REPETITIVE AND RESTRICTED BEHAVIORS AND INTERESTS IN AUTISM SPECTRUM DISORDER: RELATION TO PSYCHOPATHOLOGY

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Abstract

Repetitive and restricted behaviors and interests (RRBIs) in Autism Spectrum Disorder (ASD) have significant negative impacts on well-being and daily functioning. RRBIs vary as a function of an individual's sex, age, and cognitive level as well as the presence of comorbid psychopathology. However, findings on these relationships have been ambiguous, partly due to the use of broad categorizations of RRBIs (e.g., lower- vs higher-order) rather than specific RRBIs (e.g., stereotypy) and the use of age-corrected cognitive level (i.e., IQ). The purpose of this study was to examine the patterns of specific RRBIs, obtained via the Repetitive Behavior Scale–Revised (RBS-R), in different sex, age, and raw cognitive level groups, as well as the relationship of RRBIs with internalizing and externalizing behaviors. Secondary data analyses were conducted using the Simons Simplex Collection (SSC) dataset, which included 2,758 participants ranging in age from 4 to 18 years. Across all RBS-R subtypes, results revealed no sex differences. However, older children demonstrated higher rates of Ritualistic/Sameness behaviors than younger children and adolescents, whereas younger and older children showed more Stereotypy than adolescents. In terms of cognitive level differences, the lower cognitive level groups showed higher rates of RBS-R subtypes except for Ritualistic/Sameness. After controlling for age and cognitive level, RBS-R subtypes accounted for a substantial amount of variance in internalizing and externalizing behaviors (23% and 25%, respectively). Specifically, Ritualistic/Sameness and Self-Injurious Behavior both predicted internalizing and externalizing behaviors, whereas Stereotypy only predicted internalizing behavior. These findings have key clinical implications that emphasize not only the consideration of sex, age, and cognitive level, but also specific RRBIs and associated psychopathology, when assessing for ASD and designing individualized interventions. Limitations of the present study and future directions are discussed.

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Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterized by two core deficits: social communication and interaction deficits, and repetitive and restricted behaviors and interests (RRBIs; American Psychological Association [APA], 2013). ASD is a highly heterogeneous disorder, including individuals with a wide range of IQ and psychiatric comorbidities (Matson & Goldin, 2013). The core ASD symptoms in conjunction with the co-occurring symptoms of psychopathology present clinicians with a diagnostic challenge in disentangling ASD symptoms from comorbidity-induced symptoms. Further, the presentation of ASD symptoms tends to vary based on individual characteristics, such as sex, age, and cognitive level (Harrop et al., 2014; Turner, 1999). Thus, research is needed to examine the presentation of ASD core symptoms in different subgroups of individuals and determine their association to mental health problems. In the present study, RRBIs and their association with individual characteristics, including general psychopathology, were examined to further understand specific ASD profiles.

Descriptions and Presentations of RRBIs

Although required for a diagnosis, RRBIs are not as widely studied as social communication deficits despite being included in the initial description of ASD (Kanner, 1943). RRBIs are highly frequent, rigid repetitive behaviors that are often accompanied by a strong desire for sameness (Kanner, 1943). The presentation of RRBIs is highly variable and depends on individual developmental factors (e.g., age and IQ; Bishop et al., 2006; Richler et al., 2010) and comorbidities (e.g., anxiety; Garcia-Villamisar & Rojahn, 2015; Stratis & Lecavalier, 2013).

RRBIs, though variable, are often broadly categorized into two classes of behaviors: lower-level RRBIs (L-RRBIs) and higher-level RRBIs (H-RRBIs; Turner, 1999). L-RRBIs refer to behaviors that are not cognitively mediated and appear aimlessly repetitive and stereotypic, such as hand flapping or repetitive manipulation of an object. Higher-level RRBIs (H-RRBIs) refer to the more complex behaviors that are cognitively mediated and specialized, such as circumscribed interests or rigidity in complex routines (Turner, 1999). Similarly, Cuccaro et al. (2003) described a similar dichotomous classification after examining the factor structure of the Autism Diagnostic Interview – Revised (ADI-R). Specifically, the two categories were repetitive sensory motor behaviors, equivalent to L-RRBIs, and insistence on sameness, equivalent to H-RRBIs.

Dichotomous classifications of RRBIs, however, oversimplify the conceptualization of RRBIs and must be utilized cautiously as important differences within a class may be obscured by its broad classification (Turner, 1999). For example, although both are considered L-RRBIs, it is clear that the consequences of stereotyped behavior and self-injurious behavior are vastly different. To address this issue, Bodfish et al. (1999) created an informant-based report called the Repetitive Behavior Scale (RBS) that consisted of three categories: Stereotypic Behavior, Self-Injurious Behavior, and Compulsive Behavior. Although this scale had acceptable psychometric properties, there was feedback from clinicians and families on the shortcoming of this scale in capturing the complex behaviors seen in individuals with ASD, such as rituals and restricted interests. Thus, Bodfish et al. (2000) refined this scale and added items from existing questionnaires and scales, including the Autism Diagnostic Interview – Revised (Lord, Rutter, & Le Couteur, 1994), the Childhood Routines Inventory (Evans et al., 1997), the Sameness Questionnaire (Prior & MacMillian, 1973), and the Abnormal Focused Affections Checklist

(Schultz & Berkson, 1995). This gave rise to the Repetitive Behavior Scale-Revised (RBS-R), which conceptually grouped RRBIs into six distinct rationally derived subtypes: stereotypic behavior (e.g., hand flapping), compulsive behavior (e.g., lining), ritualistic behavior (e.g., counting objects before brushing teeth), sameness behavior (e.g., distress upon changes in furniture), self-injurious behavior (e.g., head banging), and restricted interests (e.g., fascination with traffic lights). Subsequently, Lam and Aman (2007) empirically tested this grouping of RRBIs and found that a 5-factor model of RRBIs was a better fit, which combined ritualistic and sameness into one subscale. Classifying RRBIs into separate subtypes allows for a more comprehensive and specific assessment of these behaviors.

RRBIs are not unique to ASD or atypical development but are also exhibited early in life by typically developing (TD) infants (Thelen, 1981). Thelen's (1981) developmental theory provides a description of RRBIs as behaviors that serve multiple functions in development, with motor stereotypies implicated in an infant's transition from uncoordinated movements to more controlled and voluntary movements. The development of neuromuscular control from uncoordinated movements is also essential in the development of speech production, revealing the importance of RRBI's adaptive and cascading effects. In TD infants, RRBIs begin to decrease over time when their purpose is attained, such as skill acquisition (Wolff et al., 2014). In children with ASD, however, RRBIs persist and have been shown to impede learning and contribute to adjustment difficulties, thus negatively impacting an individual's quality of life (Boyd et al., 2012). Hence, it is not surprising that long-lasting RRBIs are found to be associated with comorbid psychiatric symptoms in individuals with ASD (Garcia-Villamisar & Rojahn, 2015; Stratis & Lecavalier, 2013). Thus, to determine whether an RRBI is normative or pathological, various developmental factors must be considered (Thelen, 1981).

The presentation of RRBIs has sometimes been found to vary as a function of an individual's sex, age, and cognitive level. However, results have been ambiguous with inconsistent findings in the literature, partly due to different measures and scoring used for cognitive level (e.g., IQ, mental age, adaptive behavior). The precise patterns of associations are complicated by different RRBI categorizations used in studies, with few studies examining individual RRBIs (Courchesne et al., 2021). The following sections outline the existing literature on RRBI patterns based on sex, age, and cognitive level.

