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RESEARCH

Restricted and Repetitive Behavior Subtypes Show Distinct Associations with Adaptive Functioning in Autistic Children

Shir Rozenblat[1] · Rotem Lapidot[1] · Ditza A. Zachor[2,3] · Einat Avni[3] · Anat Zaidman Zait[4] · Judah Koller[1]

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Abstract

Restricted and repetitive behaviors (RRBs) are a core feature of autism spectrum disorder, yet their distinct impacts on adaptive functioning remain unclear. Adaptive functioning, including communication, socialization, and daily living skills, is critical for quality of life in autistic children. Here we performed exploratory factor analysis of the Repetitive Behavior Scale–Revised in 167 autistic children aged 3–12 years, identifying three RRB subtypes: sameness/ritualistic/restricted behaviors, stereotypic/self-injurious behaviors, and compulsive behaviors. In primary models adjusting for age and sex, sameness/ritualistic/restricted behaviors predicted lower socialization, whereas stereotypic/self-injurious behaviors predicted lower communication and daily living skills. In a sensitivity analysis additionally adjusting for IQ, in the subset of children with available cognitive data, only sameness/ritualistic/restricted behaviors remained a significant predictor across all three domains. These findings suggest that not all RRB subtypes are equally associated with adaptive functioning, underscoring the need to differentiate RRBs when designing interventions. Understanding subtype-specific associations may guide strategies that address behaviors hindering adaptive outcomes while considering those with potential regulatory functions.

Keywords Autism · Adaptive Functioning · Restricted and Repetitive Behaviors · Repetitive Behavior Scale-Revised · Vineland Adaptive Behavior Scales

Introduction

Autism spectrum disorder (henceforth "autism" [1]) is a neurodevelopmental condition characterized by social communication difficulties as well as restricted and repetitive behaviors and interests (RRBs) [2]. While social communication challenges have been the focus of much research, RRBs remain comparatively understudied, leaving significant gaps in our understanding of their function and development. In particular, it is unclear how different subtypes of RRBs may relate to adaptive functioning, which encompasses the conceptual, social, and practical skills that enable individuals to navigate daily life. The present study addresses this gap by investigating the associations between distinct RRB subtypes and adaptive functioning in autistic children.

RRBs

RRBs comprise a heterogeneous set of behaviors characterized by repetition, rigidity, and inflexibility. These behaviors include repetitive motor movements (e.g., hand-flapping), repetitive use of speech or objects, intense and narrowly focused interests, and adherence to routines and rituals [2, 3]. Autistic individuals also commonly show sensory hyper- and hyporeactivity (e.g., strong aversive responses to particular sounds or textures, or reduced responsiveness to sensory input), which the DSM-5 includes within the RRB criterion. RRBs can vary greatly both between individuals and within individuals over time and across different contexts [4].

✉ Judah Koller
judah.koller@mail.huji.ac.il

1 SeymourFox School of Education, The Hebrew University of Jerusalem, Jerusalem, Israel

2 Gray Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

3 The Autism Center/ALUT, Department of Pediatrics, Shamir (Assaf Harofeh) Medical Center, Zerifin, Israel

4 Constantine School of Education, Tel Aviv University, Tel Aviv, Israel

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Importantly, not all RRBs are uniformly maladaptive: some may serve adaptive functions such as self-regulation or coping, while others are associated with impaired functioning and reduced quality of life [5].

To capture this heterogeneity, researchers have proposed various measurement frameworks. One widely used distinction separates RRBs into lower-order and higher-order categories [6]. Lower-order RRBs, also known as repetitive sensorimotor behaviors (RSM), include actions such as motor stereotypies (e.g., hand-flapping), repetitive vocalizations, and repetitive manipulation of objects. In contrast, higher-order RRBs, often referred to as insistence on sameness (IS), involve behaviors such as restricted and intense interests, ritualized patterns of activity, excessive adherence to routines, and strong resistance to change [7].

The Repetitive Behavior Scale-Revised (RBS-R) [8] provides another influential framework, delineating six subtypes of RRBs (see Table 1). Although these subtypes are conceptually distinct, they are highly intercorrelated [9], and factor analytic studies of the RBS-R have yielded multiple plausible dimensional structures [10, 11]. Notably, the original six-subscale structure was theoretically specified rather than empirically derived [8], and no single factor solution has emerged as dominant, with competing models demonstrating comparable fit [11]. This variability likely reflects the marked heterogeneity of autism presentation across samples, resulting in different emergent factor structures.

RRB expression is shaped by multiple developmental factors, including age. Both cross-sectional and longitudinal studies indicate that the frequency and severity of RRBs change across development, with evidence for both quantitative (changes in amount or severity) and qualitative (changes in type or nature) shifts over time [12, 13]. Quantitative reviews suggest that RRBs tend to be less frequent and less severe in older individuals compared with younger individuals [3]. Qualitatively, developmental differences have been observed in the types of RRBs expressed, with younger children showing higher rates of lower-order behaviors and older children exhibiting more higher-order behaviors [9, 14].

