EXAMINING AUTISM SYMPTOM SEVERITY AND STRUCTURE IN IQ GROUPS

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ABSTRACT

The purpose of this study was to compare the severity and structure of autism symptoms in four cognitive-level groups: (1) those without an intellectual disability (No ID; IQ: ≥ 85;), (2) those with borderline cognitive ability (Borderline; IQ: 70-84), (3) those with an intellectual disability with verbal language (ID Verbal; IQ < 70), and (4) those with an intellectual disability without verbal language (ID Non-Verbal; IQ < 70). The data for this study were based on a sample of 2,819 children with autism who participated in the Simons Simplex Collection (SSC; Fischbach & Lord 2010).

In Objective 1, the correlations between IQ and autism symptom severity were examined, as well as comparing symptom severity in each of the four IQ groups using the Autism Diagnostic Interview-Revised (ADI-R). IQ was negatively correlated with ASD symptom severity, ranging from weak to moderate correlations. The No ID group had significantly lower scores on the Social, Communication, and Restricted Repetitive Behaviour domains in comparison to the ID Verbal and ID Non-Verbal groups. Also, the No ID group had significantly lower scores on the Social and Communication domains in comparison to the Borderline group.

In Objective 2, confirmatory factor analyses were used to compare different models of autism symptom structure in the four IQ groups using the ADI-R and then the Autism Diagnostic Observation Schedule (ADOS). Most of the common models in the literature were acceptable representations of the structure of autism, especially for children with low IQ. The *DSM-IV* and *DSM-5* models may better capture those with lower cognitive ability and more severe autism symptoms. For children with higher cognitive ability, it may be beneficial to consider elements of a 4-factor model consisting of Social, Communication, Play/Peer, and RRBI factors. This model had good fit in all four IQ groups using the ADI-R, and in three of the groups using the

ADOS. It was also the only model that had good fit for the groups with higher IQ based on the analyses from the ADI-R. This study has implications for how we conceptualize the construct of autism, specifically in terms of diagnostic criteria and assessment measures. Further replication of these findings is warranted with different measures.

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I appreciate obtaining access to phenotypic data on SFARI Base.

Approved researchers can obtain the SSC population dataset described in this study (https://www.sfari.org/resource/simons-simplex-collection/) by applying at https://base.sfari.org.

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Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder with biological and genetic underpinnings; however, to date, there is no known biological marker for the disorder (Huerta & Lord, 2012). Thus, classification and diagnosis of ASD is not based on medical procedures (e.g., blood tests) but rather on the clinical assessment of a specified set of behaviours. Although the individual behaviours or symptoms underlying the autism phenotype are well understood, there is a lack of consensus in the literature on how these symptoms are related and best structured (Shuster, Perry, Bebko, & Toplak, 2014).

Factor analytic (FA) studies can provide empirical evidence for the organization of symptoms and thereby the "structure" of the disorder. Our current understanding of ASD (American Psychiatric Association [APA], 2013) is based on FA studies providing empirical evidence for a 2-factor model of the disorder characterized by (1) impairments in Social Communication and (2) the presence of Restricted and Repetitive Behaviours and Interests (RRBI). However, it is well accepted that individuals with ASD can have a wide range of cognitive abilities, from above average cognitive ability to a cognitive level within the range of intellectual disability (ID). There is evidence in the literature that IQ-related differences may be related to ASD symptom presentation. Therefore, given the heterogeneity of symptom presentation in ASD and the potential influence of IQ on symptomatology, it is important to take cognitive level into account when examining symptom severity and structure of ASD. The objectives of this study include: (1) a detailed comparison of autism symptom severity in groups with different IQ levels, and (2) an examination of the factor structure of autism symptoms in groups with different cognitive abilities.

This dissertation will review changes in our conceptualization of autism symptom structure over the years and summarize findings of studies examining the influence of intellectual functioning on symptomatology. Furthermore, I will examine the results of all FA studies that have used the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule (ADOS-2; Lord, Rutter, Di Lavore, & Risi, 2012), two prominent assessment measures used in research and clinical practice. Using these instruments, the current study will provide empirical evidence for autism symptom severity and structure in different IQ groups.

Historical Review of Autism Symptom Structure

To understand how we have arrived at the current 2-factor model of ASD (APA, 2013), it is important to consider the historical evolution and major contributions in its conceptualization. These include major changes in terminology (e.g., from infantile autism to autistic disorder to ASD) and diagnostic criteria (e.g., changes in the number of domains of impairment, addition and removal of symptoms in each domain, and the total number of criteria). Acknowledging that terminology in the field continues to change, this document will use whichever terminology was used at the time of the cited study. The term ASD will refer to the most current classification as proposed by the most recent edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-5*; APA, 2013). The term autism will be used when discussing the underlying construct.

Kanner (1943) first coined the term “early infantile autism” to describe a group of 11 children characterized by a lack of interest in the social world and a resistance to change or insistence on sameness. Asperger (1944) used the term “autistic psychopathy” to describe similar symptoms of abnormal behaviour, with the exception that his cases had greater verbal and cognitive abilities. Rutter (1978) described characteristics of autism as impaired social relations, delayed or abnormal language development, and insistence on sameness. He also emphasized that autism often co-occurs with ID. In an early epidemiological study of autism, Wing and Gould (1979) identified a group of children as having a “triad of impairments”, which included (1) lack of social interaction, (2) impairments in language, and (3) engagement in repetitive activities in place of imaginative symbolic interests. Wing also introduced the concept of a “spectrum”, which highlights variability in symptom presentation in autism. These early descriptions of autism and its features remain essential components of the diagnostic criteria, with social difficulties as the hallmark characteristic (Volkmar & Reichow, 2013).

The *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) is commonly used by clinicians to diagnose autism and other mental health disorders. It was not until the publication of the third edition of the manual (*DSM-III*; APA, 1980) that autism became an official classified diagnosis. The *DSM-III* introduced “Infantile Autism” and other related disorders under a general class, known as Pervasive Developmental Disorders (PDD). The criteria were reflective of earlier descriptions of autism in the literature (e.g., Kanner, 1943; Rutter, 1978; Wing & Gould, 1979). The revised edition of the *DSM-III* (*DSM-III-R*; APA, 1987) included major changes in conceptualization and symptom enumeration. The name “Infantile Autism” was changed to “Autistic Disorder”, which reflected a ‘disorder’ that was no longer limited to the youngest age group (Waterhouse, Wing, Spitzer, & Siegel, 1993). While the *DSM-III* criteria were general and descriptive, the *DSM-III-R* had a minimum requirement of specific impairments in each domain to attain a diagnosis. Specifically, a total of 16 criteria were introduced to operationalize the three domains of impairment: (1) deficits in reciprocal social interaction, (2) deficits in communication and imaginative activity, and (3) the presence of a restricted repertoire of activities and interests. The PDD category also included PDD not otherwise specified (PDD-NOS), the NOS paralleling other diagnostic categories in the DSM. The *DSM-III-R* criteria allowed for a large number of permutations of symptoms; thus, autism became a broader diagnostic concept with large variability in behaviours.

DSM-IV (APA, 1994) and *DSM-IV-TR* (APA, 2000) maintained the general category of PDD, which included Autistic Disorder and PDD-NOS, and introduced Rett's Disorder, Childhood Disintegrative Disorder, and Asperger's Disorder within the PDD category. Additionally, the terminology of Autistic Disorder and the three domains of impairment were maintained. However, Autistic Disorder was characterized by a total of 12 criteria instead of 16, with four in each domain of the triad of impairment: (1) impairment in social interaction, (2) impairment in communication, and (3) restricted, repetitive, and stereotyped patterns of behaviour, interests, and activities (RRBI). Asperger's Disorder was characterized by deficits in social interaction and RRBIs, and the absence of impairments in language and cognitive level. Thus, apart from language, early development, and cognitive ability, the criteria for Asperger's Disorder were equivalent to those for Autistic Disorder (Wing, 2005). The diagnosis of PDD-NOS was used for individuals who did not meet the full criteria for Autistic Disorder but demonstrated severe and pervasive impairments in reciprocal social interaction or verbal and nonverbal communication skills, and the presence of RRBI.

The recent publication of the *DSM-5* (APA, 2013) included the most dramatic revisions to the nosology of the condition. In the *DSM-5*, the specific *DSM-IV* diagnoses of Autistic Disorder, Asperger's Disorder, Childhood Disintegrative Disorder, and PDD-NOS were merged into a unitary diagnosis called Autism Spectrum Disorder (ASD). Combining these into one category suggests that symptoms of ASD fall on a continuum of mild to severe, in contrast to a categorical approach in arriving at a diagnosis for each of the specific disorders (Tsai & Ghaziuddin, 2014). The *DSM-5* also introduced a new two-domain structure of impairments in contrast to the previous three-domain model found in the *DSM-IV* (APA, 2000). More specifically, the diagnostic criteria consist of three broad social communication (Soc-Comm) criteria (i.e., social-emotional reciprocity, nonverbal communication, and peer social relationships), all of which must be met, and four RRBI criteria (i.e., repetitive behaviour, routines and rituals, restricted interests, and sensory differences), two of which must be met. Other major changes in criteria include the removal of the criteria of delayed or absent speech (previously part of the communication domain) and preoccupation with parts of objects (previously part of the RRBI domain). Additionally, stereotyped language was included in the RRBI domain (previously part of the communication domain), and abnormal sensory behaviour was introduced as a specific criterion in the RRBI domain.

Support for the two-domain model described in *DSM-5* is based on FA research suggesting that social and communication symptoms load together and are distinct from RRBI symptoms (e.g., Frazier, Youngstrom, Kubu, Sinclair, & Rezai, 2008; Gotham, Risi, Dawson, et al., 2008; Gotham, Risi, Pickles, et al., 2007; Mandy, Charman, & Skuse, 2012). A handful of studies also support the inclusion of repetitive language (Frazier et al., 2008, Gotham et al., 2007; Gotham et al., 2008) and abnormal sensory behaviours (Mandy et al., 2012; Norris, Lecavalier, & Edwards, 2012) as part of the RRBI factor.

Intellectual Functioning and Autism Symptoms

Individuals diagnosed with ASD can have a wide range of cognitive abilities, from profound ID to above average intellectual ability. The most recent document from the Centers for Disease Control and Prevention (CDC; Baio et al., 2018) reported that 31% of children with

ASD also had ID (IQ < 70), and 25% were in the borderline range (IQ: 71-85). In a review of epidemiological studies of PDDs, Fombonne (2005) reported that 70% of those with *any* subtype of PDD also had ID, with 30% in the mild to moderate range and 40% in the severe to profound range. Notably, the prevalence of ID greatly varied depending on the subtype of PDD. For example, in a study by Chakrabarti and Fombonne (2005), 30% of preschoolers with any PDD also met criteria for ID. The rate of ID in the Autistic Disorder group was higher (67%) relative to the PDD-NOS (12%) and Asperger (0%) groups. It is clear that the reported prevalence of ID in ASD is highly variable, which may be attributed to differences in classification systems, diagnostic instruments, methodology, and sampling. Despite the discrepant rates, there is ample evidence that the two disorders often co-occur, thus it is important to take into account the impact of IQ level on autism symptomatology in both research and clinical practice.

A number of studies in the literature indicate a negative correlation between cognitive functioning and severity/presence of autism symptoms (e.g., Bishop, Richler, & Lord, 2006; DiLavore, Lord, & Rutter, 1995; Perry, Condillac, & Freeman, 2005; Spiker, Lotspeich, Dimiceli, Myers, & Risch, 2002). For example, Perry et al. (2002) reported a moderate negative correlation (-.40 to -.50) between severity of autism and severity of cognitive impairment. This makes it challenging to determine whether particular behaviours are symptoms of autism, a result of having an ID, or whether they represent shared variance between the disorders (Perry et al., 2002). In clinical practice, several key criteria for autism need to be carefully examined in relation to children's developmental level. For example, a school-age child with severe to profound ID may not have developed the ability to engage in complex reciprocal conversations or pretend play. While these deficits are a function of this child's developmental level (or his/her mental age), the same symptoms might be considered indicators of autism in a different child with a higher cognitive level.

Researchers have also used cluster analysis, which aims to group individuals according to their behavioural similarities and differences, to indicate subtypes based on severity of autism symptoms and IQ level. For example, Sevin et al. (1995) identified four subgroups in a small sample of children with autism or PDD-NOS: (1) High Functioning/Atypical PDD; (2) Mild Autism; (3) Moderate Autism; (4) Low Functioning/Severe Autism. The more severe groups were associated with greater impairments in cognitive and language levels. Similarly, Eaves, Ho, and Eaves (1994) also identified four subgroups based on severity of symptoms and level of cognitive ability. Once again, the severity of autism was related to intellectual functioning in that the subtype with the most severe symptoms had the lowest average IQ. While the results from this line of research suggest that cognitive ability is linked to a set of shared behaviours, it is unclear whether the structure of the symptoms is the same at different levels of severity.

In other studies, researchers have used IQ cut-off scores to compare high- and low-functioning groups. One of the first studies of this type (Bartak & Rutter, 1976) showed that a group of children with autism and ID (IQ < 70) had greater language delay, more disturbed personal relationships, and more disruptive behaviours in comparison to a group with autism without ID. Specifically, the authors reported that 77% of children in the group with ID did not display joint play as compared to only 21% of the group without ID. The ID group also had higher rates of insistence on sameness, whereas the group without ID had more ritualistic behaviours and greater sensitivity to noise. Both groups showed similar levels of circumscribed interests. A more recent study of children and youth with autism showed that lower IQ (<80) and/or younger age was linked to greater symptom severity in autism, specifically poor social interaction (e.g., disconnectedness), deficits in communication (e.g., lack of speech), repetitive behaviours (e.g., stereotypies, fixations), and sensory difficulties (e.g., mouthing or smelling objects, limited food preferences). In contrast, higher IQ (≥ 80) and/or older age was linked to unusual fears, selective attention, and hypersensitivity to noise (Mayes & Calhoun, 2011).

Overall, findings from a large number of studies using various methods (i.e., correlational, categorical, and cluster analyses) suggest that the severity of autism symptoms differs according to level of cognitive functioning. However, there are a number of limitations with this line of research. Firstly, most studies have compared individuals with autism with and without ID, combining the severity of ID into one category. There would be utility in building on the existing literature by examining the severity of deficits and/or strengths in subgroups of children with ASD that are based on graded levels of functioning, ranging from those with no ID to those with ID in subgroups ranging from mild ID to profound ID. Secondly, there is a gap in the literature as to whether the structure of autism symptoms (as opposed to just their severity) differs with varying levels of IQ. Therefore, it is also important to examine the factor structure of autism in more graded IQ groups. This approach to sample characterization, in a large sample of individuals with a wide range of symptom severity and cognitive ability, will be beneficial to clinical practice and can enhance sample specification relevant for many areas of research.