Sex. Frazier et al. (2014) examined sex differences in autism symptoms using data from the SFARI Simons Simplex Collection (SSC; version 14.1), which consisted of 304 females and 2,114 males with ASD ranging in age from 4 to 18 years. RRBIs were assessed via the Autism Diagnostic Observation Scale (ADOS), Autism Diagnostic Interview-Revised (ADI-R), and RBS-R, and they found that females demonstrated significantly fewer repetitive behaviors as assessed via the ADI-R and less restricted interests assessed via the RBS-R. In contrast, Antezana and colleagues (2019), using a sample of 615 individuals with ASD (507 boys) ranging in age from 3 to 18 years, assessed RRBIs via individual RBS-R items and found that females engaged in more compulsive, sameness, restricted, and self-injurious behaviors than boys, who demonstrated more stereotyped and circumscribed interests. Notably, the authors emphasize that it is unclear whether these elevated rates of RRBIs are representative of the female ASD phenotype or related to the heightened levels of comorbidities found in girls with ASD. A more recent study by Siracusano et al. (2021) examined a sample of 210 children and youth with ASD (145 males) ranging in age from 3 to 18 years and found no sex differences on any of the RBS-R subtypes. Different findings could be attributed to sample differences, especially variations in the male/female split of the sample with most studies having a disproportionately higher number of

males than females. There were also different methodologies, sample sizes, and different alpha levels used in these studies. Finally, it has been suggested that, because ASD criteria were developed based primarily on the presentation of boys, symptom presentations displayed by girls may be missed.

Age. Most studies on the relationship between age and RRBIs are cross-sectional and have slightly varying findings (Berry, 2017). Mirenda et al. (2010) found different patterns in age-related RRBI patterns using a sample of young children ranging in age from 24 months to 64 months. Specifically, they found small positive correlations between age and RRBIs, such that older age was associated with more RRBIs, except for self-injurious behavior, which was endorsed less in older age groups.

Lam and Aman (2007) found age-related patterns in RBS-R subtypes using a sample of 307 individuals (253 males) with a wide age range (3 to 48 years). Specifically, their descriptive data suggested that young individuals with ASD (<=5 years old) displayed more stereotypic movements than older individuals (6+ years old) and individuals 13 years and older displayed more ritualistic and sameness behaviors. The rates of compulsive behavior, self-injurious behavior, and restricted interests were comparable across the sample. Based on Lam and Aman's (2007) findings on age-dependent patterns of various RRBI subtypes, Esbensen et al. (2009) investigated age-related differences in RRBIs using a sample of participants ranging in age from 2 to 62. Overall, they found a negative association between age and RBS-R scores, such that older age was associated with fewer RRBIs. Interestingly, they also found that younger individuals (2-21 years) displayed more L-RRBIs, whereas older individuals (over 21) displayed more H-RRBIs.

Three short-term longitudinal studies have examined age-related changes in RRBIs in younger children. Harrop et al. (2014) examined the developmental trajectory of RRBIs of 49 preschool children and toddlers, with a mean age of 45 months, over the span of 13 months via observational methods. This study did not yield any significant changes in RRBIs in that relatively short time span. Richler et al. (2010) conducted a short-term longitudinal study on the development of RRBIs in children with ASD over the span of seven years, starting at age 2. They found that the levels of L-RRBIs remained relatively stable over time and that H-RRBIs, initially low in early childhood, increased over time. These findings suggest that RRBIs are not entirely stable and may change or develop over time. More recently, Courchesne et al. (2021) longitudinally examined the prevalence of RRBIs and its associations with NVIQ and age across three timepoints: preschool age of diagnosis, at age 6, and lastly at age 11. Using the ADI-R classifications of RRBIs, the researchers found that most RRBIs decreased with increasing age.

Based on the patterns of results in ASD samples with a wide age range, younger individuals tend to display more RRBIs than older individuals. When examining the types of RRBIs, younger children engage in more L-RRBIs whereas older individuals engage in more H-RRBIs. However, the findings differ depending on the age ranges included in the samples, methodologies employed, and RRBI measurements. Further, it is important to consider the cognitive level of the samples and differentiate between actual age effects versus developmental level effects (i.e., a 3-year-old may display higher L-RRBIs but an older individual with a mental age of 3 years may show similar RRBIs). Much of the research to date has looked at age-related patterns using broad categorizations of RRBIs; thus, more research is needed to elucidate the age-related patterns across specific subtypes of RRBIs.

IQ/cognitive level. The heterogeneity of RRBIs can also vary depending on cognitive level. Research studies examining broad categorizations of RRBIs showed that individuals with a low IQ and low adaptive functioning engaged in more severe and frequent L-RRBIs than individuals with higher IQ (Esbensen et al., 2009; Gabriels et al., 2005).

Gabriels et al. (2005) examined the associations between nonverbal IQ (NVIQ) and RBS-R subtypes in a small sample of 14 children (mean age = 10 years) with ASD. Based on the distribution of the participants' nonverbal IQ scores, they were split into "High" NVIQ (NVIQ>=97) and "Low" NVIQ (NVIQ<=56). They found a negative association between NVIQ and total RBS-R scores, such that lower NVIQ generally displayed more RRBIs. However, when examining the RBS-R subtypes individually, they only found a significant difference in Sameness behaviors between the two NVIQ groups. More specifically, those in the "Low" NVIQ group had a higher prevalence of Sameness than those in the "High" NVIQ group. There were no other differences in the prevalence of RBS-R subtypes between the two groups. In contrast, Bishop et al. (2006) examined the RRBIs of a sample of 830 children with ASD ranging in age from 15 months to 11 years. Using the ADI-R, the researchers found that NVIQ was positively related to circumscribed interests, such that higher NVIQ was associated with a higher prevalence of circumscribed interests. Interestingly, they also found that the strength of the association of NVIQ increased with age; specifically, in children older than 36 months, the negative influence of NVIQ became stronger across all RRBIs assessed except for circumscribed interests. Thus, NVIQ negatively predicted the presence of RRBIs, and this prediction became stronger in older age groups. These findings lent support to the idea of distinct RRBI classes with differential associations depending on age and cognitive level.

The longitudinal study by Richler et al. (2010) examined the RRBIs of a sample of 192 children with ASD and 22 children without ASD that were initially assessed at age 2, then ages 3, 5, and 9. Richler and colleagues (2010) found that in the ASD sample, L-RRBIs were high and remained high over time, whereas H-RRBIs were low initially and increased over time. However, they also found that having a higher NVIQ at age 2 was associated with lower levels of L-RRBI with improvement in its severity over time. Courchesne et al. (2021), in the longitudinal study mentioned above, did not observe any significant associations in RRBI patterns as a function of NVIQ alone. However, they did find that NVIQ and age interacted significantly, such that higher NVIQ predicted the stability in Sameness behaviors over time while lower NVIQ predicted an increase in those behaviors.

In sum, the evidence discussed suggests that key developmental factors (i.e., age and IQ) influence the presentation of RRBIs in the ASD population and both must be considered when designing a study examining RRBIs and associated clinical characteristics. However, with the nature of IQ being age-corrected, its use as a measure of cognitive ability in individuals with neurodevelopmental conditions has been called into question (Dennis et al., 2009; Rizeq et al., 2017). Thus, using non-age corrected measures (e.g., raw scores or mental age) of intellectual ability is recommended (Rizeq et al., 2017). Therefore, it will be preferable to clarify the role of cognitive ability level independent of age by using a raw score such as mental age. While the literature has investigated the effects of age and IQ on the presentation of RRBIs, to parcel out the effects of age from intelligence, this study will use a non-age-corrected measure (mental age) as an indicator of what we will term “cognitive level”.