Table 1 RRB subtypes as divided by the RBS-R (Bodfish et al., 2000)

RRB subtype	Definition	Example
stereotypic behavior	movement with no clear purpose that repeats itself	body swaying
self-injurious behavior	behaviors that cause or might cause harm to the body	hitting oneself
compulsive behavior	behavior that repeats itself based on a rule	arranging particular objects in a certain pattern
ritualistic behavior	doing daily activities in a similar way	insistence on eating the same food
sameness behavior	resistance to change	difficulty changing seats at meals
restricted behavior	limited or particular interests	being fascinated by one specific object

Sex has also been examined as a potential contributor to variability in RRB presentation, with mixed findings across studies. Some research reports no significant sex differences, while others suggest a higher overall prevalence or severity of RRBs in males [15–17]. When differences are observed, males are more likely to exhibit higher levels of restricted interests and stereotypic or motor behaviors [17, 18], whereas females have been reported to show higher rates of certain RRB subtypes, such as compulsive and self-injurious behaviors [13, 18].

Cognitive functioning is also associated with RRB presentation, with lower IQ generally linked to higher overall levels of RRBs [19]. However, this association differs across RRB subtypes. Repetitive motor behaviors consistently show negative associations with IQ, whereas other forms of RRBs, such as circumscribed interests, are often unrelated or even positively associated with cognitive functioning [13, 20–22]. Longitudinal findings further suggest heterogeneity in how IQ relates to developmental trajectories of RRBs [23, 24]. Taken together, these mixed findings underscore the importance of accounting for age, sex, and cognitive functioning when examining RRB subtypes and their functional correlates.

Although conceptual models of RRBs have advanced, their functions remain incompletely understood [25]. Some evidence suggests that certain RRBs, particularly stereotypic behaviors, may serve self-regulatory functions by reducing anxiety or modulating arousal [3, 26]. Repetitive motor behaviors and insistence on sameness may similarly support regulation of stress or sensory input, while restricted interests can provide focus, predictability, and a sense of meaning [5]. In contrast, other RRBs, such as self-injurious behaviors, are generally viewed as maladaptive and disruptive to learning and development [27, 28].

Attitudes toward RRBs are similarly complex. While some approaches emphasize the need to intervene on RRBs [29, 30], autistic adults and scholars within the neurodiversity movement have argued that, given the potential self-regulatory or communicative functions of these behaviors, intervention should not focus on their elimination per se [31]. At the same time, research consistently links RRBs to anxiety and intolerance of uncertainty. Intolerance of uncertainty is defined as difficulty coping with ambiguity and a strong preference for predictability, suggesting that heightened RRB expression may reflect underlying distress and that certain subtypes may warrant clinical attention [32, 33]. Understanding how different RRB subtypes relate to

meaningful aspects of autistic children's quality of life is essential for determining whether and when intervention is warranted.

Adaptive Functioning in Autism

Adaptive functioning is a commonly used outcome in autism research and represents a key indicator of everyday functioning and quality of life [34]. Adaptive functioning refers to the conceptual, social, and practical skills that enable individuals to meet everyday demands, such as forming friendships and participating in leisure activities [35]. Autistic individuals consistently demonstrate marked difficulties in adaptive functioning [36–38], and this pattern is formally recognized in the DSM-5 as Criterion D for autism diagnosis [2].

Multiple factors have been associated with variability in adaptive functioning in autism. Age is generally negatively associated with adaptive outcomes, with older individuals often showing greater relative deficits [39–41]. Findings regarding sex differences are less consistent: while many studies report no significant differences [16, 39, 40], others suggest that males exhibit higher overall adaptive functioning, including in social communication [17, 42] and motor skills [43].

Associations between age, sex, and adaptive functioning are further shaped by autism symptom severity and cognitive functioning [43, 44]. Although higher cognitive functioning is generally linked to better adaptive outcomes [45], this relationship is notably complex in autism, where many individuals demonstrate adaptive functioning levels substantially below what would be expected based on IQ alone. Such discrepancies may be influenced by developmental and demographic factors, including age and sex [46–48].

Adaptive Functioning and Autism Symptomatology

Methodological variability across studies has made it difficult to draw firm conclusions about the relationship between autism symptomatology and adaptive functioning. Overall, adaptive functioning has most often been found to associate negatively with autism symptom severity (e.g [41, 46, 49]), although some studies have replicated this association only among cognitively able individuals [50], and others have reported no significant relationship [38, 40, 51]. Importantly, much of this literature has focused primarily on social communication symptoms or has combined social communication and RRBs into a single composite score, limiting insight into domain-specific associations.