Factor Analytic Findings of Autism Symptom Structure

FA studies have been commonly used to inform our understanding and conceptualization of symptom domains in various disorders. By deriving fewer underlying or latent dimensions from a larger set of correlated items or symptoms, FA can provide empirical evidence for the organization of symptoms and thereby the "structure" of the disorder. For example, the shift from three domains of ASD symptoms in the *DSM-IV* to two domains in the *DSM-5* is supported by a number of FA studies (Shuster et al., 2014). Using this statistical approach, along with well-informed critical thinking and experience, can enhance our understanding of the nature of autism.

To date, most FA studies have relied on items on the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003), whereas a few others have used the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 1999; Lord et al., 2012). Briefly (see Measures section for more detail), the ADI-R is a caregiver interview examining symptoms in three domains: Language/Communication, Reciprocal Social Interactions, and Restricted, Repetitive, and Stereotyped Behaviours. The ADOS is a semi-structured observational/interactional measure that is designed to elicit specific behaviours related to language and communication, social interaction, play and imagination, stereotyped behaviours and restricted interests, and other behaviours. The ADOS has five different modules; the appropriate module is selected based on the individual's expressive language and chronological age. Together, these two measures are often considered the "gold standard" in research and clinical practice for the assessment and diagnosis of autism and provide a large number of items related to autism symptomatology (Kanne, Randolph, & Farmer, 2008, p. 369). In addition, there is evidence that these measures are validated and have strong psychometric properties (e.g., de Bidt et al., 2004; Gotham et al., 2007; Gotham et al., 2008; Mazefsky & Oswald, 2006). However, it is important to acknowledge that these measures may not capture the nature of autism in all affected individuals accurately as symptom presentation can vary according to IQ as discussed above (e.g., de Bilt et al., 2009; Fusar-Poli et al., 2017; Lord, et al., 1994; Oosterling et al., 2010; Sappok et al., 2013).

Shuster and colleagues (2014) reviewed 36 FA studies that examined the structure of autism symptoms derived from various measures. A further examination of the 13 studies that used the majority of the domain items of the ADI-R (Table 1) and/or the ADOS (Tables 2 and 3) revealed inconsistent models of symptom structure. The 2-factor model described by the *DSM-5* appears to receive the most support (Frazier et al., 2008; Gotham et al., 2007; Gotham et al., 2008; Snow et al. 2009). However, only one of these studies (Snow et al., 2009) included stereotyped speech in the RRBI domain, which reflects the *DSM-5* classification. The second most support was found for a 3-factor model: (1) Social Communication, (2) Play/Peer, and (3) RRBI (Boomsma et al., 2008, Frazier et al., 2008; Van Lang et al., 2006) that differed from the triad model described in the *DSM-IV* (Social, Communication, and RRBI), which received only minimal support (Snow et al., 2009). Another study found a 3-factor model consisting of the same domains as the *DSM-IV* except that non-verbal communication items loaded onto the social factor (Lecavalier at al., 2006). Additionally, Norris, Lecavalier, and Edwards (2012) found 1-, 2- (*DSM-5*), and 3- (*DSM-IV*) factor models to fit similarly well, statistically. There was some evidence for different models, including a 4-factor model of Social Communication, Anxiety and Compulsions, Stereotyped Behaviour, and Inadequate Behaviours (Kamp-Becker et al., 2009), and six clusters of Spoken Language, Social Intent, Compulsions, Milestones, Savant Skills, and Sensory Aversions (Tadevosyan-Leyfer et al., 2003). Constantino et al. (2004) also found that a 1-factor model explained 35% of variance, whereas the remaining factors explained less than 5% each.

This inconsistency in findings may be a result of differences in sample characteristics (i.e., size, participant age and level of cognitive functioning) and methodology (i.e., type of FA procedures, and/or the items used to capture symptoms; Norris et al., 2012; Shuster et al., 2014). Although the majority of the studies reviewed by Shuster et al. (2014) were based on the ADI-R, only eight (see Table 1) used most of the items needed to complete the domain scores of the measure, while the others only used some of the items pertaining to specific domains. Three of the studies were based on the ADOS (see Table 2), with two based on Modules 1 *to* 3 (Gotham et al., 2007; Gotham et al., 2008) and one only based on Modules 1 *and* 3 (Norris et al., 2012). Finally, two of the studies were based on both the ADOS and ADI-R (see Table 3), discussed further below. However, not all the domain items of the measures were used in these studies. The inclusion of different items and/or only specific domains of the measures is another important source of variability among the studies reviewed. While the inclusion of all the items of the ADI-R and ADOS would potentially provide a more comprehensive understanding of the factor structure of autism, it is not always possible due to statistical complications. When examining complex models with a large number of observations (e.g., over 92 items on the ADI-R), a greater sample size is required (e.g., Jackson, 2003; Flora & Curran, 2004). Thus, it is important to at least include all algorithm items of these measures, in order to capture symptoms on the main domains of impairment. The largest FA studies on the autism phenotype using the ADI-R or ADOS (e.g., Fraizer et al., 2008; Snow et al., 2009) have included the algorithm items only.

The type of statistical procedure and sample size also varied across the 13 studies. This variability was most evident for the eight ADI-R studies, with two using principal component analysis (PCA), three using exploratory factor analysis (EFA), and five using confirmatory factor analysis (CFA). It should be noted that PCA is not recognized as a type of FA (Flora & Flake, 2017) and it is strongly recommended that PCA be avoided in behavioural research (Preacher & McCallum, 2003). Furthermore, these studies differed greatly in terms of sample size, ranging from 105 to 1,186 participants. The three ADOS studies were all consistently based on CFA in large samples, ranging from 1,282 to 1,630 participants. The two studies that used both the ADOS and ADI-R had significant limitations. One of these studies utilized PCA (Kamp-Becker et al., 2009) and the other used a vaguely specified FA procedure (Robertson et al., 1999).

Moreover, both studies were based on small sample sizes (140 and 51 participants). Overall, this variation in sample size is another source of variability and limitation in the studies reviewed. The nature of the data in FA studies, including the strength of factor loadings and the number of variables on each factor, should be examined to determine adequate sample size (e.g., de Winter, Dodou, & Weiringa, 2009; MacCallum, Widaman, Zhang, & Hong, 1999). However, it is well accepted that EFA and CFA are considered large sample procedures, with sample sizes typically in the hundreds (Flora & Flake, 2017). This is particularly an area of concern for some of the studies based on the ADI-R and all those based on both the ADI-R and ADOS given their sample sizes.

Past studies also differed in terms of the type of sample used. Most included a heterogeneous sample of individuals with autism. Of the ADI-R studies, one included individuals with a comorbid psychiatric disorder (Constantino et al., 2004) and another included a clear ASD group and a non-ASD sample with broader social and communication problems (Van Lang et al., 2006). Two of the ADOS studies by Gotham and colleagues (2007, 2008) also included individuals with a non-ASD developmental disability. One study based on the ADI-R and ADOS (Kamp-Becker et al., 2009) also included a non-autism group with “autism like behaviour” (i.e., attention-deficit/hyperactivity disorder, emotional disorder, speech disorder, personality disorder, and developmental delay). In addition, these studies were completed at different times using different definitions of autism (i.e., *DSM-IV* versus *DSM-5*). Overall, this heterogeneity in the samples has potentially impacted the factorial models described in these studies.

The 13 FA studies were further examined in terms of sample characteristics relevant to the current study, specifically age and IQ. Some of the studies did not report on age or IQ, or did not provide detailed descriptive information on these variables (e.g., mean, range, and standard deviation). The studies used various measures and domains of IQ (i.e., verbal vs. non-verbal) and/or full-scale IQ scores from a variety of different tests, which may not be directly comparable. Overall, studies included samples with a large range in age, spanning from 3 to 46 years (with most having mean ages in the 8- to 11-year range). More specifically, the sample in the ADI-R studies ranged from 4 to 46 years, ADOS studies ranged from 14 months to 18 years, and the combined ADOS/ADI-R studies ranged from 3 to 24 years. Similarly, cognitive and language levels varied greatly across studies. The majority of studies included samples with verbal and non-verbal participants whereas others included only verbal individuals. IQ scores in the ADI-R studies ranged from 23 to 132. Six of the eight ADI-R studies provided scores for IQ based on standardized measures of cognitive ability. All three of the ADOS studies used standardized measures to derive verbal and/or nonverbal IQ, with mean scores ranging from 31 to 104. Only one of the two studies based on both the ADOS and ADI-R reported on the use of standardized measure of IQ, which ranged from 70 to 139 (i.e., no participants had IQ < 70).

Only two of the FA studies (Kamp-Becker et al., 2009; Robertson et al., 1999) used a combination of the ADI-R and ADOS to examine autism symptom models. However, as noted earlier, these studies had a number of limitations including small sample size and the use of only a subset of the items from each measure. Kamp-Becker al. (2009) used standardized measures of cognitive ability but their sample consisted of individuals with IQ scores between 70 and 139. Robertson et al. (1999) only reported that six participants had IQ scores less than 70 and did not provide IQ scores for the remaining sample. There was also a large range in age (from 3 to 24 years) in these studies. Both studies were based on a small and heterogeneous sample, consisting of individuals with varying abilities and those not on the spectrum (e.g., non-autism group with other diagnoses like attention-deficit/hyperactivity disorder). Given the great variability in age, IQ, and diagnoses, all individuals in the samples may not present similarly.

Summary of Research

Autism is heterogeneous in terms of symptom severity and presentation. Given that it is developmental in nature, it is well accepted that IQ is likely to influence much of the variation in symptomatology. Although there are a number of FA studies reporting on the symptom domains of autism, these studies have not examined the structure of symptoms in graded and more refined IQ groups. Additionally, FA studies that report on the symptom domains of autism have yielded inconsistent models of the disorder, which may be attributed to differences in methodology and sampling. Therefore, there is a need to evaluate current models of autism for individuals who have different levels of cognitive abilities, ranging from those with average or above cognitive ability to those with severe/profound ID.

The ADI-R and ADOS are considered the "gold standard" for the assessment of autism symptomatology. It is valuable to include both measures in research and clinical practice, since they provide different sources of information, historical and current parent report and direct observation/interaction. However, only two FA studies have used both measures to examine autism symptom models and there were a number of significant issues with both these studies that render conclusions difficult. Further research is needed to examine symptom profiles in different IQ groups using both the ADI-R and ADOS.

Current Study

The purpose of this study is to explore autism symptom severity and structure, in relation to IQ, in a more sophisticated manner than has been done in previous research. The current study will report on autism symptomatology in a large heterogeneous sample of children and youth using both "gold standard" measures and standardized measures of IQ, in four graded cognitive groups:

1. Without intellectual disability; No ID (IQ: ≥ 85; *M* = 103.23)
2. Borderline intellectual ability; Borderline (IQ: 70-84; *M* = 77.55)
3. Intellectual disability with verbal ability; ID Verbal (IQ < 70, *M* = 52.68)
4. Intellectual disability without verbal ability; ID Non-Verbal (IQ < 70; *M* = 35.11)

These more nuanced distinctions in level of intellectual functioning allow for an examination of differences in autism symptoms that may be associated with different cognitive levels. For example, comparisons can be made between those without ID and those with borderline ability levels, and between those with ID with and without verbal ability. The decision to divide the ID group based on verbal ability was necessitated by the fact that a set of items on the ADI-R do not apply to individuals without verbal language; for example, stereotyped use of language is an item on the ADI-R for verbal participants but not included for those without verbal language. Similarly, one of four ADOS modules (with different items) is administered based on the individual's age and expressive language. As a result, the majority of the individuals in the ID Non-Verbal group completed Module 1, which is meant for children 31 months and older who do not consistently use phrase speech, while the majority of those in the ID Verbal group completed Module 2, which is meant for children of any age who use phrase speech but are not verbally fluent. Although the decision to divide the ID groups based on verbal ability was initially a result of the measures used, it should be noted that the ID Non-Verbal group also had lower IQ than the ID Verbal group thus resulting in four distinct IQ groups.

Objective 1. The first objective of the study was to provide a detailed examination of autism symptom severity in relation to IQ across the sample as a whole. First, I correlated actual IQ scores with symptom severity scores from the ADI-R. Moreover, I compared all the symptom severity means in the four IQ groups across all domains and subdomains.

Objective 2. The second objective was to examine the factor structure of autism symptoms in the four groups. These analyses were based primarily on the historical parent report using the ADI-R and then secondarily on data from observation of current symptoms using the ADOS. Four different FA models, guided by previous studies in the literature and clinical judgment, were evaluated in each IQ group:

1. Two-factor model based on the *DSM-5* (APA, 2013) consisting of (1) Social Communication and (2) RRBI.
2. Three-factor model based on the *DSM-IV* (APA, 2002) consisting of (1) Communication, (2) Social, and (3) RRBI.
3. Modified 3-factor model consisting of (1) Social Communication, (2) Play/Peer, and (3) RRBI. This model was based on a handful of studies indicating that play and peer impairments load together and are separate from the social communication symptoms (Boomsma et al., 2008; Frazier et al., 2008; Van Lang et al., 2006).
4. Four-factor model consisting of (1) Social, (2) Communication, (3) Play/Peer, and (4) RRBI. This is a hypothesized model based on an amalgamation of the models above. Social and communication items were kept as separate factors (similar to the *DSM-IV*), repetitive language and sensory impairments were included as part of RRBI factor (similar to *DSM-5*), and play and peer impairments were expected to load

together but separate from the social and communication factors (similar to the modified 3-factor model proposed by other authors).

Method

The data for this study were based on a sample of children with ASD who participated in the Simons Simplex Collection (SSC; Fischbach & Lord 2010). The SSC is a project under the Simons Foundation Autism Research Initiative (SFARI) that includes phenotypic and genetic samples from simplex families (i.e., families with one child with ASD, and unaffected parents and siblings). Recruitment and data collection were completed in collaboration with 12 university affiliated research clinics (11 U.S. and 1 Canadian). Clinicians involved in the study received training in administration of the ADOS and ADI-R, and achieved research reliability as judged by expert clinicians. The request to gain access to the SFARI database was approved by the Simons Foundation and the York University Human Participants Review Committee approved this study.

Participants

All SFARI participants met the criteria for autism or autism spectrum on the ADOS. They were also required to meet one of the following four criteria on the ADI-R: (1) standard cutoffs on the social and communication domains; (2) standard cutoff on the social domain and within two points of communication domain cutoff; (3) standard cutoff on the communication domain and within two points of social domain cutoff; and/or (4) within one point of the standard cutoffs on both social and communication domains. Participants all had received a clinical best estimate diagnosis of autistic disorder, Asperger's disorder, or PDD-NOS according to the *DSM-IV*. SFARI exclusion criteria included: age younger than 4 or older than 18 years, nonverbal mental age below 18 months, severe neurological deficits, birth trauma, perinatal complications, or genetic evidence of fragile X or Down syndromes (SSC; Fischbach & Lord, 2010).