Psychopathological Consequences of RRBIs

Individuals with ASD may experience a wide range of co-occurring emotional and behavioral problems (Garcia-Villamisar & Rojahn, 2015; Lai et al., 2019; Matson & Goldin, 2013; Skokauskas & Gallagher, 2012). A systematic review on rates of mental health problems in the ASD population reported that approximately 70% of individuals with ASD have one or more psychiatric comorbidity and 50% are diagnosed with multiple psychiatric comorbidities (Lai et al., 2019). These psychiatric symptoms often overlap with ASD symptom presentation, making it difficult to determine whether they are symptoms of true psychopathology or a reflection of RRBIs. Psychopathology in ASD has only recently been acknowledged as potentially distinct from, rather than as a symptom of, ASD (Matson & Goldin, 2013). Comorbid psychopathologies may alter the presentation of ASD symptoms and have implications for treatment and prognosis.

Research has revealed that RRBIs negatively impact an individual's well-being, which may have cascading negative impacts on the development of psychopathology (Baribeau et al., 2020; Boyd et al., 2012; Garcia-Villamisar & Rojahn, 2015; Gabriels et al., 2005; Stratis & Lecavalier, 2013). For example, attempting to inhibit or stop an individual with ASD from engaging in RRBIs can lead to agitation, anxiety, or even aggression (Lam & Aman, 2007). With the phenomenology of RRBIs still largely unknown, it is evident that these behaviors have negative consequences for individuals and their families that go above and beyond ASD alone (Boyd et al., 2012; Ozsivadjian, et al., 2020). Thus, it is important to elucidate the relationship between RRBIs and psychiatric comorbidities.

Georgiades et al. (2011) investigated the shared phenotypes of psychiatric symptoms and core diagnostic domains of ASD. They found substantial overlap between RRBIs and emotionally reactive behaviors, anxious/depressed, attention problems, and aggressive behavior. These associations were independent of intellectual functioning, warranting further research into the link between RRBIs and emotional and behavioral problems. Another study by Stratis and Lecavalier (2013) found associations between specific RRBI subtypes and psychiatric comorbidities, some of which were moderated by level of adaptive functioning, a developmental level variable based on informant report, that is strongly correlated with cognitive level. Specifically, they found that ritualistic/sameness behaviors were positively predictive of anxiety and Oppositional Defiant Disorder severity, regardless of adaptive functioning level. Restricted interests were negatively predictive of depressive severity and compulsive behaviors were positively predictive of Attention Deficit/Hyperactive Disorder severity (Stratis & Lecavalier, 2013). There were also some interactions with adaptive level. When adaptive functioning was high, self-injurious behavior was positively predictive of anxiety and depressive severity. When adaptive functioning was low, ritualistic/sameness behaviors were positively predictive of depressive severity, and self-injurious behavior was negatively predictive of anxiety and depressive severity.

Taken together, these findings suggest that RRBIs are implicated as predictors in the later development of psychopathology and some subtypes may be dependent on (i.e., be moderated by) the developmental level of an individual. Interestingly, Garcia-Villamisar and Rojahn (2015) found that comorbid psychopathology and stress mediated the relationship between RRBIs and other autistic symptoms. They suggest that by targeting treatment of psychopathology and reducing stress, RRBI severity may decrease, leading to overall symptomatology improvement.

By examining associated psychopathology, researchers can further clarify the nature of RRBIs in ASD and consider their prevalence when designing treatments (Stratis & Lecavalier, 2013).

Not only are RRBIs often stigmatizing and deemed as socially inappropriate, but they also often occupy an individual's waking hours, interfere with learning opportunities, and affect family functioning (Boyd et al., 2012; Gabriels et al., 2005). Jang and Matson (2015) found that higher ASD severity, including higher RRBI severity, predicted higher comorbid psychopathology, which not only altered the presentation of ASD symptomatology but also led to subsequent difficulties in functioning. Further, a longitudinal study by Baribeau and colleagues (2021) tracked children's trajectory of insistence on sameness and anxiety and found that children who experienced increased severity of insistence on sameness over time also experienced an identical trajectory of increased anxiety. Thus, Baribeau et al. (2021) revealed the possibility of predicting a child's anxiety trajectory based on RRBI severity. These findings should be interpreted while keeping in mind the difficulty in distinguishing psychopathology from RRBI behaviors, as they may be alluding to the same underlying construct. Further research is needed to elucidate the association of RRBIs and psychopathology to gain a better understanding of various symptom profiles (Tureck et al., 2014). This knowledge can help inform initial assessment, prognosis, and individualized treatment plans. Given the influence of age and IQ on RRBI patterns, studies should control for these variables while examining the link between RRBIs and psychopathology.

Study Objectives and Hypotheses

Overall, the objective of this study was to elucidate the different specific types of RRBIs in a large sample of children and youth with ASD, who are heterogeneous in age and cognitive

level, and to explore the association of RRBIs with psychopathology. The two main domains of psychopathology are Internalizing Behavior (e.g., anxiety) and Externalizing Behavior (e.g., aggression; Krueger, 1999). These two domains represent psychopathological symptoms but do not definitively indicate psychiatric diagnoses. This is a particularly important point as research on emotional and behavioral functioning in ASD is typically gathered via informant- or self-report measures, and not comprehensive clinical assessments. Thus, this study will examine broad domains of psychopathology that represent the presence of symptoms.

The first objective was to examine the presence of individual RRBIs in children and youth with ASD based on various sex, age, and cognitive level variables and to look for differences across groups within each of those categorical variables. Due to the ambiguous results in the literature regarding patterns of RRBI in different sex and age groups, no hypotheses were provided regarding RRBI patterns in each of the groups. In addition, non-corrected cognitive level has not been examined in relation to RRBI; therefore, no hypotheses were made for RRBI patterns in different cognitive level groups.

The second objective was to explore the relationship of RRBIs to psychopathology, taking developmental factors of age and cognitive level into account. We anticipate based on previous literature that RRBIs will be associated with psychopathology; however, this objective was also exploratory since we set out to examine specific RRBIs and operationalized psychopathology as internalizing and externalizing behavioral difficulties. Overall, this study aimed to answer the two following research questions:

1. What pattern of RRBIs is present in different sex, age, and cognitive level subgroups?

2. What is the relationship between each subtype of RRBI and internalizing and externalizing behaviors while controlling for age and cognitive level?

Method

Participants

Participants consisted of 2,758 children and youth (86% males; age range 4-18 years) from the Simons Simplex Collection (SSC) of the Simons Foundation for Autism Research Initiative (SFARI) who met criteria for ASD as assessed via the Autism Diagnostic Interview-Revised (ADI-R) and the Autism Diagnostic Observation Schedule (ADOS). See Table 1 for the descriptive statistics of the sample. Exclusion criteria for participants included complicated medical histories (e.g., prematurity) motor or sensory impairments, or genetic syndromes (e.g., Fragile X). Probands with siblings or parents who may have ASD, suspected intellectual disability or severe learning disability, diagnosed with schizophrenia, developmental, or psychiatric disorder were excluded from this study. In addition, if probands' siblings had an IEP for extensive special education services or if parents were third-degree relatives (or closer) or did not speak English, they were excluded from this study. All participants had a nonverbal mental age of 24 months or greater.