Relatively few studies have examined associations between adaptive functioning and RRBs independent of social communication. Available correlational findings suggest a negative relationship between adaptive functioning and RRBs [16, 52], particularly for sensory-motor behaviors and object-related RRBs [10, 14, 53]. Self-injurious behavior is the only RRB subtype for which there is consistent agreement regarding its detrimental association with adaptive functioning, with less consistent evidence for other RRB subtypes [54].

Predictive models of adaptive functioning have typically identified cognitive functioning, age, and social communication symptoms as primary predictors, with RRBs showing limited predictive utility [41, 49, 55]. However, studies focusing on young children suggest that specific RRBs, including severe preoccupation with object parts, sensory interests, and stereotyped motor movements, may predict poorer adaptive outcomes [28].

Notably, most prior work has relied on diagnostic instruments such as the Autism Diagnostic Observation Schedule (ADOS) [56] or the Autism Diagnostic Interview-Revised (ADI-R) [57] to assess RRBs. These measures are not designed to capture RRBs in a fine-grained manner and often rely on total RRB scores, effectively treating RRBs as a unitary construct. Only a small number of studies have examined RRB subtypes using the RBS-R [10, 52], which limits the ability to detect meaningful subtype-specific associations given the multidimensional nature of RRBs. Thus, treating RRBs as a single construct may obscure important differences in how specific subtypes relate to adaptive functioning.

The Current Study

Building on the literature reviewed above, the current study aimed to clarify how distinct subtypes of RRBs relate to adaptive functioning in autistic children. Accordingly, rather than treating adaptive functioning as a unitary outcome, the current study examines domain-specific associations between RRB subtypes and adaptive functioning across communication, socialization, and daily living skills. Given ongoing inconsistencies regarding the optimal dimensional structure of RRBs, we first conducted an exploratory factor analysis of the RBS-R [8] to identify the best-fitting factor structure within our sample. We then examined how the resulting RRB factors predicted adaptive functioning across domains, while accounting for children's age, sex, and cognitive functioning, to provide a more precise and developmentally informed understanding of these associations.

Methods

Participants

All procedures performed in studies involving human participants were in accordance with the ethical standards of the medical center's research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Participants were children diagnosed with autism by an interdisciplinary team of experts at a tertiary autism center within a university-affiliated medical center. We analyzed data from children aged 3–12 years at time of diagnosis whose caregivers had completed the RBS-R [8] and were administered the Vineland Adaptive Behavior Scales II [35]. Given the nature of the center, the analytic sample ($N=167$, 25.75% female; three additional age-eligible children were excluded for incomplete RBS-R data) is heterogeneous in clinical characteristics of the children (e.g., symptom severity, adaptive functioning, and cognitive functioning; see Table 2). Parental education is summarized in Table 2; race and ethnicity were not systematically coded. All children were assessed at a single tertiary autism center in central Israel, and assessments were conducted in Hebrew. The sample is therefore likely to under-represent Arabic-speaking and ultra-Orthodox families. Mean parental education (approximately 15 years for both parents) indicates that, on average, parents had some post-secondary education, which may limit generalizability to families with fewer socioeconomic resources. Inclusion required a primary clinical diagnosis of autism, and children with co-occurring conditions (e.g., genetic syndromes, epilepsy, or ADHD) were not excluded. Sample size varied slightly across analyses due to item-level and measure-level missing data; exact Ns for each analysis are reported in the relevant tables.

Measures

Vineland Adaptive Behavior Scales II (VABS-II) [35]

The VABS-II is a reliable semi-structured interview used to assess individuals in their adaptive functioning. Along with an overall adaptive behavior composite standard score (ABCS), the VABS-II produces standard scores in four domains: Communication, Daily Living Skills, Socialization, and Motor Skills. The Vineland is widely used in the autism field [e.g., 48,58]. In the current study, analyses focused on the three domain standard scores of the VABS-II (Communication, Socialization, and Daily Living Skills), consistent with the study aim of examining domain-specific associations between RRB subtypes and adaptive functioning.

Repetitive Behavior Scale-Revised (RBS-R) [8]

The RBS-R is a 43-item caregiver-report questionnaire designed to examine the severity and frequency of RRBs over the past month. Each item is rated on a 4-point Likert-type scale ranging from 0 (behavior does not occur) to 3 (behavior occurs and is a severe problem). A total score is calculated to show the severity and frequency of all RRBs, as well as individual scores for 6 subscales, as shown in Table 1 above. Because the RBS-R predates the DSM-5, it does not contain a dedicated sensory subscale. Sensory-related behaviors are instead distributed across its stereotyped, self-injurious, and restricted-interest items. The RBS-R has been found to be a reliable measure of RRBs (internal consistency: $0.78<\alpha<0.91$) [58]. Given known variability in RBS-R factor structures across samples, we conducted an exploratory factor analysis to derive a