The SSC sample used in this study included 2,819 individuals (83.6% male) between 4 and 18 years of age (*M* = 9.0; *SD* = 3.5). Individuals had a wide range of Full Scale IQ (FSIQ) scores from 7 to 167 (*M* = 81.1; *SD* = 28.2), which was based on one of several psychometrically strong IQ tests. The majority of individuals (82%) completed the Differential Ability Scale, Second Edition (Elliott, 2007), and 9% completed either the Mullen Scales of Early Learning (MSEL; Mullen), 4% completed the Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler, 2011), 2% completed the Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler, 1999), and 3% completed a combination of these measures. While the majority of the FSIQs were based on deviation IQ, 22% were ratio IQs, based on the ratio of the individuals' mental age to chronological age. This type of IQ estimate would have been derived for children whose chronological age exceeded the norms for a cognitive test that was appropriate for their mental age (e.g., the Mullen). The Vineland Adaptive Behavior Scales-II (Vineland-II; Sparrow et al. 2006), based on parent interview, was used to assess adaptive functioning. See Table 4 for sample characteristics for each of the four IQ groups.

Measures

Autism Diagnostic Interview – Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003). The ADI-R is a semi-structured and standardized caregiver interview examining symptoms in three domains: Language/Communication, Reciprocal Social Interactions, and Restricted, Repetitive, and Stereotyped Behaviours (RRB). Each of the three domains consists of related subdomains items; for example, the Social Interaction domain has four subdomains, including *failure to use nonverbal behaviours to regulate social interactions*, *failure to develop peer* *relationships, lack of shared enjoyment*, and *lack of socioemotional reciprocity*. The ADI-R also includes questions regarding early development and milestones, and clinically relevant behaviours associated with autism (e.g., aggression and self-injury), not included in the present analyses. The ADI-R is designed for individuals with mental ages of 18 months and above. Overall, there are a total of 93 interview questions, with up to 42 used in scoring. Some of the scoring items are collapsed together resulting in up to 34 items used as part of the final algorithm for those with verbal ability (see Appendix for a list of the algorithm items in each of the domains and subdomains). Individuals without verbal ability do not complete verbal items, resulting in fewer algorithm items for this group (total of 27). Most items include both current and historical scores based on a 4-point response scale (responses of 0, 1, 2, or 3). To avoid placing undue weight on any individual item, algorithm items with scores of 3 are transformed to scores of 2 (Lord et al., 1994). Classification of "autism" is based on prescribed cut-off scores for all three domains.

The psychometric properties of the ADI-R have been evaluated in a number of studies by the authors of the measure. It should be noted that most studies were based on the original ADI-R (Lord, Rutter, & Le Couteur, 1994). Lord, Storoschuk, Rutter, and Pickles (1993) first reported on the sensitivity, specificity, and inter-rater reliability of the ADI-R in sample of 51 preschool children with autism and 43 with developmental delay. They reported high sensitivity (i.e., correctly identifying those with the disorder), as all but one of the children with autism met the ADI-R diagnostic cut-off score. While specificity (i.e., correctly identifying those without the disorder) was good for the verbal non-autism sample with a mental age greater than 18 months (2 of 30 met the ADI-R cutoff), specificity was poor for the nonverbal sample with a mental age below 17 months (7 of 14 met the ADI-R cutoff). Inter-rater reliability was good with kappas ranging from .62 to .89. In another study, Lord, Rutter, and LeCouteur (1994) reported on the internal consistency of the measure in a sample of 50 children, of whom half were diagnosed with autism ($n = 25$). Cronbach's alpha coefficients were .95 for the social domain, .84 for the communication domain, and .69 for the RRB domain. The authors reported high sensitivity and specificity, as all but one of the participants with autism met the ADI-R diagnostic criteria, and only two without autism met diagnostic criteria. Lord et al. (1997) also reported high sensitivity and specificity in a sample of 432 children, 319 of whom had autism.

Other researchers have also examined the ADI-R compared to other commonly used autism diagnostic measures, including the Childhood Autism Rating Scale (CARS; Schopler et al. 1988). For example, in a sample of 83 children and adults (20 months to 34 years) suspected of autism, researchers found 86% agreement between these two measures (Pilowsky, Yirmiya, Shulman, & Dover, 1998). Those who did not meet the cutoff score for autism on the ADI-R were identified as being younger and having lower mental ages. In another study of 54 children (22 months to 9.5 years) with possible autism, the agreement between the two measures was much lower (67%; Saemundsen, Magnusson, Smari, & Sigurdardottir, 2003). Additionally, the authors reported poor internal consistency relative to what was previously reported in the studies mentioned above, with alpha coefficients ranging from .35 to .85 for the three ADI-R domains.

Autism Diagnostic Observation Schedule (ADOS-2; Lord et al., 2012). While the original ADOS (Lord et al., 1999) was administered to study participants, the newest ADOS-2 algorithms were used for the Modules included in this study. The ADOS is a semi-structured standardized observational measure used to examine observable behaviours associated with autism. There are four modules and the appropriate module is selected based on the individual's expressive language and chronological age. Module 1 is for individuals who do not yet use phrase speech. Module 2 is designed for individuals of any age who use phrase speech but who have not developed verbally fluent speech. Module 3 is for verbally fluent children and adolescents. Module 4 is for verbally fluent older adolescents and adults. The new ADOS-2 also includes a Toddler Module. Each module consists of a number of tasks that take about 30 to 60 minutes to administer and are designed to elicit specific behaviours related to language and communication, reciprocal social interaction, play and imagination, stereotyped behaviours and restricted interests, and other behaviours. Classifications of "autism", "autism spectrum", or "non-spectrum" are based on cut-off scores met for both the social affect (i.e., social communication) domain, and repetitive behaviours, with higher cut-off scores required for the autism designation.

The ADOS-2 has good test-retest reliability and excellent internal consistency (see review by McCrimmon & Rostad, 2014). Psychometric data for this measure were based on three samples: an ADOS validation sample (N = 98), an ADOS-2 extended validation sample (N = 1,574), and an ADOS-2 replication sample (N = 1,282). While internal consistency for Modules 1 to 3 was highest for the social affect (SA) domain (from .87 to .92), it was lower, in the moderate range, for the RRB domain (from .51 to .66). For Module 4, internal consistency was high for the combined communication and social interaction domain (.90), exceeded .75 for the communication domain, .85 for the social interaction domain, but was only .47 for the RRB domain. Thus, internal consistency was dependent on the module used and the behaviour domain, with items on the RRB domain yielding weaker alpha coefficients. Test-retest reliability ranged from .68 to .92 for Modules 1 to 3 for SA, RRB, and overall scores. Inter-rater reliability was acceptable (71% or higher) for individual items, and the correlations for SA, RRB, and overall scores and ranged from .79 to .98. For Modules 1 to 3, sensitivity ranged from 60 to 95% and specificity ranged from 75 to 100%. Hus and Lord (2014) reported the sensitivity and specificity of a revised Module 4 algorithm exceeded 80% in the overall sample.

Although a number of studies have shown either or both of the ADI-R and ADOS to be psychometrically reliable and valid (e.g., de Bildt et al., 2004; Gotham et al., 2007), other studies have indicated that they may not be ideal for all individuals with autism. More specifically, the validity of these measures has been questioned for older individuals with and without ID (e.g., Fusar-Poli et al., 2017; Sappok et al., 2013), young and/or less skilled children (e.g., de Bilt et al., 2009; Lord et al., 1994; Oosterling et al., 2010), and children with milder impairments (e.g., Kamp-Becker et al. 2011; Overton, Fielding, & de Alba, 2008). In a recent study, which examined the multidimensional influences of autism symptoms of the ADOS and ADI-R, the authors reported that these measures had low specificity on ASD cut-offs for children with intellectual disability without ASD (Havdahl et al., 2016). However, more research is needed with these subgroups and with larger samples.

Differential Ability Scale, Second Edition (DAS-II; Elliott, 2007). The DAS-II consists of an Early Years Battery for ages 2 years 6 months to 6 years 11 months and a School-Age Battery for ages 7 years to 17 years 11 months. The measure contains 10 core subtests, which are the primary measure of cognitive ability. The subtests form the following clusters: Verbal Ability, Nonverbal Ability, Nonverbal Reasoning Ability, and Spatial Ability, and the following Composites: General Conceptual Ability (GCA), and the Special Nonverbal Composite (SNC). The average internal consistency reliability coefficients are excellent for the GCA and SNC for both test batteries (≥ .96). The stability coefficients range from .86 to .92 for the GCA and .78 to .90 for the SNC. The DAS-II has satisfactory concurrent validity, as indicated by high correlations with other measures of intelligence.

Mullen Scales of Early Learning (MSEL; Mullen, 1995). The MSEL is a measure of cognitive functioning in infants and preschoolers from birth to 68 months and is often used in autism research for older children who function in that developmental range (ratio IQs can be derived from age equivalent scores). The measure consists of five scales: Gross Motor (not typically included), Visual Reception, Fine Motor, Expressive Language, and Receptive Language. The MSEL has satisfactory median internal consistency values for the five scales (.75 to .83). The average test-retest coefficients ranged from .82 to .96 for the younger group and from .71 to .79 for the older group. Additionally, the measure has moderately high correlations with the Bayley Mental Developmental Index (Bayley, 1993).

Wechsler Intelligence Scale for Children, Fourth Edition (WISC-IV; Wechsler, 1999). The WISC-IV is a test of cognitive intelligence for children 6 to 16 years old taking approximately 1 to 1.5 hours to complete. It consists of 10 core subtests that yield four Composites scores: Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. Taken together, the 10 core subtests yield the FSIQ. The WISC-IV was standardized in a large sample of children, divided into 11 age groups with 200 children in each group. The measure is known to have strong psychometric properties (Kaufman & Flanagan, 2006). The average internal consistency coefficients ranged from .88 to .97 for the composite scores and ranged from .72 to .94 for individual subtests. The average test-retest coefficients ranged from .86 to .93 for the composites. The measure has strong validity as indicated by correlations ranging with other global measures.

Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler, 2011). The WASI-II is an abbreviated test of cognitive intelligence for individuals 6 to 90 years. The measure consists of four subtests that are combined to yield Verbal IQ, Performance IQ, and

FSIQ scores. The measure is known to have strong psychometric properties (McCrimmon & Smith, 2013). The reliability coefficients range from good to excellent for the subtest scores (.87 to .91) and are excellent for the composites (≥ .92). The measure has acceptable to excellent stability coefficients for the subtests (.79 to .90) and good to excellent coefficients for the composites (.87 to .95). The measure also has acceptable to excellent correlations with other well-recognized cognitive measures (.71 to .92).

The Vineland Adaptive Behavior Scales (Vineland-II; Sparrow et al., 2005). The Vineland-II is a measure of adaptive functioning that examines four domains: Communication, Daily Living Skills, Socialization, and Motor Skills (for children under 7 years). The scores on these domains can be combined to create an overall Adaptive Behavior Composite (ABC) score. Internal consistency estimates for domains were generally high, with most being in the upper .80s to low .90s. The ABC score had reliability coefficients in the mid .90s, with the exception of adults who were 32 to 71 years of age. The average test-retest reliability across domains within age groups ranged from .88 to .92, with the exception of those who were 14 to 21 years of age, in which the average reliability was .76. Test-retest reliability for the ABC score was above .90 in each age group, with the exception of the adolescent group at .83.

Analyses

A decision had to be made regarding which ADI-R items to use for analyses, based on pragmatic and statistical considerations, and with reference to previous research. Since only the algorithm items are considered in diagnostic classification, only the 34 ADI-R algorithm items measuring the three domains of impairments were included in the analyses. There are seven verbal items that are not scored for nonverbal individuals so the ID Non-Verbal group in this study had fewer items. Overall, there were a total of 12 subdomains in the verbal sample and 10 subdomains in the non-verbal sample. To ensure that analyses parallel the use of the measure in a clinical setting, items were analyzed according to the ADI-R rules. Scores of 3 were transformed to 2, and scores of 7 were transformed to 0; however, there were very few items with scores of 3 or 7. Historical ratings of “ever” or “most abnormal” (4- to 5-year age period) were used, except when otherwise noted (e.g., higher of two scores used in the Repetitive Behaviour domain).

The ADOS item scores were converted as they are on the algorithm, with scores of 3 recoded to 2, and scores of 7, 8, or 9 converted to 0. It should be noted that a few ADOS items (e.g., Imagination/Creativity on Module 3, Functional Play with Objects on Module 2) that are not part of the algorithm were included in the analyses to capture symptoms on associated factors. An additional complexity with ADOS scores is that they are not directly comparable across modules. Although modules on the ADOS are selected based on crude measure of level of functioning (age and amount of expressive language), there was still variability in terms of IQ within the subgroup that received a given module. Consequently, the IQ groups created for this study were related to but did not correspond completely with ADOS modules. As a result, analyses were based on a subset of the sample (N = 1,990) who received the most frequently used module for each IQ group. For example, for the No ID group, the majority of participants had received Module 3; therefore, only the subset of the participants who had completed Module 3 were included for analyses and children in the No ID group who had received a different module were dropped from these analyses. Overall, analyses were conducted for the No ID (n= 1,170) and Borderline (n= 290) groups based on Module 3, the ID Verbal group (n= 227) based on Module 2, and the ID Non-Verbal group (n = 303) based on Module 1.

For the first objective, Pearson correlations were used to examine the strength and direction of the association between IQ scores, as continuous variables, and the severity of autism symptoms. Symptom severity was examined at the domain and subdomain level using the ADI-R scores. For example, there are a total of 15 items on the social interaction domain, which are then divided into four subdomains. See Appendix for full list of items in each of the ADI-R domain and subdomains. By Cohen's (1988) convention, a correlation coefficient between .10 and .29 is considered a weak association; between .30 and .49 is considered a moderate association; and .50 and greater is considered a strong association. Next, one-way ANOVAs were used to examine differences in scores on domains and subdomains of the ADI-R in each of the four IQ groups and Bonferroni corrections were applied for the post-hoc analyses. Similar analyses were not feasible with the ADOS-2 since the selection for each module is based on the individual's age and language level. As it would be expected language level is strongly correlated with IQ, this would confound the results.

For the second objective, FA was based on polychoric correlations, which are specifically designed to measure the nonlinear bivariate associations among categorical, ordinally scaled variables (Flora, 2018). Confirmatory Factor Analysis (CFA) was used to examine each of the four potential models for each of the four IQ groups. Since the data from the ADI-R and ADOS were ordinal, the robust weighted least squares estimation (WLSMV) procedure was used to fit the models to the data.

Model fit was thoroughly evaluated using four different indices: the root mean square error of approximation (RMSEA), comparative-fit index (CFI), standardized root-mean-square residual (SRMR), and Tucker-Lewis index (TLI) fit indices. Hu and Bentler (1999) suggested adequate model fit is evident with RMSEA close to .06 or less, SRMR close to .08 or less, and CFI or TLI close to .95 or greater. Others have proposed more flexible guidelines for acceptable fit, including values of .90 or greater for CFI and TLI (Kline, 2011) and .08 or less for the

RMSEA (MacCallum, Browne, & Sugawara, 1996). Current best practice for evaluating model fit involves considering more than one type of fit index across two or more competing models, and not adhering to the Hu and Bentler guidelines too strictly (Flora, 2018). In this study, scaled chi-square difference test of Bryant and Sattora (2012) was also used to test whether the fit of each model significantly differed from one another in each of the IQ groups using the ADI-R. This type of significant testing was not possible for the models tested based on the ADOS, since the items different across models.