Table 1

Descriptive Statistics of Sample

	N	*M* (*SD)*	Range
Age (yrs)	2758	9.0 (3.6)	4.0-18.0
Cognitive level (mos)	2752	87.8 (48.8)	9.7-345.6

Procedure

We applied for and were granted permission to use the SFARI database for this study (https://www.sfari.org/). We obtained ethics approval from the York University Human Participants Review Committee. Secondary analyses of the SSC of the SFARI database were conducted in the present study. This database was created to learn more about ASD phenotypes and genotypes. The SSC dataset was a main project of SFARI, which consists of data collected from individuals with ASD from simplex families (i.e., only one child in the family is diagnosed with ASD). Participants were recruited through 12 university-affiliated research clinics, mostly based in the United States, that formed an alliance to recruit probands from simplex families that were receiving ASD services. The sites consisted of Baylor College of Medicine, Children's Hospital, Boston/ Harvard Medical School, Columbia University, Emory University, McGill University, University of California, Los Angeles, University of Illinois at Chicago, University of Michigan, University of Missouri, University of Washington, Vanderbilt University, and Yale University. The principal investigators at each site were composed of a clinical psychologist and a geneticist (Fischbach & Lord, 2010). Recruitment for this study ended in 2011.

Informed consent and child assent were obtained at the site of the study. Once identified with an ASD diagnosis, behavioral measures were administered to collect information regarding the child's intellectual ability, adaptive behavior, motor coordination, emotional and behavioral problems, and language abilities. A comprehensive medical history of the child's prenatal and perinatal development, developmental milestones, immunizations, medications, dietary supplements, and enrollment in behavioral programs were also gathered form parents via questionnaires. In addition to parking reimbursement, families were provided with $25 for completing the questionnaires and an additional $50 for each family member that participated in

the rest of the study. Duration of time needed to complete questionnaires was approximately 6 hours for the parents and 3 hours for the proband assessment. Data collected were de-identified and entered in a secure database to protect the family's privacy. See Table 1 for family demographics.

Table 2

Demographic Information of Sample

	n	%
Annual household income		
< $20,000	247	9.2
$21,000-$50,000	520	19.3
$51,000-$80,000	844	31.4
$81,000-$100,000	410	15.3
$101,000-$130,000	80	3.0
$131,000-$160,000	141	5.3
> $161,000	443	16.5
Total	2685	100.0
Mother's education		
Less than high school	6	0.2
Some high school	23	0.8
High school diploma/GED	238	8.1
Some post-secondary	613	21.8
Associate degree	226	8.0
Bachelor's degree	1020	35.7
Graduate degree	711	25.4
Total	2837	100.0
Father's education		

Less than high school	13	0.5
Some high school	54	1.9
High school diploma/GED	341	12.1
Some post-secondary	540	19.2
Associate degree	187	6.7
Bachelor's degree	882	31.4
Graduate degree	793	28.2
Total	2810	100.0
Parent's marital status		
Never married	64	2.3
Married	2563	89.7
Separated	39	1.4
Divorced	171	6.0
Total	2837	100.0

For the first objective in this study, individuals were grouped by age and cognitive level. Age was divided into early childhood (4 to 5:11 years), middle childhood (6 to 10:11 years), and adolescence (11 to 18 years), as set logically by the SFARI team based on preschool-aged children, elementary school-aged children, and middle and high school-aged youth. Cognitive level was grouped by the present authors, based on the distribution of the data and clinical judgement. Categories were constructed using the raw mental age scores (in months) to 120+, 84-119, 49-83, and <=48. See Table 3 for descriptive statistics for these categorical variables. For the second objective, however, continuous measures of age (in years) and cognitive level (mental age in months) were used.

Table 3

Descriptive Statistics for Categorical Variables

	n	%
Age groups		
Early childhood	639	23.2
Middle childhood	1361	49.3
Adolescence	758	27.5
Total	2758	100
Sex		
Males	2383	86.4
Females	375	13.6
Total	2758	100
Cognitive Level groups		
120+	615	22.3
84-119	612	22.2
49-83	921	33.5
<=48	604	22
Total	2752	100

Measures

Repetitive Behavior Scale-Revised (RBS-R; Bodfish, Symons, Parker, & Lewis, 2000). The RBS-R is a parent-report measure of the type and severity of RRBIs, consisting of 43 items

rated on a 4-point Likert scale, from 0 (*behavior does not occur*) to 3 (*behavior occurs and is a severe problem*). Raters are instructed to refer to the previous month when responding to each item. There was very little missing data but if one item was missing from any of the first three RBS-R factors, the average of the remaining items for that scale was computed; however, if two or more items were missing, the data for that scale were omitted for that individual. If even one item was missing from the latter two scales, which had fewer items, then the respective scale data was omitted from analysis for that individual.

As noted earlier, the RBS-R was conceptually grouped by Bodfish et al. (2000) into six subscales, however, Lam and Aman (2007) conducted an independent factor analysis and derived five empirically-supported subscales of the RBS-R. Five items from the original RBS-R did not load highly on any of the five factors and were omitted from the scoring. Lam and Aman's scoring system were used in this study due to its empirically supported psychometric properties. The five Lam and Aman (2007) subscales include (1) Stereotyped Behavior (e.g., *Body rocking, Body swaying*), (2) Self-Injurious Behavior (e.g., *Pulls hair or skin*), (3) Compulsive Behavior (e.g., *Collects, hoards or hides specific items*), (4) Ritualistic/Sameness Behavior (e.g., *Objects to visiting new places*), (5) Restricted Interests (e.g., *Strongly attached to one specific subject or activity (e.g., trains, computers, weather, dinosaurs*). Lam and Aman (2007) derived a Cronbach's alpha of 0.91 for Ritualistic/Sameness Behavior, 0.84 for Self-Injurious Behavior, 0.85 for Stereotyped Behavior, 0.79 for Compulsive Behavior, and 0.78 for Restricted Interests. The internal consistency of the RBS-R subscales in this sample revealed Cronbach's alpha values ranging from good to acceptable (see Table 4 for RBS-R psychometrics).

Table 4

Psychometric Properties of the RBS-R Scales

RBS-R Factors	Number of items	*M*	*SD*	Cronbach's α
R/S	12	8.31	6.45	.871
SIB	8	2.09	2.86	.718
STEREO	9	6.31	4.79	.795
COMP	6	2.98	3.00	.711
REST	3	3.71	2.46	.665

Note. R/S = Ritualistic/Sameness; SIB = Self-Injurious; STEREO = Stereotypy; COMP = Compulsive; REST = Restricted Interests.

Achenbach System of Empirically Based Assessment (ASEBA; Achenbach & Rescorla, 2001). Two of the ASEBA family of measures were used in the present study, one for the younger age group (1.5-5 years), the other for the older children and adolescents (6-18 years). The Child Behavior Checklist (CBCL) is a parent-report measure of Internalizing and Externalizing behaviors, often used to assess psychopathology. The items on the scale are rated on a 3-point Likert scale, ranging from 0 (*not true*) to 2 (*very true or often true*). The two composite scores used in the present study were Internalizing Behavior, which includes Anxious/Depressed, Withdrawn, and Somatic Complaints (α = 0.90 in CBCL/1.5-5 and 0.91 in CBCL/6-18) and Externalizing Behavior, which includes Rule-Breaking and Aggressive Behaviour (α = 0.90 in CBCL/1.5-5 and 0.92 in CBCL/6-18). A sample item from the Internalizing composite is *Feelings are easily hurt* in CBCL/1.5-5 or *Worthless* in CBCL/6-18. A sample item of the Externalizing composite is *Hits others* in CBCL/1.5-5 or *Fights* in CBCL/6-18. The two versions have similar scales but not all identical items. Therefore, *T* scores (an age

and sex standardized score with a mean of 50 and SD of 10) for Internalizing and Externalizing behaviors were used as the dependent variable measures of psychopathology.