Table 2 Descriptive Statistics

Sex	% male (*n*)		% female (*n*)	
	74.3% (124)		25.7% (43)	
Variable	N	M	SD	Range
Age (in years)	167	6.49	2.4	3-11.10
IQ	93	89.1	18.16	42–133
ADOS-2 CSS	160	7.76	1.79	3–10
VABS-II Com	164	79.33	12.77	28–110
VABS-II Soc	164	69.56	12.94	16–105
VABS-II DL	164	75.29	12.16	24–101
Mother education (in years)	162	15.17	2.54	8–24
Father education (in years)	157	14.89	2.95	5–22
Factor 1	167	1.12	0.76	0-2.82
Factor 2	167	0.29	0.45	0-2.5
Factor 3	167	0.46	0.61	0-2.67

Abbreviations: *IQ* Intelligence quotient, *ADOS-2* Autism Diagnostic Observation Schedule, Second Edition, *CSS* Calibrated severity score, *VABS-II Com* Vineland Adaptive Behavior Scales II communication score, *VABS-II Soc* Vineland Adaptive Behavior Scales II socialization score, *VABS-II DL* Vineland Adaptive Behavior Scales II daily living score

sample-specific factor solution. Results indicated that a three-factor model provided the best fit (see Supplementary Table S1).

Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) [59]

The ADOS-2 is a semi-structured, standardized assessment of communication, social interaction, and RRBs used to support autism diagnosis. Calibrated severity scores (CSS) were derived and are reported descriptively in Table 2. Data were collected between 2017 and 2020, and the ADOS-2 was administered using modules 1 to 3. Calibrated severity scores were available for 160 children.

Intelligence Quotient (IQ)

IQ scores were used as an indication of the participants' cognitive capacity. Different tests with established psychometric properties were used to obtain IQ scores, a common case in autism practice and research [22, 37, 40, 60].

Mullen Scales of Early Learning (Mullen) [61]

The Mullen assess cognitive and motor development of children from birth to 68 months across 5 indices: Gross Motor, Visual Reception, Fine Motor, Expressive Language, and Receptive Language. The Mullen yields an Early Learning Composite score, with an equivalent distribution to IQ scores. In the current study, only the Composite Score was used.

Wechsler Preschool and Primary Scale of Intelligence (WPPSI) [62]

The WPPSI is an intelligence test for children aged 2.5–7.7 years old (editions III and IV were administered), designed to assess cognitive abilities. It consists of two main scales: Verbal IQ Scale, measuring verbal abilities such as comprehension and vocabulary, and Performance IQ Scale, measuring nonverbal abilities such as perceptual reasoning and visual-spatial abilities. Only the Full-Scale IQ, comprised out of the two scales and representing general intellectual ability, was used.

Wechsler Intelligence Scale for Children - Fourth Edition (WISC-IV) [63] and Wechsler Intelligence Scale for Children-Revised (WISC-R95)[64]

The WISC is an intelligence test for children aged 6-17.11 designed to assess cognitive abilities. It is the most widely used IQ test for school-age children. Over the years, the test has been revised, re-normed and updated, such that different versions exist and both the WISC-IV and the WISC-R95 were used in our sample. Both the WISC-IV and the WISC-R95 consist of 5 primary indices: Verbal Comprehension Index, Visual Spatial Index, Fluid Reasoning Index, Working Memory Index, and Processing Speed Index. Only the Full-Scale IQ, comprised out of the 5 indices and representing general intellectual ability, was used.

All IQ scores were age-normed standardized scores (M = 100, SD = 15), allowing comparability across instruments. Cognitive measures were selected on the basis of age and developmental level: the Mullen was used for the youngest children and the Wechsler scales for older children, and a full-scale or composite score was used in all cases, with no substitution of nonverbal or ratio IQ. Among the 93 children with usable IQ scores, the instruments administered were the WPPSI (n = 49), WISC-IV (n = 30), Mullen (n = 12), and WISC-R95 (n = 2). Full-scale or composite scores may be less valid indicators of ability for minimally verbal children, who are also more likely to be absent from the subsample with available IQ data.

Data Analysis

To determine the factor structure of the RBS-R appropriate to our sample, we conducted an exploratory factor analysis using principal axis factoring with oblimin rotation. Principal axis factoring does not rely on assumptions of multivariate normality and is well suited for ordinal data [65]. Items were retained on a factor if they demonstrated a loading of 0.35 or higher and if this loading exceeded loadings on other factors by at least 0.10 [58]. Full item-level factor loadings and intercorrelations among study variables are provided in the Supplementary Materials.