Results

Objective 1: Symptom Severity in Relation to Cognitive Level

The ADI-R domain of Reciprocal Social Interaction includes the sum of four subdomains: *failure to use non-verbal behaviours to regulate social interaction* (A1), *failure to develop peer relationships* (A2), *lack of shared enjoyment* (A3), *and lack of socio-emotional reciprocity* (A4). Table 5 shows the Pearson correlations between IQ level and symptom severity on the overall domain (sum of all the A items) and the four subdomains of Reciprocal Social Interaction. The overall domain and each of the individual subdomains had moderate negative correlations with IQ, with the exception of A1.

The ADI-R domain of Communication is based on two verbal and two non-verbal subdomains. The non-verbal subdomains include: *lack of or delay in spoken language and failure to compensate through gesture* (B1), and *lack of varied spontaneous make-believe or social imitative play* (B4). The verbal subdomains include: *relative failure to initiate or sustain conversational interchange* (B2), and *stereotyped, repetitive or idiosyncratic speech* (B3). The three IQ groups with verbal ability (No ID, Borderline, and ID Verbal) had data for the verbal and non-verbal subdomains (B1 to B4), while the ID Non-Verbal group only completed the non-verbal subdomains (B1 and B4). As a result, two domains of Communication are calculated: 1) a Verbal Communication score based on the sum of all the subdomains (B1 + B2 + B3 + B4), which could only be calculated for those with verbal ability, and 2) a Non-Verbal Communication score based on the sum of only the non-verbal subdomains (B1 + B4), which could be calculated for the entire sample.

Table 6 shows the Pearson Correlations between IQ level and the Verbal Communication domain (sum of all B items) and four subdomains (B1 to B4) for the verbal sample. In the verbal sample, the Verbal Communication domain had a moderate negative correlation with IQ, while the individual subdomains were weakly correlated with IQ. Table 7 shows the Correlations between IQ and the scores for the Nonverbal Communication domain (sum of B1 + B4) and nonverbal subdomains for the entire sample. For the whole sample, the overall Non-Verbal Communication domain and two non-verbal subdomains had moderate negative correlations with IQ.

The ADI-R domain of RRB includes the sum of four subdomain items: *encompassing preoccupation or circumscribed pattern of interest* (C1), *apparently compulsive adherence to non-functional routines or rituals* (C2), *stereotyped and repetitive motor mannerisms* (C3), *and preoccupations with part of objects or non-functional elements of material* (C4). Table 8 shows the Pearson Correlations between IQ level and symptom severity on the overall domain (sum of all C items) and the four subdomains of the RRB. The overall domain was uncorrelated with IQ. C1 was weakly positively correlated with IQ, C2 was uncorrelated, and C3 and C4 subdomains had weak negative correlations.

Next the symptom severity was compared across IQ groups. Figure 1 shows the mean score for each of the four Reciprocal Social Interaction subdomains (A1 to A4) across the four

IQ groups. For all four subdomains, visual inspection shows the No ID group had the lowest score, followed by the Borderline, the ID Verbal, and the ID Non-Verbal groups. ANOVAs were used to explore whether there were significant differences among the mean scores on the domain and subdomains of Reciprocal Social Interaction across the four IQ groups (see Table 9). The ANOVA for the overall domain (sum of the A items) was significant with a large effect size, and the ANOVAs for each individual subdomain were also significant with effect sizes ranging from small to large. For the subdomains of A2, A3 and A4, the No ID group had significantly lower scores than all other IQ groups. The Borderline group also had significantly lower scores than the two groups with ID, and the ID Verbal group had significantly lower scores than the ID Non-Verbal group. This pattern was also evident for the overall domain of impairments in reciprocal social interaction (i.e., sum of all A items). For the A1 subdomain, the No ID group had significantly lower scores than the ID Verbal and Non-Verbal groups, while the Borderline group had significantly lower scores than the ID Non-Verbal group.

Figure 2 shows the mean score for each of the four Communication subdomains (B1 to B4). Once again, the nonverbal subdomain (B1 and B4) was completed by the entire sample, while the verbal subdomains (B2 and B3) were only completed by the verbal sample. For the B1 and B4 non-verbal subdomains, the No ID group had the lowest score, followed by the Borderline, the ID Verbal group, and the ID Non-Verbal group. While a similar pattern emerged for the B2 verbal subdomain, for the B3 subdomain, the ID Verbal group had a lower score than the Borderline group.

Table 10 shows the ANOVAs for the overall Communication domains and subdomains. For the verbal groups (No ID, Borderline, ID Verbal), the ANOVA for the overall Verbal Communication domain (sum of all B items) was significant with a medium effect size. The individual verbal subdomains (B2 and B3) were also significant with small effect sizes. For the subdomains of B2 and B3, the No ID group had significantly lower scores than Borderline and ID Verbal group. For the overall Verbal Communication domain, the No ID group had significantly lower scores than the other two groups. The Borderline group also had significantly lower scores than the ID Verbal group.

When the verbal and non-verbal groups were combined (all four IQ groups), the Non-Verbal Communication domain (sum of B1 and B4) was significant with a large effect size (see Table 10). The individual nonverbal subdomains (B1 and B4) were also significant with medium to large effect sizes. For the subdomains of B1 and B4, the No ID group had significantly lower scores than all other IQ groups. The Borderline group also had significantly lower scores than the two groups with ID, and the ID Verbal group had significantly lower scores than the ID Non-Verbal group. This pattern was also evident for the overall domain of impairments in the Non-Verbal Communication domain for all four IQ groups.

Finally, Figure 3 shows the mean score for each of the four RRB subdomains (C1 to C4) across the four IQ groups. For the C3 and C4 subdomains, the No ID group had the lowest score, followed by the Borderline, the ID Verbal, and the Non-Verbal group. For the C1 and C2 subdomains, the ID Non-Verbal group had the lowest score. Additionally, the No ID and Borderline groups had the highest score for the C1 subdomain.

ANOVAs were used to explore significant differences between the mean scores on the domain and subdomains of RRB across the four IQ groups (see Table 11). The ANOVAs for the overall domain (sum of the C items) and each individual subdomain were significant but with small effect sizes. C1 was the only subdomain where the No ID group had significantly higher scores than both of the ID groups. For C2, the No ID group had significantly lower scores than the ID Verbal group but higher scores than the ID Non-Verbal group. For C3 and C4, the No ID group had significantly lower scores than the two groups with ID. The group with No ID also had significantly lower scores than the Borderline group on C4. For the C1 and C2 subdomains, the Borderline group had significantly greater scores than the ID Non-Verbal group, while for C3 and C4, the Borderline group had significantly lower scores than the ID Non-Verbal group. For C3 this group also had significantly lower scores than the ID Verbal group. The ID Verbal group also had significantly higher scores than the ID Non-Verbal Group on C2. For the overall domain of RRB (sum of all C items), the No ID group had significantly lower scores than the ID Verbal group, and greater severity than the ID Non-Verbal group. The Borderline group had significantly greater scores than ID Non-Verbal group, and the ID Verbal group had significantly greater scores that the ID Non-Verbal group.

Objective 2a: Factor Structure of Autism using the ADI-R in the IQ Groups

The polychoric correlations among all included ADI-R items were examined for each IQ group (see Tables 12 to 15). The correlations among the majority of the items ranged from small (e.g., .10) to moderate (e.g., .40) for all groups. A few of the items in each IQ group had no relation with one another, for example for the No ID group, Items 35 (reciprocal conversation) and 67 (unusual preoccupations) had .00 correlation with one another.

Fit indices for the four CFA models for each IQ group using the ADI-R are presented in Tables 16 to 19. All fit indices were examined to determine which models had good fit (indicated in bold in the tables). Models with CFI and TLI values at or greater than .90 and SRMR and RMSEA values at or less than .08 were considered to have good fit (see Analyses section for details). For the No ID group, Model 4 was the only model that had good fit (CFI= .91; TFI = .91; RMSEA = .06; SRMR = .07), as shown in Table 16. This was also the case for the

Borderline group, as shown in Table 17 (CFI= .91; TFI = .90; RMSEA = .05; SRMR = .08) groups. For the No ID and Borderline groups, other models tested (Models 1, 2, and 3) did not have adequate fit, with CFI and TLI below .90, and in some cases with RMSEA and SRMR above .80. For the two ID groups, the pattern was different in that all models had adequate fit for the ID Verbal and ID Non-Verbal groups, as seen in Tables 18 and 19. However, Model 4 had the best fit statistics in each case: ID Verbal (CFI= .93; TFI = .92; RMSEA = .05; SRMR = .07); ID Non-Verbal (CFI= .97; TFI = .97; RMSEA = .03; SRMR = .07) groups. In addition to examining fit indices, significance testing showed that Model 4 fit the data significantly better than Models 1, 2, and 3 in all IQ groups (see corresponding tables).

Given that Model 4 was the only model that had good fit for all the groups based on an examination of fit indices and significance testing, the standardized factor loading estimates for Model 4 are reported (see Table 20). Model 4 was a 4-factor model consisting of Social, Communication, Play/Peer, and RRBI factors. The majority of items had significant positive loadings (> .30) on corresponding factors across IQ groups with very few exceptions. For the No ID and Borderline groups, only Item 31 (use of another's body) did not significantly load onto the Social Factor. For the ID Verbal group, Item 36 (inappropriate questions) and Item 38 (neologisms) did not significantly load onto the RRBI Factor. For the ID Non-Verbal group, once again Item 31 (use of another's body) did not significantly load onto the Social Factor, as well as Item 68 (circumscribed interests) did not significantly load onto the RRBI Factor. Specifically, factor loadings ranged from .17 (use of other's body) to .93 (head-shaking) for the No ID group, from .16 (use of other's body) to .89 (nodding) for the Borderline group, from .31(use of other's body) to .90 (nodding) for the ID Verbal group, and from .08 (use of other's body) to .82 (conventional instrumental gestures) for ID Non-Verbal group.

Objective 2b: Factor Structure of Autism using the ADOS in the IQ Groups

The polychoric correlations among all ADOS items were examined for each IQ group (see Tables 21 to 24). The correlations among the majority of the items ranged from small (e.g., .10) to moderate (e.g., .40) for all groups. A few of the items in each IQ group had no relation with one another, for example for the No ID group, Item B2 (facial expressions directed to others) and D2 (hand and finger mannerisms) had .00 correlation with one another.

Fit indices for the four CFA models for each IQ group using the ADOS are presented in Tables 25 to 28. None of the tested models had good fit for the No ID group who had received Module 3 (Table 25). Interestingly, for the remaining three IQ groups, *all* the models fit the data well and had similar fit statistics. Although all the models had good fit for three of the four IQ groups, Model 4 was examined more closely so as to compare to results from the ADI-R. Specifically, based on the ADOS, the 4-factor model fit the data well for the Borderline group who received Module 3 (CFI= .97; TFI = .97; RMSEA = .04; SRMR = .07), the ID Verbal group who received Module 2 (CFI= .95; TFI = .94; RMSEA = .06; SRMR = .09), and the ID Non-Verbal group who received Module 1 (CFI= .95; TFI = .94; RMSEA = .05; SRMR = .08).

In light of the findings from the ADI-R, which also provided support for the 4-factor model, it was important to examine the factor loadings for the same model based on the ADOS. The standardized factor loading estimates using the ADOS Module 3 for the No ID and Borderline groups are presented in Table 29, using Module 2 for the ID verbal group in Table 30, and using Module 1 for the ID Non-Verbal group in Table 31. All of the items had significant positive loadings on corresponding factors across IQ groups (majority of the loadings > .40). Specifically, factor loadings ranged from .24 (unusual eye contact) to .82 (amount of reciprocal interactions) for the group with IQ $\geq$ 85, from .23 (unusual eye contact) to .89 (amount of social communication) for the Borderline group, from .23 (repetitive interests/behaviours) to .83 (Amount of reciprocal social communication and functional play with objects) for the ID Verbal group, and from .25 (repetitive interests/behaviours) to .81 (imagination/creativity) for the ID Non-Verbal group.

Discussion

The purpose of this study was to carefully examine autism symptom severity and structure in four graded IQ groups: 1) No ID (IQ: ≥ 85; $M = 103.23$), 2) Borderline (IQ: 70-84; $M = 77.55$), 3) ID Verbal (IQ < 70; = 52.68), and 4) ID Non-Verbal (IQ < 70; $M = 35.11$). In Objective 1, correlations between IQ and autism symptom severity were examined and symptom severity was compared across the four IQ groups. In Objective 2, confirmatory factor analyses were used to explore and evaluate different models of the structure of autism symptoms in each of the four IQ groups. The results and implications of each objective will be discussed in reference to previous literature and various conceptualizations of autism. Finally, the limitations of the overall study will be highlighted along with suggestions for future research.

Autism Severity in Relation to IQ

An important aspect of this study was to examine the relation between cognitive functioning and core autism symptoms on the ADI-R domains of reciprocal social interactions, communication, and RRB. Overall, the severity in all three domains significantly differed in varying IQ groups. Specifically, the two groups with ID were reported to have significantly more severe symptoms, followed by the Borderline group, and then the No ID group. Additionally, the presence of verbal language was also linked to the severity of symptoms for the groups with ID. The ID Non-Verbal group had significantly more severe autism symptoms relative to the ID Verbal group, though this is likely a function of the level of intellectual ability more broadly, with the ID group without verbal language having significantly lower IQ scores than the verbal group with ID (means of 35 vs. 53).

A similar pattern emerged on the subdomain level for impairments in social interaction (i.e., failure to develop peer relationships, lack of shared enjoyment, lack of social-emotional reciprocity) and communication (i.e., delay/lack of language and use of gestures to compensate, failure to initiate and sustain conversation, repetitive and idiosyncratic language, limited make-believe play). This was also the case for most of the subdomains in RRBI (i.e., compulsive adherence to non-functional routines or rituals, stereotyped and repetitive motor mannerisms, and preoccupations with part of objects). Notably, an opposite pattern emerged on the subdomains of encompassing preoccupation/circumscribed pattern of interests and compulsive adherence to non-functional routines/rituals, as the No ID group had significantly more severe symptoms than both verbal and non-verbal ID groups, and the Borderline group had significantly more symptoms than the ID Non-Verbal group.

These results were generally as expected. Several previous studies have also linked lower cognitive level to greater symptom severity on core domains of autism (e.g., Bartak & Rutter, 1976; Matson et al., 2008; Mayes & Calhoun, 2011). The severity/presence of most RRBI symptoms, such as repetitive behaviors and sensory differences, has also shown to be negatively associated with IQ (e.g., Cuccaro et al. 2003; Mayes & Calhoun, 2011; Szatmari et al., 2006), except for circumscribed interests (Bishop et al., 2006). Thus, the current study provides further evidence that RRBIs may consist of higher-order and lower-order manifestations of these symptoms, which correspond to high- versus low-IQ groups (e.g., Lam, Bodfish, & Piven, 2013; Szatmari et al. 2006).