Cognitive level measures. The dataset includes a measure of the child's cognitive level, based on one of several different IQ measures (as is common in autism research depending on an individual's age and developmental level). These measures were the Differential Ability Scales-Second Edition (DAS-II; Elliott, 2007), Mullen Scales of Early Learning (MSEL; Mullen, 1995), Weschler Intelligence Scale for Children-Fourth Edition (WISC-IV; Wechsler, 2003) or the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). Deviation IQs were available for 82% of the sample and Ratio IQs for 18% of the sample. For purposes of this study, IQ scores from all tests were converted into mental age scores (MA= (IQ x chronological age) /100), which were then used in all analyses as a raw measure of cognitive level.

Statistical Analyses

IBM SPSS Statistics V27 was used for all data analyses in the present study. First, preliminary data analyses were conducted in which descriptive statistics were run for all our variables of interest, grouped by age, sex, and cognitive level. This summary data enabled us to scan the dataset for any missing and impossible values, determined via the range of scores, as well as any potential input errors from data entry. The distributions and descriptive statistics were computed for all variables. There were no significant concerns and all values fell within a sensible range. Due to the very large sample size and to be as conservative as possible, the alpha value was set as $p < .001$ to determine significance. Further, Games-Howell post hoc tests were used when appropriate to account for the possibility of unequal population variances in various subgroups.

The first research question on the level of each RRBIs in age (early childhood, mid childhood, and adolescence), sex, and cognitive level (120+, 84-119, 49-83, and <=48) subgroups was determined via a *t* test (for sex) and two one-way ANOVA analyses for age and cognitive level subgroups, followed by Games-Howell post hoc tests as appropriate.

The second research question on the association between RBS-R subscales and Internalizing and Externalizing Behavior *T* scores was examined via correlational and regression analyses. Thus, the distributions of all variables were examined. The CBCL *T* scores of Internalizing and Externalizing Behavior were normally distributed, whereas all RBS-R mean subscale scores appeared positively skewed. However, due to the large sample size, deviations from normality does not invalidate the results (Field, 2018). The linearity and homogeneity of variance assumptions were met, determined via inspecting the relationship of each RBS-R subscale with Externalizing and Internalizing Behavior. The lack of substantial correlations between predictors, as demonstrated via the correlational analysis, indicates a lack of collinearity in the data, satisfying the multicollinearity assumption. Further, Durbin-Watson for Externalizing and Internalizing Behaviors revealed independence of residual values. Finally, no influential cases were found (Cook's Distance < 1).

Results

Objective 1: Levels of RRBIs Across Individual Characteristics

The first objective of the present study was to determine any significant differences of RRBI severity across the groups within each of the child variables (i.e., sex, age, and cognitive level, all used as categorical variables). A *t* test was used to determine any difference between males and females. Two one-way ANOVAs were conducted to determine any differences within

the three age groups and the four cognitive level groups. These ANOVAs were followed up by post hoc comparisons to specify where any potential differences lie within each variable.

RRBIs in Males and Females

The *t* test revealed similar rates of RRBIs in males and females with no significant differences on any of the RBS-R scales (using our conservative *p* value). See Table 5 for the *t* scores between males and females for each of the RBS-R scales.

Table 5

Mean Scores of RBS-R Severity in Males and Females for Each Subscale

	Sex						*t*	*p*	*d*
	Male			Female					
	n	*M*	*SD*	*n*	*M*	*SD*			
R/S	2370	.69	.54	373	.71	.53	.60	.548	.03
SIB	2369	.26	.34	374	.30	.37	2.05	.041	.11
STER	2361	.71	.53	372	.63	.51	-2.64	.008	-.15
COMP	2374	.50	.50	375	.52	.49	.95	.344	.05
REST	2380	1.25	.82	373	1.17	.81	-1.74	.083	-.10

Note. R/S = Ritualistic/Sameness; SIB = Self-Injurious; STER = Stereotypy; COMP = Compulsive; REST = Restricted Interests.

* $p < .001$.

RRBIs in Each Age Group

RBS-R scores were compared across the three age groups (early childhood, middle childhood, and adolescence). See Table 6 for RBS-R descriptive statistics within each age group and Table 7 for the group comparison results. Significant between-group differences were found

in the Ritualistic/Sameness and Stereotypy scales of the RBS-R. In the Ritualistic/Sameness scale, post hoc tests revealed that the middle childhood group demonstrated more Ritualistic/Sameness than the early childhood group (M = .74, SD = .55 vs. M = .62, SD = .50). This between-group difference within the Ritualistic/Sameness scale was significant with a small effect size. In the Stereotypy scale, individuals in the early childhood (M = .80, SD = .55) and middle childhood group (M = .72, SD = .53) demonstrated more Stereotypy than those in the adolescence group (M = .57, SD = .50). This between-group difference within the Stereotypy scale was significant with a small effect size. No between-group differences were found for the Self-Injurious, Compulsive, or Restricted Interests scales.

Table 6

Descriptive Statistics of RBS-R Severity for Each Subscale Across Age Groups

RBS-R Factors	Age Groups								
	Early Childhood			Middle Childhood			Adolescence		
	n	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
R/S	636	.62	.50	1356	.74	.55	751	.69	.54
SIB	635	.24	.36	1354	.27	.35	754	.27	.37
STER	637	.80	.55	1349	.72	.53	747	.57	.50
COMP	638	.49	.49	1356	.51	.51	755	.49	.49
REST	639	1.19	.85	1359	1.29	.82	755	1.19	.80

Note. R/S = Ritualistic/Sameness; SIB = Self-Injurious; STER = Stereotypy; COMP = Compulsive; REST = Restricted Interests.

* $p < .001$.

Table 7

RBS-R Severity across Age Groups

RBS-R Factors	*F*	*df1*	*df2*	*p*	η^2	Games-Howell Post Hoc
R/S	11.19*	2	2740	< .001	.01	M > E
SIB	1.13	2	2740	.32	.00	-
STER	33.63*	2	2730	< .001	.02	E, M > A
COMP	.55	2	2746	.58	.00	-
REST	5.24	2	2750	.01	.00	-

Note. R/S = Ritualistic/Sameness; SIB = Self-Injurious; STER = Stereotypy; COMP = Compulsive; REST = Restricted Interests. E = Early Childhood; M = Middle Childhood; A = Adolescence.

* $p < .001$.

RRBIs in Each Cognitive Level Group

Similar comparisons were made across the four cognitive level groups (120m+, 84m-119m, 49-83m, and <=48m). See Table 8 for RBS-R descriptive statistics within each cognitive level group. Significant between-group differences were found in all scales of the RBS-R.