Following identification of the factor structure, Pearson correlations were computed between the extracted RBS-R factors, age, IQ, and adaptive functioning domains assessed by the VABS-II communication, socialization, and daily living scores. To examine the unique contribution of RRB subtypes to adaptive functioning, we conducted three separate two step hierarchical linear regression models, one for each adaptive functioning domain. In each model, age and sex were entered at step one, with sex dummy coded as male = 1 and female = −1. Age was included given known developmental variation in RRB expression [9, 13, 14], and sex was included due to mixed findings regarding sex differences in adaptive functioning [16]. The RBS-R factors identified in the exploratory factor analysis were entered at step two.

Given the strong association between cognitive ability and adaptive functioning [40, 41], an additional set of hierarchical regression models including IQ as a predictor was conducted as a sensitivity analysis. Because IQ data

were missing for a subset of participants, these analyses were performed in a reduced subsample, with age, sex, and IQ entered at Step 1 and the RBS-R factors entered at Step 2. Corrections for multiple comparisons were not applied across the two dataset variations (full sample vs. subsample), as the subsample analysis was intended to assess the robustness of the primary findings and to rule out confounding by IQ, rather than to test a separate family of hypotheses (based on the approach suggested by [66]).

Results

Exploratory factor analysis pointed to a three-factor structure as the optimal model. Factor 1 includes items predominantly from the sameness, ritualistic and restricted behaviors subscales, Factor 2 includes items from the stereotypic and self-injurious behaviors subscales, and Factor 3 includes items predominantly from the compulsive behaviors subscale. The RBS-R sensory item loaded on Factor 1 (sameness/ritualistic/restricted) rather than with the stereotyped motor items on Factor 2 (Supplementary Table S1). Five items were removed from the structure due to an insignificant match to any of the factors. These items did not load strongly or uniquely on any single factor, suggesting poor fit with the emergent structure. The removed items were hand and finger movements, repetitive object use, repeating routines, specific walking or pacing patterns, and fascination with parts of objects; these span stereotyped-motor and higher-order content and did not load uniquely on any single factor. The three factors showed good internal reliability, Factor 1 $\alpha = 0.94$, Factor 2 $\alpha = 0.84$, Factor 3 $\alpha = 0.79$. In the current sample, internal consistency for the full RBS-R was excellent ($\alpha = 0.95$). Three-Factor endorsement can be seen in Supplementary Table S1. Correlations among the six original RBS-R subscales (Bodfish et al., 2000), their intercorrelations, and their associations with the three VABS-II domains are reported in Supplementary Table S3; all six subscales were negatively and significantly associated with all three domains (rs from −0.29 to −0.46).

To account for missing RBS-R data on the item level, we calculated the average score for each factor, rather than a sum score, preserving comparability across participants with partial data. To account for missing data on other variables, we used pairwise deletion. Pearson correlations were conducted to examine associations between all variables but sex due to the binary nature of the variable (see Supplementary Table S2). All three RBS-R factors significantly correlated with adaptive functioning across the three domains, with greater RRB severity correlating with lower adaptive functioning (r = -0.31 to -0.47). Age was also negatively correlated with adaptive functioning (r = -0.19 to -0.22), whereas IQ was positively associated ($r = 0.37$ to 0.56). Factor 3 was negatively correlated with age (r = -0.17), and all three RBS-R factors were negatively correlated with IQ (r = -0.25 to -0.32).

The three RBS-R factors were moderately correlated with each other ($r = 0.53$ to 0.69), however, collinearity diagnostics (i.e., VIF) were within acceptable limits, with all values remaining relatively low (VIFs < 2.5). Adaptive functioning domains were strongly intercorrelated ($r = 0.68$ to 0.76), reflecting substantial shared variance. Accordingly, Holm-Bonferroni correction was applied to the target variables to control for multiple dependent tests [67].

Primary analyses consisted of three two-stage hierarchical linear regression models excluding IQ, conducted on 164 observations, with adaptive functioning domains as the dependent variables. Age and sex were entered at step one, and the three RBS-R factors were entered at step two. In step 1, age and sex together explained between 4% and 7% of the variance in adaptive functioning. The addition of the RBS-R factors at Step 2 resulted in a significant increase in explained variance for all three domains: 21% increase for communication ($R^2 = 0.25$, F (5,158) = 10.78, $p < 0.001$), 25% for socialization ($R^2 = 0.3$, F (5,158) = 13.33, $p < 0.001$) and 27% for daily living ($R^2 = 0.35$, F (5,158) = 17.2, $p < 0.001$). While Factor 3 was not a significant predictor of any of the domains ($p > 0.05$), Factors 1 and 2 contributed differently to the three domains: Factor 2 was a significant predictor of communication (β = -0.33, Holm-corrected p = 0.002) and of daily living (β = -0.30, Holm-corrected p = 0.002), and Factor 1 was a significant predictor of socialization (β = -0.41, Holm-corrected $p < 0.001$). Although Factor 1 initially predicted daily living skills ($\beta = -0.21$, $p = 0.022$), this effect did not remain significant following correction for multiple comparisons (Holm-corrected $p = 0.134$). Age was consistently a significant predictor across domains, while sex was a significant predictor for daily living only. Full regression results are reported in Table 3.