Overall, the present data lend support to the notion that the severity of autism is inversely related to the degree of intellectual ability. Furthermore, studies have shown that there is a considerable amount of shared variance between level of IQ and autism severity (e.g., Perry et al. 2002). This association poses a challenge in determining whether certain autism symptoms are concrete expressions of autism or a function of low IQ (Perry et al. 2002). Therefore, a cognitive assessment is important in making diagnostic decisions in this population. A handful of practice guidelines in the literature stress the use of standardized measures of cognitive functioning as part an autism assessment (e.g., Dua et al., 2003; Filipek et al., 2000; Nachshen et al., 2008; Perry et al. 2002). While others indicate that an initial cognitive assessment is not necessary for a diagnosis of autism, they recommended an assessment of cognitive functioning after a child has been diagnosed with autism in order to individualize treatment planning (Brian, Zwaigenbaum, & Lp, 2019; Volkmar et al. 2014).

The results from the current study also emphasize that planning for intervention should be based on an evaluation of cognitive ability and severity of symptoms, rather than just a diagnosis of ASD. For example, the findings from this study show that a child with autism and ID without expressive language will likely require more substantial support to aid with impairments in social and/or communication skills, while a child with autism and average cognitive skills might require minimal support in these domains and/or different types of support. It is also important to target skills related to developmental level, such as self-help, language, and pre-academic skills, for individuals with autism and co-occurring ID. It is also important to consider targeted interventions in relation to the structure of autism in each IQ group, which will be discussed later as part of the second objective of the study.

Autism Structure in Different IQ Groups

While there is extensive research on the relation between cognitive ability and autism severity, previous studies have not examined whether the inter-connections among symptoms, or the "structure" of autism would differ in graded IQ subgroups, which was intended to be a substantive contribution of the present study. Four plausible models of autism structure were examined in the IQ groups: (1) 2-factor model based on the *DSM-5* consisting of Social Communication, and RRBI factors, (2) 3-factor model based on the *DSM-IV* consisting of Communication, Social, and RRBI factors, (3) modified 3-factor model consisting of Social Communication, Play/Peer, and RRBI factors, and (4) 4-factor model consisting of Social, Communication, Play/Peer, and RRBI factors. The models examined were based on different conceptualizations of autism, existing literature and clinical experience. The parameters of each model were evaluated using CFA to determine which models had good fit for each IQ group. The analyses were based on the ADI-R primarily and then repeated using the ADOS.

The results from the ADOS should be interpreted cautiously due to a number of methodological issues. Firstly, the ADOS has fewer items that capture autism symptoms (15 to 17 items depending on the module administered vs. 34 ADI-R items). Secondly, the analyses were based on smaller subsets of the sample with data from the most frequently used module for each IQ group (Module 3 for No ID and Borderline groups; Module 2 for ID Verbal group; Module 1for ID Non-Verbal group). Given that the analyses for each group were based on different modules using different items, the CFAs from each group are not directly comparable. Finally, significance testing was not possible to compare models tested based on the ADOS, since the items differed across models used in each group. Due to these methodological issues using the ADOS, greater weight is given to the analyses based on the ADI-R. Further, it is important to remember that the two measures represent different sources and timeframes of information. The ADOS is based on scores from a brief examiner-administered interaction/observation at one point in time, whereas the ADI-R is based on parent report of the child's past as well as present behaviour across a variety of contexts. The implications and limitations for different types of measures assessing autism symptoms will be discussed later.

Based on the results from the ADI-R, for the No ID and Borderline groups, only the 4-factor model had good fit. For the ID Verbal and ID Non-Verbal groups, the *DSM-5, DSM-IV*, modified 3-factor, and 4-factor models all had good fit. When the analyses were extended using the ADOS, with the exception of the No ID group, all the models tested had good fit for all IQ groups. Once again, the results based on the ADOS should be interpreted with caution given the abovementioned limitations. Overall, the findings suggest that most of the common models of autism found in the literature are acceptable representations of the structure of autism, especially when individuals present with low IQ. The *DSM-IV and DSM-5* models may better capture those with lower cognitive ability and more severe autism symptoms. For individuals with autism and higher IQ, it may be beneficial to consider the structure of the 4-factor model.

Contrary to what was expected, the factor structure of autism did not differ in different IQ groups. Even though autism symptom severity varied in the different IQ groups (as shown in Objective 1), a consistent 4-factor structure was found across groups using the ADI-R. Additionally, all of the models tested had good fit for most of the IQ groups using the ADOS. Thus, it appears that the construct of autism is stable in a heterogeneous sample and truly represents a ‘spectrum’ with varying levels of behavioural and cognitive impairments. Although it has been debated that there might be separate diagnostic subgroups, as assumed in *DSM-IV*, with milder symptom presentations and higher cognitive abilities (i.e., those with Asperger’s disorder or PDD-NOS), it appears that the underlying structure of symptoms for these subgroups is no different than individuals with more severe presentations (i.e., those with autistic disorder). Therefore, this study provides further support for the shift from the *DSM-IV* to the *DSM-5* to merge previous diagnostic categories into one category that captures all individuals with varying levels of autism symptom severity.

The 4-factor model consisting of Social, Communication, Play/Peer, and RRBI factors, was the only model that was supported in *all* the IQ groups using the ADI-R and was also supported using the ADOS. Therefore, the factors of this model and the individual symptoms that loaded onto corresponding factors are further examined. It is important to note that placing extensive weight on one model over another is not warranted given that other models also had good fit, especially for the groups with low cognitive ability. Rather the goal is to consider elements of the 4-factor model that might lend itself to better capture the underlying structure of autism in certain groups, particularly those with higher IQ and less severe autism symptoms. It should also be noted that the 4-factor model is not entirely novel, as it is based on existing research and includes many elements of our current understanding of autism, including the *DSM* conceptualization and other studies that support a distinct factor related to play and peer impairments.

In the 4-factor model, the Social Factor was based on 11 ADI-R items, while the Communication Factor consisted of a total of six verbal (e.g., social chit-chat) and nonverbal (e.g., pointing) ADI-R items. The total number of ADOS items differed based on the module administered for the Social Factor (ranging from 7 to 12 items) and the Communication Factor (ranging from 2 to 7 items). The 4-factor model found in the current study suggests that social and communication symptoms load onto two distinct factors, which parallels the *DSM-IV* model of ASD and differs from the decision made by the developers of the *DSM-5*. Other support for the distinction between these two domains comes from a small number of FA studies based on the ADI-R (Lecavalier et al., 2006; Snow et al., 2009) and other autism specific measures, such as the Gilliam Autism Rating Scale (Lecavalier, 2005). This finding suggests that, although communication and social symptoms are correlated, it might be worth considering them separate domains of impairment especially for individuals with higher cognitive ability.

The factor called Play/Peer Factor was based on a total of eight items from the ADI-R, and two to three ADOS items depending on the module administered. This factor includes ADI-R items related to imitation of actions, imaginative play, interest and play with other children, and friendships. Depending on the module used, the ADOS items related to functional and imaginative play, empathy, and insight into social relationships. The name for this factor was based on the convention adopted by previous FA research (Boomsma et al., 2008, Frazier et al., 2008; Van Lang et al., 2006).

Deficits in social relationships and play have been considered core symptoms of autism since Kanner's first description of the disorder. Under the *DSM* classification, these impairments have consistently been included as part of the social communication or the communication domains depending on the edition of the manual. The results from the current study, alongside a few other FA studies (Boomsma et al., 2008, Frazier et al., 2008; Van Lang et al., 2006), suggest that play and peer impairments may need to be considered as a separate symptom domain in autism. While basic social communication skills, such as engaging in reciprocal conversations and providing appropriate social responses, are related to and may be prerequisites for the ability to form peer relationships, the understanding and competence in peer relationships is a much more complex ability, such as having an interest in and insight into relationships, and should be considered a separate group of symptoms. Similarly, while social communications skills, such as joint attention, are early components linked to play skills, specific impairments in pretend and imitative play may need to be considered as part of a separate domain of impairment.

The variability in results based on the ADOS and ADI-R suggests that the factor structure of autism is somewhat dependent on the measure used to capture symptoms. On the ADOS, only two to three algorithm items capture impairments in play and peer interactions. The scores on these items are solely based on interactions with an adult examiner or a caregiver during an observational assessment with no peers present, and these observations may not generalize to play or interactions with same-aged peers. On the ADI-R, there are seven algorithm items related to this domain, which are based on parents' knowledge of the child's behaviour across time and settings, including parent perceptions of the child's peer relationships. While caregiver report can help fill the gap in our understanding of peer and play interactions, parents may not know specific details of their child's interactions in other settings, such as at school, camps, or during community activities. It would be beneficial to use a variety of methods, including multi-informant interviews or questionnaires (i.e., parent, teacher, and self-report if possible) as well as live observation of the child with peers in the school or community. This is especially important for children with higher IQ, since only the 4-factor model with the Play/Peer factor had good fit for this group based on the results from the ADI-R. Capturing impairments in play and or peer relationships is particularly important for individuals with higher cognitive ability, since these children may demonstrate the basic social communication skills but struggle with more subtle symptoms related to play and peer interactions.

The RRBI Factor was based on a total of 10 items from the ADI-R and four or five ADOS items. Similar to all other FA work and the *DSM-IV/DSM-5* classification, the model from this study provides support for a RRBI domain that is distinct from social communication items. The model found in this study includes repetitive verbal behaviours (e.g., stereotyped utterances) in the RRBI Factor rather than the Communication Factor and the RRBI Factor also includes sensory interests. The inclusion of these symptoms as part of the RRBI domain is consistent with the *DSM-5* model and supported by other studies (e.g., Gotham et al., 2007; Gotham et al., 2008; Snow et al. 2009).

The 4-factor model can be used to identify treatment targets specific to each factor. In a recent report by the Ontario Association for Behaviour Analysis (ONTABA, 2017), the authors provide a list of evidence-based practices for individuals with autism, based on a synthesis of two major comprehensive treatment reviews (NAC, 2014; Wong et al., 2015). Comprehensive interventions based on Applied Behaviour Analysis (ABA) are recommended for individuals who require intervention across multiple developmental domains. The authors also provide a list of evidence-based focused interventions that target specific developmental domains, which can be applied to the four factors identified in this study. For example, Picture Exchange Communication System or functional communication training to target impairments found in the Communication factor, antecedent-based interventions or behaviour interventions can target impairments in the Social and RRBI factors, and behavioural skills training or peer mediated interventions can be used to explicitly target impairments in the Play/Peer factor.

Limitations and Future Directions

This is the only study that has utilized both the ADOS and ADI-R in a large sample of children to capture symptoms based on both caregiver report and live observation. However, it is important to acknowledge that the sample used in this study may not represent all individuals with autism. Specifically, the sample consisted of only simplex families (i.e., only one child with autism) and participants were required to meet specific criteria on the measures used in the study, which may suggest that the sample did not include more complex or ambiguous cases of children with autism. Similar to other FA studies the results were also limited to the measures used and the individual items from each measure that were submitted for analysis, and the statistical procedures used. In the present study, decisions were made to include only algorithm items for both the ADOS and ADI-R instead of individual items, which may not represent all the behaviours associated with autism. As mentioned earlier, items on the ADOS especially and ADI-R to some extent as well, may not capture symptoms related to the Play/Peer factor. Thus, in clinical applications, it is important to consider the use of multiple measures and multiple respondents, such as teacher questionnaires/interviews and/or live observations of peer interactions when possible.

Most of the studies in the literature that have examined the role of ID in autism diagnosis have simply compared autism symptomatology for those with ID versus those without ID. In the current study, cognitive functioning was further graded to potentially capture subtle differences in level of functioning. For example, comparisons were made between those with average cognitive abilities and those with borderline abilities, and between those with ID with verbal abilities and those with ID and non-verbal abilities (who had significantly lower IQ as well). However, it should be noted that the measures used might not capture all the associated symptoms across the four cognitive groups equally well. Specifically, there is some evidence that the ADI-R and ADOS have low specificity for individuals with low IQ and who are nonverbal, and low sensitivity for capturing those with average or above cognitive ability and less severe symptom presentations (e.g., de Bilt et al., 2009; Havdahl et al., 2016; Lord et al., 1994; Oosterling et al., 2010). This implies there is a need to use other measures in future studies or clinically with particular segments of the autism spectrum (e.g., the Childhood Autism Rating Scale and the Diagnostic Instrument for Social and Communication Disorders).

One of the strengths of this study was the use of standardized cognitive measures to categorize the groups. One of several cognitive measures was administered, depending on the individual's age and level of functioning (a common practice in research and clinical settings working with individuals with autism), although over 80% of the sample completed the same measure (DAS-II). It is important to acknowledge that an IQ score on one test is not necessarily the same as an IQ score on another, especially a deviation IQ versus ratio IQ, introducing a degree of unaccounted-for variability by using the various measures. It is recommended that future research studies examine IQ using a consistent measure across all groups if possible (e.g., the Stanford-Binet Intelligence Scales; Roid, 2013), which would help ensure that results speak more precisely to how autism symptoms may relate to cognitive ability.

In this study, I examined and compared previously supported models of autism symptom structure that were based on existing literature and clinical practice. However, it would be worthwhile, in future research, to consider alternate approaches, specifically bifactor models. A bifactor model consists of a general factor as well as specific factors. The general factor is a single common factor that directly influences all observed variables, while specific factors are identified to explain the variances not accounted for by the general factor (Flora, 2018). A bifactor factor model has been supported in other clinical samples; for example, in children with attention-deficit/hyperactivity disorder, researchers found support for a general factor and two specific factors, inattention and hyperactivity/impulsivity (Toplak et al., 2009). There is limited research on bifactor models for autism samples. In an unpublished dissertation, Shuster (2011) found that a bifactor model had the best fit for verbal individuals with autism. Her model included a general autism factor, two specific social/communication and inflexible language and behaviours factors, and a separate correlated repetitive sensory and motor behaviours factor. Given the large number of items on the ADI-R and the ADOS, the sample size from the current study was not large enough to test potential bifactor models in each IQ group. Future research is needed to examine bifactor models in autism using large samples and various measures.

The four groups examined in this study were based solely on IQ cut-off scores. However, other variables, such as age, have also been known to contribute to the heterogeneity in autism. There is evidence that increasing age is linked to a decrease in autism symptoms. Mayes and Calhoun (2011) found that lower IQ and/or younger age were linked to greater severity in social interaction, communication, repetitive behaviours and sensory difficulties, while higher IQ and/or older age was linked to greater unusual fears, selective attention, and hypersensitivity to noise. In another longitudinal study, parents reported improvements in social interactions, repetitive and stereotyped behaviours, empathy, and adaptive behaviours in late adolescence compared with middle childhood (McGovern & Sigman, 2005). These authors also found improvements for those with IQ scores 70 or greater in comparison to those with scores below 70. Esbensen and colleagues (2009) found that older individuals had less frequent and less severe restricted and repetitive behaviours in comparison to younger individuals. In some cases, these differences in behaviours with age were also dependent on level of cognitive functioning. Although the groups in the current study did not significantly differ in terms of age, it would be important to consider examining the presentation of autism symptoms in different age groups. Sex has also been linked to differences in symptom presentation in autism. A few studies have shown that, after controlling for age and cognitive level, boys had more stereotyped and repetitive behaviours than girls with autism (e.g., Mandy et al., 2011). Given these differences, the application of the 4-factor model proposed here would be better supported if replicated in separate male and female samples.