Table 8

Descriptive Statistics of RBS-R Severity for Each Subscale Across Cognitive Level Groups

RBS-R Factors	Cognitive Level Groups							
	120m+		84-119m		49m – 83m		<=48m	
	n	*M(SD)*	*n*	*M(SD)*	*n*	*M(SD)*	*n*	*M(SD)*
R/S	611	.69(.54)	607	.76(.56)	919	.71(.53)	601	.62(.53)
SIB	614	.24(.34)	609	.22(.33)	917	.25(.36)	598	.34(.40)
STER	608	.47(.43)	607	.63(.51)	913	.71(.49)	600	1.00(.56)
COMP	612	.43(.47)	611	.47(.51)	921	.53(.50)	600	.55(.50)
REST	614	1.11(.76)	611	1.24(.81)	921	1.29(.84)	602	1.30(.82)

More specifically, as shown in Table 9, within the Ritualistic/Sameness scale, Games-Howell post hoc tests revealed that the 84-119m group (M = .76, SD = .56) demonstrated greater severity on this scale than the <=48mm group (M = .62, SD = .53). This between-group difference within the Ritualistic/Sameness subscale was significant with a small effect size. Within the Self-Injurious scale, Games-Howell post hoc tests revealed that the <=48m group (M = .34, SD = .40) demonstrated greater severity than the 120+m group (M = .24, SD = .34), the 84-119m group (M = .22, SD = .33), and the 49-83m group (M = .25, SD = .36). These between-group differences within the Self-Injurious subscale were significant with a small effect size. Within the Stereotypy scale, those in the <=48m group (M = 1.0, SD = .56) demonstrated greater severity than those in the 49-83m group (M = .71, SD = .49) and those in the 84-119m (M = .63,

SD = .51). Further, the 84-119m group showed greater severity than the 120m+ group (*M* = .47, *SD* = .43). Overall, the lower the cognitive level, the higher the levels of Stereotypy. These between-group differences were significant with a medium-to-large effect size. Within the Compulsive subscale, the 49m-83m group (*M* = .53, *SD* = .50) and the <=48m group (*M* = .55, *SD* = .50) showed greater severity than the 120m+ group (*M* = .43, *SD* = .47). These between-group differences within the Compulsive subscale were significant with a small effect size. Similarly, within the Restricted Interests subscale, those in the 49m-83m (*M* = 1.29, *SD* = .84) group and the <=48m group (*M* = 1.30, *SD* = .85) showed greater severity than the 120m+ group (*M* = 1.11, *SD* = .76). These between-group differences within the Restricted Interests subscale were significant with a small effect size.

Table 9

RBS-R Severity across Cognitive Level Groups and Post Hoc Comparison

RBS-R Factors	*F*	*df1*	*df2*	η^2	Post Hoc
R/S	6.36*	3	2734	.01	2 > 4
SIB	12.40*	3	2734	.01	4 > 1, 2, 3
STER	116.28*	3	2724	.11	4 > 3 > 2 > 1
COMP	7.62*	3	2740	.01	3, 4 > 1
REST	6.72*	3	2744	.01	3, 4 > 1

Note. 1 = 120m+, 2 = 84m–119m, 3 = 49m–83m, 4 = <=48m.

* $p < .001$.

Objective 2: Association between RRBIs and Internalizing and Externalizing Behaviors

The second objective was to determine the association of each of the five RBS-R scales with the dependent variables, Internalizing Behavior and Externalizing Behavior. First,

correlations were done to screen for multicollinearity. Then, two three-step hierarchical regressions were conducted to examine the associations between the five RBS-R scales and each of the two dependent variables, Internalizing Behavior and Externalizing Behavior, controlling for age (Step 1) and cognitive level (Step 2), using continuous scores for all variables.

Correlation Analyses

Correlations were examined prior to the regression analysis between all continuous variables of interest, including the covariates (age and cognitive level), independent variables (RBS-R scales), and dependent variables (CBCL Internalizing and Externalizing *T* scores). See Table 10 for the correlation matrix. Note that, because of the decision to use raw scores of cognitive level, rather than age-corrected IQ type scores, age and cognitive level were quite strongly correlated since both reflect an aspect of developmental level (with 49% shared variance). There were minimal correlations between age and the RBS-R scales, although Stereotypy showed a small negative correlation (r = -.17). Cognitive level also demonstrated mostly small negative correlations with all RBS-R scales, with the highest being with Stereotypy (r = -.33). Thus, higher Stereotypy scores were associated with younger age and lower cognitive level.

The dependent variables, Externalizing and Internalizing Behaviors, were strongly positively correlated with each other (r = .52). They both showed similar small to moderate correlations with the five RRBI scores (ranging from r =.24 to .42), with the highest correlations for both being with Ritualistic/Sameness (r = .42 for Externalizing Behavior and r = .41 for Internalizing Behavior). Thus, RBS-R scores are correlated with both indices of psychopathology, specifically with Ritualistic/Sameness, such that higher scores are associated

with higher scores on Externalizing and Internalizing behaviors. Not surprisingly, the RBS-R scores were substantially intercorrelated with the highest correlation being between Ritualistic/Sameness and Restricted Interests (r = .60), and Ritualistic/Sameness and Compulsive (r = .56). Overall, there were no substantial correlations between any of the independent variables that would invalidate the regression analyses.

Table 10

Correlation Matrix

	Age	CL	EB	IB	R/S	SIB	STER	COMP	REST
Age	-								
CL	.70**	-							
EB	-.14	-.10	-						
IB	.05	.15	.52**	-					
R/S	.03	.02	.42*	.41*	-				
SIB	.03	-.09	.35*	.27	.35*	-			
STER	-.17	-.33*	.30	.24	.44*	.42*	-		
COMP	-.01	-.10	.25	.25	.56**	.31*	.47*	-	
REST	-.01	-.09	.28	.27	.60**	.29	.46*	.47*	-

Note. CL = Cognitive Level, EB = Externalizing Behavior, IB = Internalizing Behavior, R/S = Ritualistic/Sameness; SIB = Self-Injurious; STER = Stereotypy; COMP = Compulsive; REST = Restricted Interests.

* medium correlation (>.3)

** strong correlation (>.5)

Regression Analyses

Regression of Age, Cognitive Level, and RBS-R Scales on Internalizing Behavior. A three-step hierarchical regression analysis was conducted for Internalizing Behavior (see Table 11). Age was entered in the first block, cognitive level in the second block, and the five RBS-R predictor variables in the third block. Model 1 was not significant at F (1, 2695) = 7.04, p = .008 with an R^2 = .003, indicating that age alone accounted for negligible (0.3%) variance in Internalizing Behavior. At Step 2, adding in cognitive level accounted for an additional 2.7% of the variance in Internalizing Behavior, which was significant at F (1, 2694) = 75.84, p < .001. At Step 3, adding in the five RBS-R subtypes accounted for an additional 20.4% of the variance, which was significant at F (5, 2689) = 143.54, p < .001. In the final model, the significant predictors were age (β = -.170, p < .001), cognitive level (β = .322, p < .001), Ritualistic/Sameness (β = .288, p < .001), Self-Injurious Behavior (β = .139, p < .001) and Stereotypy (β = .117, p < .001), all of which had small to medium effect sizes (η_p^2 = .02, η_p^2 = .06, η_p^2 = .05, η_p^2 = .02, and η_p^2 = .01, respectively). Thus, lower age with a higher cognitive level and higher scores on the Ritualistic/Sameness, Self-Injurious Behavior, and Stereotypy subscales were associated with greater levels of Internalizing Behavior. However, Compulsive Behaviors and Restricted Interests were not significant predictors.

Table 11

Three-Step Regression for Internalizing Behavior – Age, Cognitive Level, and RBS-R

Model	B	SE.B	β	*t*	R^2	ΔR^2	η_p^2
1 (Constant)	59.02	.502		117.64	.003	.003	
Age	.011	.004	.051	2.65			.02
2 (Constant)	58.99	.495		119.20	.030	.027	
Age	-.026	.006	-.114	-4.25*			.01
Cognitive level	.046	.005	.233	8.71*			.00
3 (Constant)	52.32	.550		95.11	.234	.204	
Age	-.038	.005	-.170	-7.03*			.02
Cognitive level	.063	.005	.322	12.62*			.06
R/S	5.106	.419	.288	12.19*			.05
SIB	3.701	.513	.139	7.22*			.02
STER	2.112	.408	.117	5.18*			.01
COMP	.058	.413	.003	.14			.00
REST	.410	.258	.035	1.59			.00
F (7, 2689) = 117.54*							

Note. R/S = Ritualistic/Sameness; SIB = Self-Injurious; STER = Stereotypy; COMP = Compulsive; REST = Restricted Interests.