The analyses were then repeated in the IQ subsample ($n = 92$) as a sensitivity analysis. Children with available IQ data ($n = 93$) did not differ from those without ($n = 74$) in age (M = 76.4 vs. 79.8 months, t = -0.77, p = 0.44), autism severity (ADOS-2 calibrated severity M = 7.8 vs. 7.7, p = 0.89), or VABS-II Communication (M = 80.6 vs. 77.8, p = 0.17). Because VABS-II Communication indexes everyday functional communication, this pattern suggests that the IQ subsample was not composed

Table 3 Full regression statistics of regression models excluding IQ, *N* = 164

Communication Score					
	β	*p*	*p*(Holm)	R^2	ΔR^2
Step 1				0.04	
Sex	0.07	0.357			
Age	**-0.18**	**. 018**			
Step 2				0.25	0.21
Sex	0.10	0.14			
Age	**-0.23**	**0.001**			
Factor 1	-0.11	0.27	1		
Factor 2	**-0.33**	**<0.001**	**0.002**		
Factor 3	-0.01	0.34	1		
Socialization Score					
	β	*p*	*p(Holm)*	R^2	ΔR^2
Step 1				0.05	
Sex	0.08	0.283			
Age	**-0.21**	**0.007**			
Step 2				0.3	0.25
Sex	0.1	0.134			
Age	**-0.24**	**<0.001**			
Factor 1	**-0.41**	**<0.001**	**<0.001**		
Factor 2	-0.14	0.097	0.483		
Factor 3	0.01	0.907	1		
Daily Living Score					
	β	*p*	*p (Holm)*	R^2	ΔR^2
Step 1				0.08	
Sex	**0.17**	**0.004**			
Age	**-0.22**	**0.026**			
Step 2				0.35	0.27
Sex	**0.2**	**0.002**			
Age	**-0.27**	**<0.001**			
Factor 1	**-0.21**	**0.022**	0.134		
Factor 2	**-0.3**	**<0.001**	**0.002**		
Factor 3	-0.1	0.293	1		

Bold font represents significant coefficients

disproportionately of more verbally able children. One child with IQ data lacked VABS-II data, so the sensitivity models included 92 children. Age, sex, and IQ scores were entered at step one, and the three RBS-R factors were entered at step two. The three predictors in step 1 explained 33% of the variance in communication, 17% in socialization, and 35% in daily living. The inclusion of the three factors led to a significant increase in explained variance in all three models: 12% increase for communication ($R^2 = 0.45$, F (6,85) = 11.82, $p < 0.001$), 23% for socialization ($R^2 = 0.4$, F (6,85) = 9.41, $p < 0.001$) and 16% for daily living ($R^2 = 0.51$, F (6,85) = 15.1, $p < 0.001$). Factor 1 was the only RBS-R factor that significantly predicted adaptive functioning, negatively predicting all three domains (communication: β = -0.30, $p = 0.019$; socialization: β = *-0.62*, $p < 0.001$; daily living: β = -0.38, $p = 0.002$). Age and IQ were significant predictors across all models, whereas sex was not significant in any of the models. Full results of the second set of regressions are shown in Table 4.

Table 4 Full regression statistics of sensitivity analysis including IQ, *N* = 92

Communication Score				
	β	*p*	R^2	ΔR^2
Step 1			0.33	
Sex	0.02	0.833		
Age	-0.15	0.082		
IQ	**0.54**	**<0.001**		
Step 2			0.45	0.12
Sex	0.083	0.309		
Age	**-0.21**	**0.011**		
IQ	**0.45**	**<0.001**		
Factor 1	**-0.3**	**0.019**		
Factor 2	-0.2	0.06		
Factor 3	0.14	0.2		
Socialization Score				
	β	*p*	R^2	ΔR^2
Step 1			0.17	
Sex	0.06	0.566		
Age	-0.19	0.049		
IQ	**0.35**	**<0.001**		
Step 2			0.4	0.23
Sex	0.12	0.179		
Age	**-0.24**	**0.006**		
IQ	**0.24**	**0.01**		
Factor 1	**-0.62**	**<0.001**		
Factor 2	-0.06	0.595		
Factor 3	0.15	0.216		
Daily Living Score				
	β	*p*	R^2	ΔR^2
Step 1			0.35	
Sex	0.07	0.391		
Age	-0.16	0.061		
IQ	**0.54**	**<0.001**		
Step 2			0.51	0.16
Sex	0.14	0.065		
Age	**-0.22**	**0.003**		
IQ	**0.42**	**<0.001**		
Factor 1	**-0.38**	**0.002**		
Factor 2	-0.13	0.181		
Factor 3	0.06	0.591		

Bold font represents significant coefficients

Discussion

The current study examined associations between distinct RRB subtypes and adaptive functioning to clarify the nature of these relationships. Given inconsistent findings regarding RRB dimensionality in prior research, we first identified the factor structure that best fit our sample and found support for a three-factor model. Consistent with previous work

[10, 14, 16], higher overall RRB severity was associated with lower adaptive functioning in autistic children, across all three domains of adaptive functioning. Critically, however, RRB subtypes differed in their predictive relevance: only Factor 1, primarily reflecting sameness, ritualistic, and restricted behaviors, emerged as the most consistent predictor of adaptive functioning, and the only subtype to predict all three domains once IQ was accounted for, whereas effects in the primary models were domain-specific.

