2) it is possible that some RRBs might be more related to receiving diagnosis and services for ASD than others, although ASD diagnosis does not rely on the presence of specific RRBs. Future independent research with larger sample sizes is warranted to test these hypotheses.

4.1. Implications

Our findings may prove to be useful for researchers, clinicians, and caregivers. Using a representative community population of children with ASD, our study replicates prior findings suggesting the presence of RRBs with greater severity and variability in children with ASD than in those without ASD. There is also the suggestion that children with ASD who are unidentified and untreated in the community are different from those with ASD who have clinical/educational service experiences with respect to RRBs. Compared to the ASDws group, children in the ASDwos Group engaged in no/less severe RMS and less variable RRBs while exhibiting more severe compulsive/ritualistic behaviors, resistance to changes, and circumscribed interests than those in the No ASD group. Although identifying ASD among verbally fluent school-aged children is difficult (Grzadzinski et al., 2016), our results may improve the ability of clinicians and parents to detect ASD in the community by observing specific RRBs, especially in cognitively intact school-aged children who show

significant compulsive/ritualistic behaviors and rigidity to routines/sameness RRBs, even in the absence of multiple RRBs or severe RSM behaviors.

4.2. Limitations and Future Directions

There are several limitations to our study. First, RRBs were measured using retrospective parental reports on the ADI-R items, which are subject to recall bias. Since a full range of RRBs cannot be easily captured using in-person assessments, parental reports are commonly used in measuring RRBs in clinical and research settings. Past research has demonstrated acceptable reliability on parental RRB measures (e.g., Arnott et al., 2010; Troyb et al., 2016; Wolff et al., 2016). Nonetheless, future research may use supplementary methods such as direct observation of children's behaviors in daily settings to substantiate and/or augment parental reports of RRBs. In addition, a single item of the ADI-R was used to measure children's language level. Clinician-led, comprehensive language assessment is warranted in future studies. Second, the sample size in the current study was modest. Since multiple comparisons between the research groups were conducted, with each group constituting approximately 100 or less children, the modest sample size may have limited the statistical power. Future research with larger sample sizes will be able to better elucidate differences in RRBs exhibited by children from different populations. Moreover, the current study only included children with ASD among ASSQ screen positive children, thereby excluding children who were screen negative but had ASD. Future research is warranted to evaluate RRB patterns in this specific false screen negative group of children with ASD. Third, the current study focused on how RRBs in the ASDwos group differed from those in the ASDws and the No ASD groups in order to understand the relationships between RRBs and early service seeking or ASD diagnosis. Future research needs to consider other important factors for service-seeking behaviors such as family income and cultural stigma.

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Highlights

- Inclusion of ASD population without prior histories of service use
- Higher prevalence of severe circumscribed interests in ASDwos group
- Specific RRB patterns by group membership of ASDws vs. ASDwos vs. No-ASD
- Utility of specific RRB in identifying cognitively intact older children with ASD

Figure 1. Comparisons of percentages of ADI-R item scores among the three groups

Note. Only 272 verbal children were included in the analyses for *stereotyped utterances*, *inappropriate questions/statements*, *pronominal reversal*, *neologisms/idiosyncratic language*, and *verbal rituals*. ASDws denotes ASD with service experiences and ASDwos denotes ASD without service experiences.

Table 1

Characteristics of the ASDws, ASDwos, and No ASD groups (N = 296)

	ASDws (<i>n</i> = 104)	ASDwos (<i>n</i> = 84)	No ASD (<i>n</i> = 108)	χ^2	<i>F</i>
Gender: <i>n</i> (%)					
Boy	87 (83.65)	62 (73.80)	68 (62.96)	11.61**	-
Girl	17 (16.35)	22 (26.20)	40 (37.04)		
Age (years): Mean (<i>SD</i>)	10.36 (1.81)	9.86 (1.63)	10.20 (1.80)	-	1.94
Leiter-R performance IQ: Mean (<i>SD</i>)					
	73.33 (27.93) ^a	97.77 (20.08) ^b	98.44 (18.85) ^b	-	39.92***
Overall level of language: <i>n</i> (%)					
Functional use of language	81 (77.88)	84 (100.00)	107 (99.10)	40.74***	
No functional use of 3-word phrases	10 (9.62)	0 (0.00)	0 (0.00)		
Fewer than 5 words	13 (12.50)	0 (0.00)	1 (0.90)		
Overall CSS: Mean (<i>SD</i>)	7.70 (2.09) ^a	6.81 (2.31) ^b	3.67 (2.67) ^c		81.97***
SA-CSS: Mean (<i>SD</i>)	7.98 (1.91) ^a	7.33 (2.30) ^a	4.11 (2.88) ^b	-	76.06***
RRB-CSS: Mean (<i>SD</i>)	6.55 (2.50) ^a	5.02 (2.95) ^b	3.53 (2.36) ^c	-	35.50***