* $p < .001$.

Regression of Age, Cognitive Level, and RBS-R Scales on Externalizing Behavior. A similar three-step hierarchical regression analysis was conducted to examine each RBS-R scale's predictive power on Externalizing Behavior while controlling for the effects of age and cognitive level (see Table 12). Model 1 was significant at F (1, 2696) = 47.96, $p < 001$ with an $R^2 = .017$,

indicating that age accounted for 1.7% of the variance in Externalizing Behavior. At Step 2, adding cognitive level only accounted for an additional 1.7% of the variance in Externalizing Behavior, which was not significant at F (1, 2694) = .001, p = .976. At Step 3, adding in the five RBS-R subtypes accounted for an additional 23.6% of the variance, which was significant at F (5, 2689) = 170.23, p < .001. In the final model, the significant predictors were age (β = -.195, p < .001), Ritualistic/Sameness (β = .332, p < .001), and Self-Injurious (β = .235, p < .001), all of which had small to medium effect sizes (η_p^2 = .02, η_p^2 = .07, and η_p^2 = .05, respectively). Thus, younger age and higher scores on Ritualistic/Sameness and Self-Injurious subscales were associated with greater levels of Externalizing Behavior. However, Cognitive level, Stereotypy, Compulsive, and Restricted Interests were not significant predictors of Externalizing Behavior.

Table 12

Three-Step Regression for Externalizing Behavior – Age, Cognitive Level, and RBS-R

Model	B	SE.B	β	*t*	R^2	ΔR^2	η_p^2
1 (Constant)	60.12	.551		109.03*	.017	.017	
Age	-.033	.005	-.132	-6.93*			.02
2 (Constant)	60.12	.552		109.01*	.017	.000	
Age	-.033	.007	-.133	-4.92*			.01
Cognitive level	.000	.006	.001	.03			.00
3 (Constant)	53.46	.601		90.60*	.254	.236	
Age	-.048	.006	-.195	-8.53*			.02
Cognitive level	.016	.005	.074	2.92			.00
R/S	6.51	.458	.332	14.22*			.07
SIB	6.96	.560	.235	12.43*			.05

STER	.99	.446	.049	2.22	.00
COMP	-.55	.451	-.026	-1.22	.00
REST	.15	.282	.012	.544	.00
F (7, 2689) = 130.59*					

Note. R/S = Ritualistic/Sameness; SIB = Self-Injurious; STER = Stereotypy; COMP = Compulsive; REST = Restricted Interests.

* $p < .001$.

Discussion

The purpose of this exploratory study was to identify patterns in RRBIs experienced by children with ASD, based on an individual's sex, age, and cognitive level, and to explore the association between RRBIs and psychopathology. This study used individual RRBI scales rather than an overall measure, for a more precise understanding of the differential associations of each with individual characteristics and general psychopathology.

Similar to the findings found in Siracusano et al. (2021), the results of this study revealed no significant sex differences in the patterns of RBS-R subtypes between males and females. Thus, in this sample, males and females engaged in similar levels of each of the types of RRBIs. Although Frazier et al. (2014) used the same sample and did report that females generally showed lower RRBIs assessed via the ADI-R and fewer restricted interests assessed via RBS-R, our findings may have diverged due to the additional measure of RRBIs used and our use of a more stringent alpha level (.05 in Frazier et al. (2014) vs .001 in this study). Interestingly, although females were rated as having fewer problems with restricted interests in this study, this was not statistically significant (p=.08). The largest sex difference (but still a small effect size, d=.15) was for Stereotyped Behaviour in which females scored lower (p=.008). Importantly,

studies have shown that the types of RRBIs in females are more difficult to characterize as "atypical" (e.g., random behaviors) than those found in males (e.g., excessive lining up of toys; Hull et al., 2017; Knutsen et al., 2019). The findings on RRBI sex differences should be interpreted with caution as the RRBI assessment measures have been normed using majority male samples, which may more accurately detect RRBIs in boys than in girls (Mandy et al., 2012). Thus, parents of girls with ASD may not find this measure as accurately capturing their child's RRBI tendencies.

With respect to age differences, there were discrepancies found in the level of Ritualistic/Sameness and Stereotypy across age groups. Specifically, the middle childhood group engaged in significantly more Ritualistic/Sameness behaviors than the early childhood group, similar to patterns observed in Uljarević and colleagues (2022). This increase in Ritualistic/Sameness parallels the development of common fears and phobias in a typically-developing sample (Evans et al., 1999) and suggests that the increase in these behaviors reflect an underlying mechanism of self-regulation to reduce unpredictability in the environment (Uljarević et al., 2022). Further, the early and middle childhood group both engaged in significantly more Stereotypy than the adolescent age group, similar to previous cross-sectional and longitudinal studies (Bishop et al., 2006; Richler et al., 2010). This pattern is also found in typically-developing young children, who also display a high rate of repetitive stereotypy (Turner, 1999) that is believed to contribute to the development of motor and language skills as well as the development of general cognitive abilities; these behaviors then demonstrate a steep decline with age. There were no other significant age-related differences among Self-Injurious Behavior, Compulsive Behavior, or Restricted Interests, which deviates from findings by Uljarević et al. (2022). They found parabolic patterns in Self-Injurious Behavior and Restricted

Interests in which there were increases in the behavior followed by reductions as well as a continuous reduction in Compulsive Behaviors with age. It is important to note that Uljarević et al. (2022) used methods that captured nonlinear relationships between each RBS-R subtype with age, which may help elucidate their findings of clear age-related trajectories. If these differences were to truly exist in this sample, it may have been obscured by the nature of ANOVA capturing only linear relationships. Overall, however, it can be concluded that there seem to be some clear age-related differences in the types and severities of RRBIs rated in this sample.

With respect to cognitive level differences, we found group differences in all subtypes of RRBIs. Those with higher cognitive level engaged in significantly more Ritualistic/Sameness than those with lower cognitive level. Previous research has identified Ritualistic/Sameness as a consistent deficit found in the ASD population, independent of individual characteristics such as sex, age, and cognitive level (Bishop et al., 2006; Brierley et al., 2020). However, Uljarević et al. (2022) did find a small increase in insistence on sameness behaviors with increasing cognitive level scores. More problems with Ritualistic/Sameness in higher functioning groups can be thought of as a means of self-regulation, allowing the individual to reduce fears of uncertainty and maintain consistency in day-to-day life by engaging in rituals (Uljarević et al., 2022).

In line with previous literature (Bishop et al., 2013; Brierley et al., 2021; Mirenda et al., 2010), Self-Injurious Behaviors, Stereotypy, Compulsive Behavior, and Restricted Interests were significantly more prevalent among those in the lower functioning groups. These findings provide supporting evidence that most types of RRBIs tend to be less prevalent in individuals with higher cognitive level than those with lower cognitive level. Despite our study using non-age-corrected measures of IQ, we found similar results to those that used NVIQ or overall IQ (Brierley et al., 2021), supporting the utilization of different types of measures of cognitive level.

With the potential of RRBIs to interfere with daily functioning, learning, and well-being, it is important to get a grasp of the patterns of RRBIs that are likely to emerge in different age and cognitive level groups. In particular, research has suggested that RRBIs differ as a function of an individual's characteristics, which this study supported. Clarifying the patterns of specific RRBIs experienced by children and youth with specific characteristics is important in clinical contexts. Clinicians are encouraged to consider the patient's characteristics to provide an individualized approach to assessing and treating particular types of RRBIs children may manifest.