In contrast to commonly cited theoretical and empirical models of the RBS-R, our findings supported a three-factor structure rather than the more frequently reported five-factor solution [11]. Although a three-factor model has previously been identified as a viable alternative [10], the composition of the factors in the present study differed from those reported previously. While Factor 2, largely comprising self-injurious behaviors, showed some overlap with prior work, the composition of Factors 1 and 3 diverged across studies. Together with existing inconsistencies in the literature, these findings suggest that the optimal factor structure of the RBS-R may vary across samples, likely reflecting the substantial phenotypic heterogeneity characteristic of autism.

In the initial regression models excluding IQ, lower adaptive functioning across all domains was associated with older age and greater severity of RRBs, with domain-specific contributions of Factors 1 and 2. In the second model, conducted in the subsample with available IQ data ($N=92$), cognitive functioning emerged as a significant predictor of adaptive functioning domains, and self-injurious and stereotypic behaviors were no longer significant. This pattern likely reflects the strong association between cognitive functioning and self-injurious behaviors in autism [68, 69], suggesting that these behaviors may not be independently associated with adaptive functioning beyond IQ in this sample. Nevertheless, given their clearly maladaptive nature and substantial impact on quality of life, self-injurious behaviors remain an important clinical concern when working with autistic individuals [70].

Across both models, compulsive behaviors, primarily represented by Factor 3, did not independently predict adaptive functioning domains once other RRB subtypes were taken into account. In prior work using factor structures with three or fewer factors, compulsive behaviors have often been grouped with ritualistic and sameness behaviors [10]. In the present study, Factor 1 included sameness and ritualistic behaviors as well as several items from the compulsive behaviors subscale, and this factor emerged as a consistent predictor of adaptive functioning. In behavioral terms, Factor 1 drew items from five of the six RBS-R subscales and centered on resistance to change and distress when routines are disrupted (sameness), completing everyday activities in a fixed or ordered way (ritualistic), and narrow, intense interests (restricted), together with several compulsive items. It is therefore likely that the variance associated with compulsive behaviors was captured by Factor 1, rendering Factor 3 non-predictive. Notably, Factor 1 was broad, incorporating items from five of the six RBS-R subscales, and the three factors were moderately correlated, suggesting that the identified factor structure may not fully disentangle the complex relationships among RRB subtypes and their associations with adaptive functioning.

In contrast to prior work suggesting broad age-related changes in RRB expression [3], age in the present study was associated only with Factor 3, with older children exhibiting lower levels of compulsive behaviors. Consistent with the broader literature, age was negatively associated with adaptive functioning, such that older age predicted poorer functioning outcomes [39–41]. Notably, whereas previous studies have suggested that age is a stronger predictor of adaptive functioning than autism symptom severity [41, 49], our findings indicate that certain RRB subtypes, particularly those captured by Factor 1, are associated with adaptive functioning to a similar extent as age.

Among the covariates included in the models, sex showed limited predictive value, emerging as significant in only one model step and contributing minimally to the explanation of adaptive functioning, consistent with mixed findings regarding its role in adaptive outcomes in autism [39, 42]. In contrast, IQ was a strong and robust predictor of adaptive functioning, with an effect size comparable to that of RRBs. Although this pattern aligns with associations observed in the general population, it contrasts with prior work suggesting a weaker or more complex relationship between IQ and adaptive functioning in neurodevelopmental conditions [71], underscoring the need for further investigation in larger and more diverse samples.

The negative correlations observed between all three RRB factors and adaptive functioning, together with the robust predictive value of Factor 1 and the more limited, IQ-dependent associations observed for Factor 2, are consistent with the idea that high levels of RRB engagement are associated with lower adaptive functioning [3]. In particular, pronounced sameness behaviors, a core component of Factor 1, may lead children to rigidly adhere to specific routines, people, or activities and to strongly resist change. Although such rigidity may reduce anxiety by increasing predictability, it can simultaneously constrain exposure to novel experiences, thereby limiting exploration and learning opportunities. In this context, our findings suggest that greater behavioral flexibility and tolerance of change are associated with more favorable adaptive functioning outcomes in autistic children.