Conclusion

Autism symptom severity significantly differed among four IQ groups. As expected, those with ID had significantly greater symptom severity than those without ID. Most of the common models of autism found in the literature are acceptable representations of the structure of autism, especially when individuals present with low IQ. The *DSM-IV and DSM-5* models may better capture those with autism who have lower cognitive ability and more severe autism symptoms. For individuals with autism and higher cognitive ability, it may be beneficial to consider a 4-factor model. The 4-factor structure of autism consists of Social, Communication, Play/Peer, and RRBI factors. This model provided the best fit in all four IQ groups using the ADI-R, and in three of the four IQ groups using the ADOS. Additionally, it was the only model that had adequate fit for the groups with higher IQ based on the analyses from the ADI-R. The results suggest that there is a consistent autism factor structure despite varying levels of cognitive and behavioural impairments found in each of the groups. This study has important implications for how we conceptualize the construct of autism, specifically in terms of diagnostic criteria and assessment measures. Further replication of these findings is warranted with other large datasets using different instruments and informants (e.g., teachers interviews or questions, live observations of peer interactions). Additionally, it would be important to conduct studies to replicate and also validate the 4-factor structure in different age and sex groups.

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Table 1

FA Studies Based on ADI-R (N = 8)

Citation	Sample	IQ	Analyses	Results
Boomsma et al. (2008)	*N* = 356; all verbal 86% male Dx: ASD/AS/PDD Age: *(M)* = 11 yrs Range: 4 - 24 yrs	Range: 35-152 Wechsler scales Raven 's Matrices Dutch intelligence test RAKIT	12 ADI-R subdomains CFA with MLE	• **3-factor**: social communication, stereotyped language and behaviours, and impaired make-believe and play skills (as per van Lang et al**.** 2006)
Constantino et al. (2004)	*N* = 105 with psychiatric disorders or ASD Dx: 59% PDD; 41% non-PDD Age: Range = 4 -18 yrs	N/A	63 individual ADIR items and SRS Cluster analysis and PCA	• **10-cluster** solution with items from 3 domains (Cluster analysis) • **14-factor** solution items from 3 domains (PCA) • **1-factor** explained 35% of variance, with 4 remaining factors explaining less than 5% each
Frazier et al. (2008)	*N* = 1,170 all verbal with ASD 77.3% male Dx: 83% AD; 15% PDD-NOS/AS; 2% no dx Age: *M* (*SD*) = 9 yrs (4.88) Range: 2 – 46 yrs	Raven's Matrices *M* (*SD*): 101.16 (22.09) PPVT *M (SD)*: 87.63 (24.32)	12 ADI-R subdomain scores EFA; CFA	• **2-factor**: Social communication and RRB • Almost equal support for **3-factor:** social communication, peer relationships/play, and RRB

Table 1. Continued

FA Studies Based on ADI-R (N = 8)

Citation	Sample	IQ	Analyses	Results
Georgiades et al. (2007)	*N* = 209 verbal and non-verbal with PDD 75% male Dx: 79% AD; 10% PDD-NOS; 11% AS Age: *M (SD)*: 108.75 months (65.30)	Leiter-R *M (SD)*: 65.55 (26.97) Range: 23-132	12 ADI-R subdomains PCA with Varimax rotation; CFA	• **3-factor**: social communication, inflexible language and behaviour, and repetitive sensory and motor • Age and level of functioning (VABS + IQ) accounted for a small amount of variance in these domains (<20% for Soc-com and RSMB)
Lecavalier et al. (2006)	*N* = 226 verbal and non-verbal with PDD 85% males Dx: 76% AD; 3% AS; 9% PDD-NOS; 13% not specified Age: *M (SD)*: 8.3 yrs (2.7)	*N* = 197 based on various standardized tests IQ Ranges: 7.5% < 20; 11% 21-35; 12% 36-49; 20% 50-70; 13% 71-85; 16% >85 VABS composite: *M (SD)*: 45.5 (17.7)	34 ADI-R items EFA	• **3-factor:** social, communication, and RRB. Non-verbal communications items fell in the social domain
Snow et al. (2009)	*N* = 1,861 verbal and non-verbal with PDD 78% male Dx: not reported Age: *M (SD)* = 8.3 yrs (3.2) Range = 4 -18 yrs	Raven's (*N* = 830) *M (SD):* 99.4 (19.3) PPVT-III (*N* = 949) *M (SD):* 84.0 (26.9) VABS (*N* = 1,039) *M (SD)*: 55.0 (21.2)	34 ADI-R items EFA; CFA	• CFA supported both 2 and 3- factor models • EFA supported **2-factor**: social-com and RRB (authors have preference for this model) • Repetitive language was included in the RRB domain

Table 1. Continued

FA Studies Based on ADI-R (N = 8)

Citation	Sample	IQ	Analyses	Results
Tadevosyan-Leyfer et al. (2003)	*N* = 292 with autism Dx: not reported Age: Range= 2-47 yrs	N/A	98 ADI-R items; ever and current PCA	• **6 clusters** (with 62 items): spoken language, social intent, compulsions, milestones, savant skills, and sensory aversions
Van Lang et al. (2006)	*N* = 255 verbal and non-verbal 77% male Dx: 21% AD; 30% AS/PDD-NOS; 49% TD (with social communication problems) Age: TD (*M*): 11yrs 6m PDD-NOS/AS (*M*): =12yrs 1months AD (*M*): = 11yrs 3months	TD *M (SD):* 49 (19) PDD-NOS/AS *M (SD):* = 61 (27) AD *M (SD):* 55 (24) Standardized measures; FIQ ≤ 20 excluded	12 ADIR subdomains CFA with MLE	• **3-factor**: social communication, stereotyped language and behaviours, and impaired make-believe and play skills

Table 2

FA Studies Based on ADOS (N = 3)

Citation	Sample	IQ	Analyses	Results
Gotham et al. (2007)	*N* = 1,630 57-86% male (depending on module) Dx: 56% AD; 27% Non AD ASD; 17% Non-ASD DD Age: Mean Range = 14 –192 months (depending on module)	NVQI mean range: 57.68 (23.18) – 97.78 (19.86) VIQ mean range: 31.28 (18.52) – 99.47 (21.50) Based on MSEL or DAS	ADOS items scores of 3 converted to 2 Mod 1- 3 EFA: CFA	• **2-factor**: social affect and RRB; with stereotyped language in RRB
Gotham et al. (2008)	*N* = 1,282 72% male Dx: 75% AD; 7.6% Non AD ASD; 17% Non ASD DD Age: Mean Range = 18mon - 16yrs (depending on module)	NVQI mean range: 59.2 (20.5)-105.1 (16.7) VIQ mean range: 36.4 (17.3) – 101.0 (24.4) Based on MSEL or WISC	ADOS items scores of 3 converted to 2 Mod 1- 3 Divided into 5 developmental level depending on age and language CFA	• **2-factor**: social affect and RRB; with stereotyped language in RRB

Table 2. Continued

FA Studies Based on ADOS (N = 3)

Citation	Sample	IQ	Analyses	Results
Norris et al. (2012)	*N* =1,409 w ASD 78% male Age: Range = 3-18 yrs Module 1 *M (SD)* = 7.2 (3.1) Module 3 *M (SD)*= 9.5 (2.7)	Raven's NVIQ Module1 (*N* = 185) *M(SD):* 89.4 (21.3) Module 3 (*N*= 617) *M(SD)*: 104 (17.3)	Individuals ADOS items Module 1 (*N* = 720) Module 3 (*N* = 689) CFA	• **1-factor, 2-factor (DSM-5), and 3-factor (DSM-IV) all fit similarly** • Module 1 better indices of fit across all models • Each module was divided into subgroups: youngest, oldest, and lowest and highest functioning (based on VABS and/or NVIQ) o Poorest fits for all analyses were in the lowest-functioning subgroup of module 3 The best fit were in the lowest functioning subgroup of module 1

Table 3

FA Studies Based on both ADI-R and ADOS (N = 2)

Citation	Sample	IQ	Analyses	Results
Kamp-Becker et al. (2009)	*N* =140 96% male Dx: 37% AS; 31% HF-AD; 6% Atypical-Autism; 25% Non-autism (i.e., autism like behaviour: ADHD; emotional disorder, speech disorder; personality disorder, developmental delay) Age: *M (SD)* = 12.4 yrs (4.59) Range = 6–24 yrs	*M (SD):* 100.90 (18.31) Range: 70-139 Based on WISC; WAIS	47 ADI-R items 24 ADOS-G items PCA with varimax rotation	• ADOS – **5-factor:** social communication; non-verbal behaviour; hyperactivity; stereotyped behaviour; interest and compulsions ADIR – **4-factors:** social communication; anxiety and compulsions; stereotyped behaviour; inadequate behaviours
Robertson et al. (1999)	*N* = 51 86% male Dx (not specified): AD; AS; PDD-NOS Age: *M* = 88 months Range = 36-191 months	*N* = 6 with IQ < 70 Others not reported	Only examined social communication items FA with varimax rotation	• **3 social communication factors:** joint attention; affective reciprocity; theory of mind

Table 4

Sample Characteristics in the Four IQ Groups

		No ID *n* = 1451	Borderline *n* = 498	ID Verbal *n* = 558	ID Non-Verbal *n* = 312
Age	*M (SD)*	8.1 (3.5)	9.0 (3.4)	9.8 (3.7)	8.3 (3.5)
FSIQ	*M (SD)*	103.2 (13.6)	77.6 (4.1)	52.7 (12.6)	35.1 (13.4)
	Range	85 - 167	70 - 84	17 - 69	7 - 68
Vineland ABC Score	*M (SD)*	79.7 (9.7)	73.3 (8.0)	65.5 (8.2)	56.4 (8.8)
Sex	% Male	89.3	87.4	78.6	86.2

Note: No ID = IQ: ≥ 85; Borderline = IQ: 70 – 84; ID Verbal = IQ < 70 with verbal language; ID Non-Verbal = IQ < 70 without verbal language.

Table 5

Pearson Correlations between IQ and ADI-R Social Interaction Domain

	IQ
A1: Failure to use non-verbal behaviours to regulate social interaction	-.13
A2: Failure to develop peer relationships	-.36
A3: Lack of shared enjoyment	-.33
A4: Lack of socio-emotional reciprocity	-.38
Total A = A1 + A2 + A3 + A4	-.39

Table 6

Pearson Correlations for IQ and ADI-R Communication Domain for the Verbal Sample

	IQ
B1: Lack of, or delay in, spoken language and failure to compensate through gesture	-.26
B2: Relative failure to initiate or sustain conversational interchange	-.23
B3: Stereotyped, repetitive or idiosyncratic speech	-.07
B4: Lack of varied spontaneous make-believe or social imitative play	-.18
Total B Verbal: B1 + B2 + B3 + B4	-.29

Table 7

Pearson Correlations for IQ and ADI-R Communication Domain for the Entire Sample

	IQ
B1: Lack of, or delay in, spoken language and failure to compensate through gesture	-.38
B4: Lack of varied spontaneous make-believe or social imitative play	-.26
Total B Nonverbal: B1 + B4	-.39

Table 8

Pearson Correlations between IQ and ADI-R RRB Domain

	IQ
C1: Encompassing preoccupation or circumscribed pattern of interest	.15
C2: Apparently compulsive adherence to non-functional routines or rituals	.04
C3: Stereotyped and repetitive motor mannerisms	-.23
C4: Preoccupations with part of objects or non-functional elements of material	-.21
Total C: C1 + C2 + C3 + C4	-.03

Figure 1

Scores on the ADI-R Subdomains of Reciprocal Social Interaction Across IQ Groups

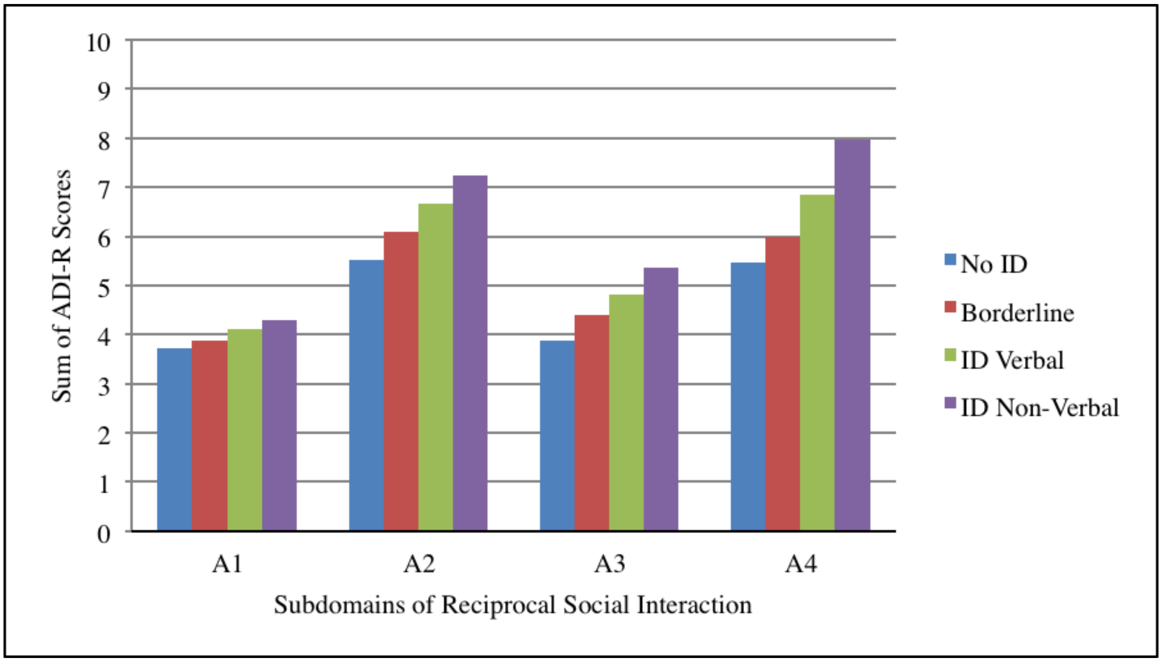

Table 9

Comparing Symptom Severity in Reciprocal Social Interaction Across IQ Groups

	No ID *M (SD)*	Borderline *M (SD)*	ID Verbal *M (SD)*	ID Non-Verbal *M (SD)*	*F*	*p*	Partial η^2	*Bonferroni Post Hoc Group Differences*
A1	3.73 (1.58)	3.87 (1.65)	4.11 (1.67)	4.29 (1.62)	14.95	<.001	.02	No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001
A2	5.52 (1.75)	6.08 (1.65)	6.67 (1.39)	7.24 (1.09)	137.47	<.001	.02	No ID < Borderline; *p* < .001 No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001 ID Verbal < ID Non-Verbal; *p* < .001
A3	3.89 (1.77)	4.40 (1.63)	4.82 (1.55)	5.35 (.99)	108.22	<.001	.10	No ID < Borderline; *p* < .001 No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001 ID Verbal < ID Non-Verbal; *p* < .001
A4	5.46 (2.03)	5.99 (2.15)	6.85 (2.11)	7.96 (1.71)	160.15	<.001	.15	No ID < Borderline; *p* < .001 No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001 ID Verbal < ID Non-Verbal; *p* < .001
Total A	18.50 (5.42)	20.34 (5.39)	22.44 (5.32)	24.85 (4.14)	164.35	<.001	.15	No ID < Borderline; *p* < .001 No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001 ID Verbal < ID Non-Verbal; *p* < .001

Note: ADI-R Subdomains for Impairments in Reciprocal Social Interactions: (A1) failure to use non-verbal behaviours to regulate social interaction, (A2) failure to develop peer relationships, (A3) lack of shared enjoyment, (A4) lack of socio-emotional reciprocity. Total A = A1 + A2 + A3 + A4.