Given the all-encompassing nature of RRBIs and their potential hindrance of learning and positive peer interactions (Nadig et al., 2010), we sought to examine their association with psychopathology symptoms, specifically internalizing and externalizing behaviors.

Internalizing Behaviour. After controlling for the effects of age and cognitive level, our regression analyses revealed that young individuals with ASD with a higher cognitive level who had more problems with Ritualistic/Sameness, Self-Injurious Behavior, and Stereotypy demonstrated high levels of internalizing behavior. Cognitive level was the strongest predictor of internalizing behavior in this regression. Further, higher cognitive level is generally associated with increased depression and anxiety in children and youth with ASD, as seen in a study by Mayes et al. (2011). This suggests that children with lower cognitive level may not experience such feelings, or more likely, parents reporting about their children with lower cognitive level may not recognize feelings of anxiety or depression in their children. Further, these findings add to the literature on the influence of RRBIs on internalizing psychopathology. Our findings are similar to previous studies that found that Ritualistic/Sameness (Stratis & Lecavalier, 2013) and Self-Injurious Behavior (Muskett et al., 2019; Stratis & Lecavalier, 2013) were positively

associated with levels of anxiety and depression. To our knowledge, studies examining the association between Stereotypy and internalizing behaviors are sparse with only a number of studies demonstrating that toddlers with comorbid ASD and anxiety demonstrated higher levels of Stereotypy than those with just ASD (Gritti et al., 2003; Hill & Furniss, 2006). These findings suggest that young children with higher cognitive levels and who show more problems with RRBIs exhibit more symptoms of internalizing behavior.

Externalizing Behaviour. After controlling for the effects of age and cognitive level, we found that young individuals with ASD who showed more problems with Ritualistic/Sameness and Self-Injurious Behavior demonstrated high levels of externalizing behavior. Ritualistic/Sameness was the strongest predictor of externalizing behavior. Like internalizing behavior, young children seem to "grow" out of these externalizing behaviors. Guererra et al. (2019) reveals that younger children score higher on measures of aggressive behaviors, which make up our measure of externalizing behavior. These behaviors generally tend to decrease over time (Vaillancourt et al., 2017). Similar to this study, more problems with Ritualistic/Sameness have been found to be associated with Oppositional Defiant Disorder severity in previous literature (Kanne & Mazurek, 2011; Stratis & Lecavalier, 2013). Mazurek et al. (2013) also found a significant association between self-injury and aggression, in line with the findings from this study. This could be explained as the emergence of reactive aggressive behavior when a child is interrupted from engaging in rituals or self-injury; however, further research is needed to elucidate these associations. Surprisingly, cognitive level did not significantly predict Externalizing Behavior. The Externalizing Behavior score, which only includes two subscale scores (i.e., Rule-Breaking Behavior and Aggressive Behavior) may not be comprehensive enough to detect cognitive level impacts. Research suggests that the measure of CBCL

Externalizing Behavior may not be as sensitive to the types of problem behaviors experienced by individuals with ASD who have lower cognitive levels (Dovgan et al., 2019).

Overall, these findings suggest that, in addition to age and cognitive level, RRBIs are also strongly implicated in the presence of psychopathology in children and youth with ASD, accounting for about 20% of the variance. Specifically, Ritualistic/Sameness and Self-Injurious Behavior were predictive of both internalizing and externalizing behaviors; Stereotypy was only predictive of internalizing behavior. Thus, although both are lower-order RRBIs, Stereotypy and Self-Injurious Behavior were differentially related to psychopathology, suggesting different mechanisms of operation.

Although it is unclear whether RRBIs serve as coping strategies by individuals to help alleviate distress or whether RRBIs are a result of distress, the findings of this study have implications for clinicians. The differential associations between RRBIs and psychopathology indicate variability within specific RRBIs, which emphasizes the importance of using more comprehensive RRBI measures. The use of RRBI subtypes instead of a total score or a broad categorization (e.g., lower- and higher-order) allows for a clearer understanding of distinct RRBI profiles, which may suggest different mechanisms of operation that can be used as targets for intervention. For example, based on the results of this study, it may be possible to reduce symptoms of anxiety by targeting Ritualistic/Sameness behaviors, or vice versa. Given the association between RRBIs and psychopathology, clinicians are encouraged to not only consider an individual's sex, age, and cognitive level, but also the presence of specific RRBIs when assessing an individual with ASD to design an individualised intervention. It is important for RRBIs to be treated early before becoming more fixed and challenging to manage, which may impact well-being and adaptive functioning (Leekam et al., 2011; Hong & Matson, 2021).

Lastly, RRBIs are heterogenous and may tap into varying underlying neural circuity (Langen et al., 2011). Thus, identifying specific RRBI subtypes may allow researchers to identify more homogenous subgroups of individuals with ASD based on neurobiological underpinnings (Lam & Aman, 2007) and this too may have treatment implications.

Limitations and Future Research

Despite the interesting findings in this study, it is not without its limitations. Although we had a large sample size with a wide range of cognitive abilities, families voluntarily participated in the study, only had one child with ASD, making it difficult to ascertain generalizability. There were substantially more children than adolescents in the sample and more males than females, as is typically the case in ASD samples. Thus, future studies are needed with equal representations of age and sex, particularly as the female ASD phenotype is becoming more recognized. This study used informant reports to assess RRBIs and psychopathology, which, though common, may not always be accurate as parents may have habituated to the atypicality of the behavior or may overinterpret their child's behaviors. Further, although RBS-R is a well-validated measure of RRBIs, it is not without shortcomings. Specifically, Restricted Interests in the empirically supported five-factor model of the RBS-R has inadequate reliability in this study and consists of only three items, which may not capture the entirety of this domain (Lam & Aman, 2007). Additionally, research suggests that the CBCL should be used with caution in children and youth with ASD as emotional and behavioral problems may be expressed differently than in TD children (Medeiros et al., 2017). Thus, we may not be capturing the underlying construct of interest (e.g., anxiety) when examining CBCL scores in an ASD sample. By using different methods of measuring RRBIs (e.g., observational) and psychopathology (e.g., self-report if

possible; individual items of CBCL), future studies will be able to examine their association more accurately.

Moreover, this study used linear statistics to examine associations between RRBIs and psychopathology. However, a recent study has shown a nonlinear trajectory of RRBIs (Uljarević et al., 2022). Thus, future studies would benefit from using nonlinear statistics to ensure the presence of any significant nonlinear relationship is not obscured by using linear statistics. Finally, given the heterogenous nature of RRBIs, our cross-sectional design does not provide us with information on the presentation of RRBIs over time and associated changes in psychopathology. Thus, this study demonstrates the need for longitudinal studies to capture the lifetime trajectories of RRBIs and their association with psychopathology. The possibility of different developmental trajectories for subsets of children by cognitive level or sex might be a fruitful line of future research.

This study revealed some interesting differential associations of various RRBIs with individual characteristics and psychopathology. This supports the notion that RRBIs are highly heterogenous and have distinct profiles of relationships with sex, age, cognitive functioning, and psychopathology. This is of particular importance as it underscores the use of distinct RRBIs to better elucidate ASD profiles and to help clinicians select appropriate interventions that not only target individual RRBIs but also psychopathology. With the potential of RRBIs to interfere with functioning, and the consequential distress this has on families, research on accurate assessments of RRBIs and effective interventions is of utmost importance.

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