An alternative interpretation of the negative associations between RRBs and adaptive functioning is that RRBs serve a regulatory function [3]. In autism, RRBs are closely linked to anxiety and intolerance of uncertainty [32], with different subtypes thought to play distinct roles in reducing anxiety and promoting a sense of control or predictability [5]. When environmental demands exceed an individual's coping capacity and stress or anxiety increases, reliance on RRBs may intensify as a form of self-regulation [33]. Heightened engagement in RRBs may therefore both signal and contribute to difficulties in adaptive functioning.

Limitations and Future Research

The findings of this study should be interpreted in light of several limitations. First, although the results provide insight into associations between RRB subtypes and adaptive functioning, they do not allow for broad generalization. The literature in this area remains inconsistent, likely reflecting substantial phenotypic heterogeneity within autism. Larger and more diverse samples will be necessary to support more robust analyses, including meaningful subtyping and stratification. In particular, the present single-center sample likely under-represents Arabic-speaking and ultra-Orthodox families and families with fewer socioeconomic resources.

Second, reliance on caregiver-report measures introduces subjectivity and the potential for shared method variance in the observed associations. Although the RBS-R is a widely used and well-validated instrument that captures multiple dimensions of RRBs, it remains a relatively broad measure based on caregiver report. Future research would benefit from the development and use of multi-method approaches that integrate objective clinical observation with caregiver and clinician reports to more precisely characterize RRBs and their functional correlates [11, 13].

Third, the models were limited by the availability of data on potentially relevant confounding variables. Factors not included in the present study, such as executive functioning difficulties [72–74], sensory processing differences [75], motor skills [76], disruptive behaviors [77, 78], and sleep difficulties [79], have all been linked to adaptive functioning. In addition, sociodemographic factors (e.g., socioeconomic status, household income) and common co-occurring conditions in autism, including anxiety, depression, and ADHD [46, 80, 81], may further shape the relationship between RRBs and adaptive functioning and should be examined in future work.

In addition, the IQ-adjusted models were conducted in a smaller subsample ($n = 92$). Because standardized cognitive testing is more readily completed by more able children, this subsample might be expected to over-represent older or more verbal children; it did not. Children with usable IQ data did not differ from the rest of the sample in age, autism severity, or adaptive communication, the last indexing everyday functional communication, so the IQ-adjusted findings are unlikely to reflect selective inclusion of more able children. A dedicated verbal measure was nonetheless unavailable, and the reduced subsample size warrants some caution. Finally, data for this study were collected at a single time point, limiting inferences about directionality or developmental change. Longitudinal studies using larger datasets are needed to more clearly characterize developmental trajectories linking RRB subtypes and adaptive functioning over time.

Conclusion

The current findings advance understanding of how distinct RRB subtypes relate to adaptive functioning by highlighting the importance of disaggregating this symptom domain. When RRBs are treated as a single construct, meaningful differences in the functional significance of specific subtypes may be obscured. By examining three RRB factors independently, we observed negative associations between all subtypes and adaptive functioning, although only a subset contributed meaningfully to the prediction of adaptive outcomes in autistic children aged 3–12 years.

At the same time, emerging research highlights the potentially regulatory and protective functions of RRBs in relation to mental health. For example, Waizbard-Bartov et al. [33] suggest that increases in RRBs may be associated with improved mental health, whereas decreases may coincide with heightened anxiety. This growing body of evidence underscores the need for a nuanced approach to intervention. Although the present study found that all three RRB subtypes were negatively associated with adaptive functioning, only some demonstrated meaningful predictive utility. This pattern suggests that while subtype classification is informative, it may still be insufficient to capture the individualized and context-dependent functions of these behaviors. Consequently, our findings suggest that intervention approaches targeting RRBs may benefit from considering the subjective and potentially adaptive roles of specific behaviors, rather than relying solely on categorical distinctions. On a functional and ethical level, intervention research should ensure that behaviors shown to be maladaptive are addressed, while those serving self-regulatory or protective functions are preserved. Longitudinal studies with larger, well-characterized samples are needed to further clarify the directionality and mechanisms underlying these associations.

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Authors' Contributions S.R. led the study, performed the statistical analyses, and wrote the main manuscript text. R.L. and A.Z.Z. contributed to the statistical analyses and reviewed the analytic approach. D.Z. and E.A. contributed to data collection and provided the clinical dataset. J.K. supervised the project, contributed to study conceptualization and interpretation. All authors reviewed and approved the final manuscript.

Data Availability Data will be made available upon reasonable request.

Declarations

Declaration of Generative AI and AI-assisted Technologies in the Writing Process During the preparation of this work, the authors used ChatGPT to enhance readability, improve flow, and correct grammatical errors. Following the use of this tool, the authors thoroughly reviewed and edited the content as needed and take full responsibility for the final version of the manuscript.

Competing Interests The authors declare no competing interests.

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