Figure 2

Scores on the ADI-R Subdomains of Communication Across IQ Groups

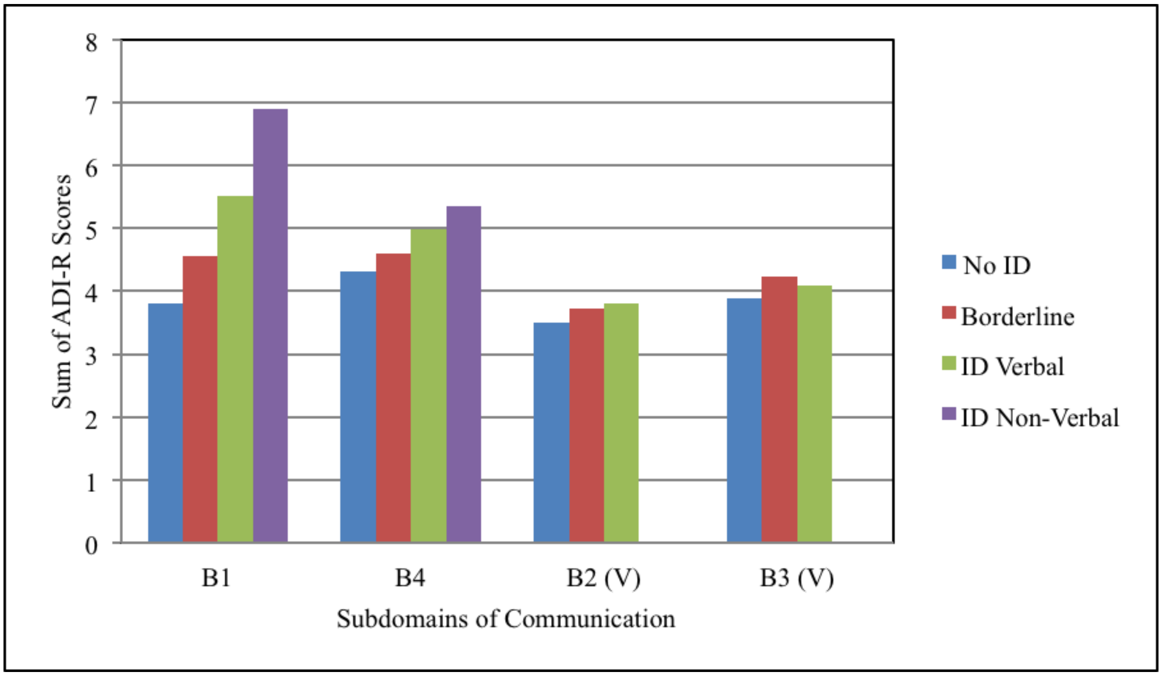

Table 10

Comparing Symptom Severity in Communication Across IQ Groups

	No ID *M (SD)*	Borderline *M (SD)*	ID Verbal *M (SD)*	ID Non-Verbal *M (SD)*	*F*	*p*	Partial η^2	*Bonferroni Post Hoc Group Differences*
B1	3.80 (2.50)	4.55 (2.46)	5.51 (2.45)	6.90 (1.60)	175.90	<.001	.16	No ID < Borderline; $p < .001$ No ID < ID Verbal; $p < .001$ No ID < ID Non-Verbal; $p < .001$ Borderline < ID Verbal; $p < .001$ Borderline < ID Non-Verbal; $p < .001$ ID Verbal < ID Non-Verbal; $p < .001$
B4	4.32 (1.46)	4.60 (1.33)	4.98 (1.15)	5.36 (0.89)	71.01	<.001	.07	No ID < Borderline; $p < .001$ No ID < ID Verbal; $p < .001$ No ID < ID Non-Verbal; $p < .001$ Borderline < ID Verbal; $p < .001$ Borderline < ID Non-Verbal; $p < .001$ ID Verbal < ID Non-Verbal; $p < .001$
Total B Nonverbal	8.12 (3.35)	9.15 (3.20)	10.49 (3.11)	12.26 (2.10)	184.71	<.001	.16	No ID < Borderline; $p < .001$ No ID < ID Verbal; $p < .001$ No ID < ID Non-Verbal; $p < .001$ Borderline < ID Verbal; $p < .001$ Borderline < ID Non-Verbal; $p < .001$ ID Verbal < ID Non-Verbal; $p < .001$
B2 (V)	3.50 (0.82)	3.73 (0.58)	3.81 (0.54)	--	47.14	<.001	.04	No ID < Borderline; $p < .001$ No ID < ID Verbal; $p < .001$
B3 (V)	3.88 (1.84)	4.24 (1.70)	4.10 (1.67)	--	8.89	<.001	.01	No ID < Borderline; $p < .001$ No ID < ID Verbal; $p < .001$
Total B Verbal	15.49 (4.28)	17.13 (4.02)	18.39 (3.73)	--	108.18	<.001	.08	No ID < Borderline; $p < .001$ No ID < ID Verbal; $p < .001$ Borderline < ID verbal; $p < .001$

Note: ADI-R Subdomains for Impairments in Communication: (B1) Lack of, or delay in, spoken language and failure to compensate through gesture, (B2) Relative failure to initiate or sustain conversational interchange, (B3) Stereotyped, repetitive or idiosyncratic speech, (B4) Lack of varied spontaneous make-believe or social imitative play. Total Nonverbal B = B1 + B4; Total Verbal = B1 + B2 + B3 + B4.

Figure 3

Scores on the ADI-R Subdomains of RRB Across IQ Groups

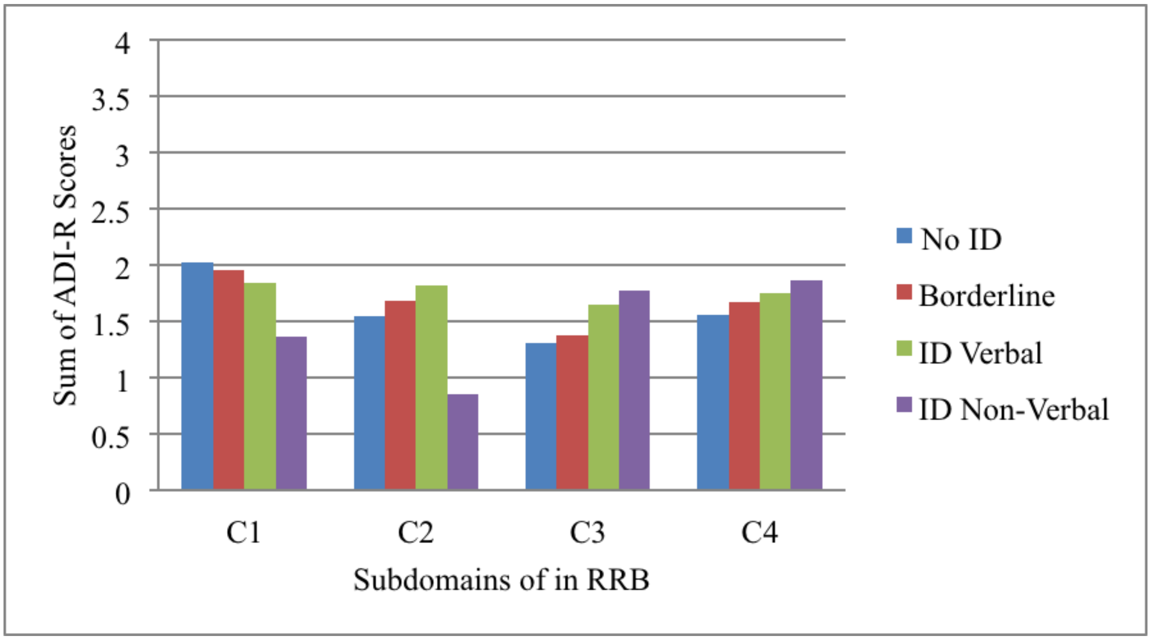

Table 11

Comparing Symptom Severity in RRB Across IQ Groups

	No ID *M (SD)*	Borderline *M (SD)*	ID Verbal *M (SD)*	ID Non-Verbal *M (SD)*	*F*	*p*	Partial η^2	*Bonferroni Post Hoc Group Differences*
C1	2.02 (1.13)	1.96 (1.13)	1.84 (1.25)	1.37 (1.26)	27.41	<.001	.03	No ID > ID Verbal; *p* = .01 No ID > ID Non-Verbal; *p* < .001 Borderline > ID Non-Verbal; *p* < .001
C2	1.55 (1.43)	1.68 (1.47)	1.82 (1.47)	0.86 (.93)	33.91	<.001	.04	No ID < ID Verbal; *p* < .001 No ID > ID Non-Verbal; *p* < .001 Borderline > ID Non-Verbal; *p* < .001 ID Verbal > ID Non-Verbal; *p* < .001
C3	1.31 (0.84)	1.38 (0.83)	1.65 (0.68)	1.77 (0.56)	47.63	<.001	.05	No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Verbal; *p* < .001 Borderline < ID Non-Verbal, *p* < .001
C4	1.56 (0.65)	1.67 (0.59)	1.75 (0.52)	1.86 (0.40)	29.19	<.001	.03	No ID < Borderline; *p* < .01 No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001
Total C	6.44 (2.56)	6.69 (2.55)	7.06 (2.45)	5.86 (1.91)	17.51	<.001	.02	No ID < ID Verbal; *p* < .001 No ID < ID Non-Verbal; *p* < .001 Borderline < ID Non-Verbal; *p* < .001 ID Verbal < ID Non-Verbal; *p* < .001

Note: ADI-R Subdomains for Impairments in Restricted, Repetitive, and Stereotyped Patterns of Behaviour: (C1) Encompassing preoccupation or circumscribed pattern of interest, (C2) Apparently compulsive adherence to non-functional routines or rituals, (C3) Stereotyped and repetitive motor mannerisms, (C4) Preoccupations with part of objects or non-functional elements of material. Total C = C1 + C2 + C3 + C4.

Table 12

ADI-R Polychoric Correlations for the No ID Group (IQ: ≥ 85; n = 1451)

Item	31	33	34	35	36	37	38	39	42	43	44	45	47	48	49	50	51	52	53	54
31	-																			
33	.24	-																		
34	.20	.27	-																	
35	.23	.29	.52	-																
36	.05	.05	-.11	-.03	-															
37	.35	.34	.20	.25	.08	-														
38	.04	.18	-.01	-.01	.19	.15	-													
39	.21	.34	.11	.08	.24	.22	.22	-												
42	.09	.09	.07	.25	.12	.04	.06	.22	-											
43	.08	.19	.18	.15	-.04	.07	.00	.10	.37	-										
44	.10	.11	.02	.19	-.03	.08	.00	.05	.49	.89	-									
45	.05	.07	.22	.26	.03	.03	-.02	.07	.53	.59	.53	-								
47	.04	.11	.23	.21	.04	-.02	.01	.03	.35	.24	.23	.41	-							
48	.04	.13	.23	.23	.08	.02	.02	.10	.31	.24	.22	.35	.44	-						
49	.09	.15	.25	.30	.24	.09	.01	.08	.30	.20	.20	.37	.37	.59	-					
50	.08	.07	.14	.15	.00	.05	.11	.01	.24	.14	.20	.28	.24	.25	.30	-				
51	.05	.08	.26	.15	.15	.00	.11	.09	.30	.31	.30	.44	.03	.25	.30	.35	-			
52	.08	.09	.27	.29	.11	.05	-.03	.07	.52	.24	.30	.41	.40	.40	.45	.32	.37	-		
53	.12	.13	.28	.02	.15	.04	.00	.10	.25	.27	.23	.35	.30	.29	.36	.26	.33	.40	-	
54	.01	.06	.23	.24	.12	.02	.08	-.06	.36	.31	.33	.46	.29	.33	.49	.24	.33	.63	.40	-
55	.01	.06	.30	.17	.16	.01	.03	.09	.29	.24	.33	.42	.34	.28	.28	.24	.38	.42	.36	.53
56	.11	.11	.23	.23	.21	.06	.03	.10	.38	.28	.26	.39	.29	.28	.32	.47	.36	.43	.30	.44
57	.07	.08	.17	.20	.24	-.02	.06	.09	.33	.31	.34	.43	.32	.30	.34	.33	.47	.43	.30	.46
58	.23	.24	.21	.10	.27	.07	.08	.16	.10	-.01	-.04	.10	.08	.08	.23	.11	.24	.14	.24	.03
59	.10	.13	.18	.26	.14	.02	.05	.13	.24	.15	.16	.31	.29	.25	.30	.33	.46	.35	.32	.38
61	.00	.08	.15	.15	.18	-.04	.18	.09	.27	.19	.24	.35	.34	.32	.37	.27	.36	.37	.31	.26
62	.01	.02	.22	.11	.08	-.03	.01	.09	.26	.14	.14	.29	.26	.29	.40	.23	.33	.36	.32	.34
63	.18	.16	.24	.25	.12	.10	.08	.11	.20	.16	.23	.26	.19	.26	.39	.24	.32	.33	.30	.33
64/65	.09	.15	.21	.20	.09	.07	.03	.10	.27	.21	.18	.32	.27	.31	.47	.29	.30	.35	.33	.42
67	.09	.19	.05	.00	.06	.17	.08	.26	.07	.05	.09	.04	-.02	.12	.11	.03	.04	.05	.01	.03
68	.02	.05	-.19	-.05	.24	-.07	.06	.13	.03	-.01	-.01	.03	.09	.05	.08	.09	.12	.08	.05	.06
69/71	.31	.33	.19	.24	.04	.23	.06	.24	.12	.14	.10	.09	.14	.18	.19	.09	.04	.14	.13	.11
70	.13	.19	.02	.08	.17	.06	.12	.38	.11	.04	.03	.08	.04	.08	.10	.06	.11	.04	.10	.02
77/78	.18	.20	.11	.14	.08	.13	.12	.19	.06	.02	.02	.06	.07	.09	.10	.05	.04	.11	.09	.18