Note. The data regarding age for one participant and the ADOS CSSs for four participants (one from ASDws, one from ASDwos, and two from No ASD) were missing. Different letters indicate significant differences at $p < .05$

**
 $p < .01$,

 $p < .001$

Table 2

Group differences in distribution of RRB item scores (N = 296)

	ASDws (<i>n</i> = 104)	ASDwos (<i>n</i> = 84)	No ASD (<i>n</i> = 108)	χ^2	Cramer's V
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)		
Stereotyped utterances/delayed echolalia					
0	30 (37.0)	56 (66.7)	75 (70.1)	34.95***	0.25
1	20 (24.7)	21 (25.0)	19 (17.8)		
2	31 (38.3)	7 (8.3)	13 (12.1)		
Inappropriate questions/statements					
0	38 (46.9)	32 (38.1)	65 (60.7)	11.57*	0.15
1	19 (23.5)	29 (34.5)	23 (21.5)		
2	24 (29.6)	23 (27.4)	19 (17.8)		
Pronominal reversal					
0	44 (54.3)	6 (7.3)	79 (73.8)	21.05***	0.20
1	22 (27.2)	19 (22.6)	25 (23.4)		
2	15 (18.5)	3 (3.6)	3 (2.8)		
Neologisms/idiosyncratic language					
0	70 (86.4)	68 (81.0)	98 (91.6)	5.36	0.10
1	10 (12.4)	13 (15.5)	8 (7.5)		
2	1 (1.2)	3 (3.5)	1 (0.9)		
Verbal rituals					
0	73 (90.1)	77 (91.7)	104 (97.2)	9.37	0.13
1	3 (3.7)	6 (7.1)	2 (1.9)		
2	5 (6.2)	1 (1.2)	1 (0.9)		
Unusual preoccupations					
0	43 (41.3)	64 (76.2)	96 (88.9)	68.35***	0.33
1	19 (18.3)	11 (13.1)	7 (6.5)		
2	42 (40.4)	9 (10.7)	5 (4.6)		
Circumscribed interests					
0	24 (23.1)	11 (13.1)	49 (45.4)	29.01***	0.22
1	35 (33.6)	26 (31.0)	29 (26.8)		
2	45 (43.3)	47 (55.9)	30 (27.8)		
Repetitive use of objects or interest in parts of objects					
0	30 (28.9)	44 (52.4)	82 (76.0)	67.91***	0.34
1	12 (11.5)	16 (19.0)	17 (15.7)		
2	62 (59.6)	24 (28.6)	9 (8.3)		
Compulsions/rituals					
0	59 (56.7)	52 (61.9)	96 (88.9)	36.82***	0.25
1	14 (13.5)	18 (21.4)	7 (6.5)		
2	31 (29.8)	14 (16.7)	5 (4.6)		

	ASDws (<i>n</i> = 104)	ASDwos (<i>n</i> = 84)	No ASD (<i>n</i> = 108)	χ^2	Cramer's V
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)		
Unusual sensory interests					
0	26 (25.0)	34 (40.5)	54 (50.0)		
1	37 (35.6)	44 (52.4)	50 (46.3)	58.00**	0.31
2	41 (39.4)	6 (7.1)	4 (3.7)		
Undue general sensitivity to noise					
0	61 (58.7)	61 (72.6)	92 (85.2)		
1	8 (7.7)	9 (10.7)	7 (6.5)	24.09***	0.20
2	35 (33.6)	14 (16.7)	9 (8.3)		
Abnormal response to sensory stimuli					
0	61 (58.7)	56 (66.7)	85 (78.7)		
1	17 (16.3)	10 (11.9)	16 (14.8)	15.55**	0.16
2	26 (25.0)	18 (21.4)	7 (6.5)		
Difficulties with minor changes					
0	55 (52.9)	50 (59.5)	91 (84.2)		
1	18 (17.3)	22 (26.2)	14 (13.0)	38.31***	0.25
2	31 (29.8)	12 (14.3)	3 (2.8)		
Resistance to trivial changes					
0	87 (83.6)	75 (89.3)	106 (98.1)		
1	9 (8.7)	7 (8.3)	2 (1.9)	15.88**	0.16
2	8 (7.7)	2 (2.4)	0 (0.0)		
Hand and finger mannerisms					
0	76 (73.1)	77 (91.7)	102 (94.4)		
1	4 (3.8)	5 (5.9)	4 (3.7)	35.32***	0.24
2	24 (23.1)	2 (2.4)	2 (1.9)		
Other complex mannerisms					
0	63 (60.6)	75 (89.3)	107 (99.1)		
1	17 (16.3)	7 (8.3)	1 (0.9)	62.60***	0.33
2	24 (23.1)	2 (2.4)	0 (0.0)		

Note. Only 272 verbal children were included in the analyses for *stereotyped utterances*, *inappropriate questions/statements*, *pronominal reversal*, *neologisms/idiosyncratic language*, and *verbal rituals*.

*
 $p < .05$,

**
 $p < .01$,

 $p < .001$.

Table 3

Group differences in variability of RRBs

	(N = 296)				
	ASDws (n = 104)	ASDwos (n = 84)	No ASD (n = 108)	F	η^2
	(SD)	(SD)	M (SD)		
Number of RRBs	4.35 (2.81) ^a	2.20 (1.71) ^b	1.03 (1.42) ^c	.98 ***	.17

Note. Gender, age, performance IQ, overall language level, and SA-CSS were included as covariates. Different letters indicate significant differences at $p < .05$ according to Scheffe's post-hoc tests.

 $p < .001$

Table 4

Results from multinomial logistic regression predicting group membership

(N = 296)									
Model 1: Reference Group (ASDws)					Model 2: Reference Group (No ASD)				
ASDws					ASDws				
B	SE	OR	B	SE	OR	B	SE	OR	
Stereotyped utterances/delayed echolalia									
1	0.54	0.41	1.71	0.44	0.89	0.65	0.48	1.92	
2	1.75	0.51	5.78**	0.58	1.46	1.38	0.53	3.96**	
Pronominal reversal									
1	0.53	0.41	1.70	0.44	0.57	1.10	0.50	2.99*	
2	1.83	0.70	6.25**	0.94	0.47	2.60	0.87	13.41**	
Unusual preoccupations									
1	0.79	0.49	2.20	0.61	0.31	1.96	0.65	7.09**	
2	1.59	0.47	4.92**	0.67	0.29	2.83	0.66	17.04***	
Circumscribed interests									
1	-0.06	0.53	0.94	0.50	0.39	0.88	0.51	2.41	
2	-0.58	0.50	0.56	0.47	0.16***	1.25	0.50	3.49*	
Repetitive use of objects									
1	-0.04	0.50	0.96	0.48	0.60	0.47	0.56	1.60	
2	0.78	0.39	2.18*	0.52	0.17**	2.56	0.54	12.92***	
Compulsions/rituals									
1	-0.86	0.49	0.42	0.59	0.12***	1.23	0.69	3.41	
2	0.21	0.44	1.23	0.61	0.18**	1.95	0.63	7.00**	
Unusual sensory interests									
1	-0.06	0.37	0.94	0.36	0.63	0.41	0.41	1.50	
2	1.32	0.56	3.74*	0.78	0.32	2.45	0.75	11.58**	
Undue general sensitivity to noise									

(N = 296)										
Model 1: Reference Group (ASDws)			No ASD			Model 2: Reference Group (No ASD)			ASDws	
	B	SE	OR	B	SE	OR	B	SE	OR	
Difficulties with minor changes in routines	1	0.13	0.58	1.14	-1.17	0.64	0.31	1.30	0.73	3.69
	2	0.72	0.43	2.06	-0.57	0.52	0.56	1.30	0.52	3.66*
Resistance to trivial changes	1	0.10	0.42	1.11	-0.91	0.45	0.40*	1.01	0.51	2.75*
	2	1.09	0.47	2.98*	-1.98	0.72	0.14**	3.08	0.75	21.69***
Hand and finger mannerisms	1	0.41	0.69	1.51	-2.20	0.90	0.11*	2.61	1.01	13.61*
	2	0.81	0.91	2.26	-	-	-	-	-	-
Other complex mannerisms	1	-0.64	0.83	0.53	-0.48	0.75	0.61	-0.16	0.93	0.85
	2	1.69	0.80	5.40*	-0.14	1.10	0.87	1.82	0.92	6.20*
	1	0.99	0.54	2.69	-2.52	1.19	0.08*	3.50	1.20	33.29**
	2	1.85	0.82	6.38*	-	-	-	-	-	-

Note. Model 2 does not include the contrast between the No ASD and ASDws groups as it corresponds to that in Model 1. Further, models were adjusted by gender, age, performance IQ, overall language level, and SA-CSS. Only 272 verbal children were included in the analyses for *stereotyped utterances*, *inappropriate questions/statements*, *pronominal reversal*, *neologisms/idiosyncratic language*, and *verbal ritual*. As the number of No ASD children coded as 2 was zero in *resistance to trivial changes* and *other complex mannerisms*, *p*-values were not calculated.

* $p < .05$,

** $p < .01$,

*** $p < .001$