Item	55	56	57	58	59	61	62	63	64/65	67	68	69/71	70	77/78
55	-													
56	.37	-												
57	.43	.40	-											
58	.22	.19	.25	-										
59	.31	.35	.44	.18	-									
61	.33	.37	.35	.13	.31	-								
62	.29	.28	.32	.16	.35	.4	-							
63	.26	.31	.30	.16	.37	.38	.60	-						
64/65	.28	.30	.37	.23	.34	.46	.5	.56	-					
67	.08	.06	.10	.15	.06	.07	.02	.09	.16	-				
68	.15	.09	.10	.22	.12	.1	.07	.11	.13	.10	-			
69/71	.06	.09	.07	.13	.11	.11	.08	.16	.21	.27	.14	-		
70	.14	.13	.13	.20	.17	.14	.09	.09	.15	.26	.16	.20	-	
77/78	.06	.13	.09	.11	.08	.06	.05	.01	.11	.19	.13	.26	.14	-

Table 13

ADI-R Polychoric Correlations for the Borderline Group (IQ: 70 – 84; n = 498)

Item	31	33	34	35	36	37	38	39	42	43	44	45	47	48	49	50	51	52	53	54
31	-																			
33	.19	-																		
34	.05	.10	-																	
35	.17	.24	.39	-																
36	.21	-.04	-.10	-.04	-															
37	.24	.31	.25	.23	-.09	-														
38	.21	-.03	-.10	.02	.22	.23	-													
39	.11	.31	.00	.10	.11	.20	-.03	-												
42	.01	.18	.22	.23	.18	.05	.19	.11	-											
43	.19	-.14	.26	.20	-.10	.16	-.02	.02	.49	-										
44	-.20	-.07	.35	.11	-.03	.12	-.01	.07	.48	.64	-									
45	.02	.14	.23	.22	.09	.10	.22	.00	.52	.52	.42	-								
47	.02	.12	.26	.27	.12	.06	.03	.01	.46	.29	.23	.48	-							
48	.00	.08	.19	.21	-.01	.07	.17	.04	.17	.23	.18	.27	.42	-						
49	.02	.02	.22	.19	.11	.09	.02	-.02	.27	.26	.15	.36	.46	.58	-					
50	.08	.10	.21	.16	.17	.04	.13	-.04	.27	.19	.10	.42	.35	.23	.30	-				
51	.16	.13	.09	.19	.06	.05	.12	.05	.25	.24	.17	.43	.36	.29	.33	.47	-			
52	.07	.18	.32	.30	.23	.06	.23	.07	.62	.22	.15	.40	.42	.37	.44	.40	.48	-		
53	.06	.09	-.20	.20	.21	.09	.08	.12	.24	.23	.16	.38	.34	.29	.38	.31	.45	.39	-	
54	.09	.21	.11	.23	-.12	.09	.24	.06	.37	.26	.22	.42	.41	.32	.34	.40	.46	.58	.53	-
55	.04	.08	.25	.20	.22	.08	.07	.09	.26	.26	.24	.41	.42	.27	.36	.33	.36	.44	.37	.32
56	.02	.14	-.12	.23	.23	.00	.06	.09	.48	.23	.18	.45	.39	.24	.27	.51	.42	.45	.35	.27
57	.00	.08	.12	.20	.11	-.01	.11	.08	.29	.22	.13	.31	.29	.26	.27	.42	.44	.38	.37	.28
58	.25	-.01	.04	.17	.53	.08	.06	.16	.14	.21	.12	.04	.22	.27	.24	.10	.25	.34	.24	-.03
59	.13	.14	.12	.31	.11	.05	.13	.13	.42	.32	.18	.41	.37	.29	.38	.43	.54	.45	.42	.27
61	.06	-.02	.03	.09	.06	.00	.09	.04	.30	.25	.17	.36	.25	.27	.33	.27	.36	.38	.28	.27
62	.16	.22	.19	.24	-.15	.09	.08	.09	.32	.22	.12	.32	.23	.25	.34	.30	.41	.35	.29	.24
63	.18	.23	.20	.22	.06	.13	.14	.09	.24	.31	.18	.32	.24	.24	.37	.34	.39	.30	.29	.30
64/65	.11	.17	-.16	.18	.11	.07	.13	.09	.27	.26	.13	.29	.28	.23	.39	.26	.31	.26	.29	.24
67	.15	.06	.14	.08	.18	.16	.19	.24	.04	.05	.13	.04	-.08	.03	-.02	.03	-.02	.00	.00	-.02
68	-.01	.07	-.21	-.07	.22	.05	.15	.11	-.04	.04	.17	-.02	.06	.06	.05	.01	.13	.07	.04	.06
69/71	.19	.25	.12	.09	.09	.18	.52	.18	.23	.07	.50	.05	.08	.20	.09	.08	.11	.14	.17	.25
70	.12	.01	.03	.02	.12	.03	.23	.39	.10	.08	.03	.07	.08	.12	.16	.12	.14	.15	.12	-.01
77/78	.12	.17	-.13	.14	.08	.13	.06	.20	.12	-.12	.08	.09	.11	.12	.10	.05	.13	.09	.18	.21

Item	55	56	57	58	59	61	62	63	64/65	67	68	69/71	70	77/78
55	-													
56	.38	-												
57	.41	.45	-											
58	.31	.2	.23	-										
59	.35	.44	.43	.20	-									
61	.29	.29	.34	.05	.29	-								
62	.19	.32	.27	.08	.37	.35	-							
63	.17	.34	.26	.16	.42	.25	.58	-						
64/65	.23	.29	.31	.21	.34	.35	.52	.47	-					
67	.09	.04	.01	.25	.11	-.01	.05	-.03	.04	-				
68	.21	.12	.14	.16	.08	.13	.09	.08	.07	-.01	-			
69/71	.16	.09	.04	.20	.15	.02	.14	.18	.10	.28	.14	-		
70	.15	.13	.20	.16	.24	.10	.16	.21	.21	.20	.19	.23	-	
77/78	.15	.15	.11	.23	.13	.05	.12	.14	.14	.21	.06	.31	.20	-

Table 14

ADI-R Polychoric Correlations for the ID Verbal Group (IQ: < 70, n = 558)

Item	31	33	34	35	36	37	38	39	42	43	44	45	47	48	49	50	51	52	53	54
31	-																			
33	.16	-																		
34	.46	.28	-																	
35	.28	.27	.33	-																
36	-.22	-.01	-.19	-.22	-															
37	.22	.25	.15	.07	.06	-														
38	-.07	.17	-.02	-.03	.22	.05	-													
39	.01	.26	-.17	-.02	.24	.24	.51	-												
42	.52	.29	.44	.27	-.05	.24	-.05	.12	-											
43	.31	.15	.19	.14	-.32	.23	.17	.03	.44	-										
44	.18	.15	.24	.26	-.21	.21	.21	.14	.51	.69	-									
45	.21	.18	.23	.24	-.11	.11	-.02	.12	.52	.46	.48	-								
47	.17	.23	.37	.27	-.07	.13	-.05	.15	.53	.48	.42	.42	-							
48	.04	.18	.40	.24	-.08	.13	.12	.15	.37	.33	.32	.41	.49	-						
49	.15	.17	.30	.29	-.02	.18	.02	.09	.37	.38	.38	.35	.41	.54	-					
50	.13	.12	.22	.21	-.02	.07	.18	.13	.41	.25	.27	.35	.27	.23	.23	-				
51	.23	.15	.45	.21	-.1	.11	.03	.11	.42	.45	.42	.46	.37	.29	.32	.47	-			
52	.17	.12	.05	.32	-.08	.08	-.21	.08	.66	.47	.51	.52	.45	.40	.40	.36	.46	-		
53	.09	.16	.43	.19	-.07	.02	-.11	.05	.33	.30	.22	.43	.38	.32	.36	.31	.43	.40	-	
54	.21	.14	.38	.23	.00	-.02	-.06	.07	.49	.49	.36	.47	.38	.51	.29	.48	.40	.57	.48	-
55	.22	.15	.23	.33	-.16	.07	-.03	.18	.42	.40	.32	.46	.43	.35	.37	.36	.44	.49	.43	.49
56	.13	.12	.23	.27	.03	.07	.18	.12	.46	.29	.28	.38	.33	.31	.29	.54	.45	.47	.35	.24
57	.08	.10	.18	.17	-.01	.08	.22	.15	.38	.37	.25	.41	.37	.29	.30	.42	.47	.45	.36	.51
58	.23	.17	.39	.24	.10	.23	-.11	.20	.35	-.05	.34	.19	.31	.23	.16	.20	.22	.20	.12	.21
59	.30	.15	.3	.29	-.10	.11	-.04	.17	.38	.30	.25	.47	.26	.27	.32	.46	.53	.38	.35	.44
61	.04	.09	.16	.17	.15	.03	.10	.10	.24	.14	.33	.34	.32	.28	.34	.24	.31	.38	.32	.36
62	.18	.16	.33	.24	-.10	.14	.00	.08	.35	.28	.23	.38	.29	.31	.34	.38	.47	.44	.38	.48
63	.27	.24	.33	.27	-.11	.13	.09	.08	.35	.33	.49	.34	.30	.29	.46	.34	.45	.39	.39	.24
64/65	.21	.22	.37	.30	-.13	.14	.06	.07	.33	.31	.26	.37	.36	.41	.54	.32	.34	.43	.39	.41
67	.11	.18	.12	.07	.11	.04	.14	.19	-.04	.00	-.01	.00	-.04	.12	.06	.05	.01	.01	.02	.09
68	.09	.16	-.01	-.03	.27	.08	.17	.19	-.07	.12	-.05	.00	.03	.00	.09	.07	.09	-.01	.11	.07
69/71	.24	.23	.31	.22	.03	.16	.09	.16	.27	.48	.27	.28	.23	.24	.24	.20	.25	.24	.19	.51
70	.05	.09	.04	.03	.09	.12	.20	.40	.12	.02	.06	.09	.05	.05	.11	.12	.12	-.01	.04	.17
77/78	.21	.18	-.24	.15	-.21	.12	.02	.17	.16	.39	.20	.21	.21	.13	.16	.20	.11	.23	.13	.06

Item	55	56	57	58	59	61	62	63	64/65	67	68	69/71	70	77/78
55	-													
56	.46	-												
57	.41	.41	-											
58	.23	.14	.27	-										
59	.41	.52	.45	.23	-									
61	.36	.29	.32	.15	.25	-								
62	.42	.43	.40	.17	.46	.39	-							
63	.37	.39	.30	.22	.45	.32	.54	-						
64/65	.42	.34	.31	.14	.40	.46	.54	.52	-					
67	.08	.09	.04	.12	.04	.09	.03	.12	.08	-				
68	.03	.06	.09	.15	.03	.10	.09	.05	.03	.04	-			
69/71	.31	.23	.18	.22	.26	.22	.20	.27	.27	.24	.07	-		
70	.14	.17	.09	.13	.09	.15	.06	.13	.13	.07	.15	.32	-	
77/78	.27	.16	.17	.18	.14	.13	.18	.23	.22	.20	.04	.28	.10	-

Table 15

ADI-R Polychoric Correlations for the ID Non-Verbal Group (IQ: < 70, n = 312)

Item	31	42	43	44	45	47	48	49	50	51	52	53	54	55	56	57	58	59	61	62	63
31	-																				
42	.03	-																			
43	.30	.52	-																		
44	.06	.10	.19	-																	
45	.04	.45	.53	.40	-																
47	.08	.32	.24	.34	.42	-															
48	.09	.43	.32	.31	.47	.51	-														
49	.06	.35	.27	.22	.38	.42	.65	-													
50	.15	.08	.26	.16	.33	.23	.17	.33	-												
51	.00	.29	.27	.42	.45	.33	.26	.33	.46	-											
52	-.01	.24	.50	.34	.42	.46	.38	.45	.28	.40	-										
53	-.07	.43	.36	.21	.46	.32	.36	.38	.28	.42	.56	-									
54	-.17	.51	.33	.13	.47	.26	.32	.33	.41	.54	.49	.53	-								
55	-.04	.24	.31	.24	.35	.33	.43	.41	.34	.40	.44	.39	.45	-							
56	.14	.18	.28	.25	.39	.26	.29	.38	.5	.48	.38	.34	.50	.43	-						
57	.03	.26	.24	.21	.37	.27	.30	.37	.48	.49	.39	.36	.51	.43	.50	-					
58	.15	.15	-.04	-.17	.19	.19	.42	.37	.02	.22	.21	.21	.46	.09	.22	.14	-				
59	.04	.47	.35	.32	.38	.33	.35	.40	.44	.58	.43	.41	.54	.36	.41	.48	.41	-			
61	.03	.33	.24	.26	.42	.38	.42	.42	.37	.34	.38	.39	.52	.40	.42	.39	.22	.38	-		
62	.05	.53	.33	.25	.41	.29	.33	.43	.35	.36	.38	.36	.34	.40	.37	.32	-.19	.30	.41	-	
63	.00	.23	.35	.13	.29	.28	.32	.37	.26	.24	.40	.38	.43	.32	.33	.22	.20	.39	.25	.54	-
64/65	.05	.36	.24	.23	.33	.23	.36	.37	.29	.28	.37	.34	.32	.33	.27	.33	.09	.44	.41	.54	.44
67	.13	-.04	.12	.17	.10	.08	.12	.10	.10	.11	.04	.12	.18	.29	.07	.29	.06	.11	.07	.03	.05
68	.13	-.12	-.22	.03	-.02	.00	-.06	.04	.05	.08	-.02	.03	-.22	.05	.06	.14	-.19	.06	.01	.07	.01
69/71	.20	.28	.18	.22	.23	.20	.24	.20	.26	.19	.26	.27	.18	.20	.17	.22	.23	.27	.22	.17	.25
70	.08	.09	.11	.18	.09	.11	.04	.10	.05	.13	.09	.02	.19	.07	.05	.18	.07	.2	.03	.06	.13
77/78	.12	-.01	.22	.11	.07	.13	.15	.08	.19	-.06	.20	.14	.09	.11	.07	.18	-.05	.13	.14	0.15	.24

Item	64/65	67	68	69/71	70	77/78
64/65	-					
67	.10	-				
68	.11	-.03	-			
69/71	.22	.18	.07	-		
70	.12	.11	.16	.06	-	
77/78	.20	.04	.00	.26	.17	-

Table 16

ADI-R CFA Model Fit for No ID Group (IQ ≥ 85; $n = 1451$)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	526	5869.5	.80	.84	.08	.09
2.	524	5199.4	.85	.84	.08	.09
3.	524	4623.9	.87	.86	.07	.09
4.	**521**	**3312.4**	**.91**	**.91**	**.06**	**.07**

Note: Model 4 had significantly better fit than Model 1, X^2 (5) = 627.21, $p < 0.01$; Model 2, X^2 (3) = 634.6, $p < 0.01$; and Model 3, X^2 (3) = 560.05, $p < 0.01$

Table 17

ADI-R CFA Model Fit for Borderline Group (IQ 70 to 84; $n = 498$)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	526	1723.8	.85	.84	.07	.07
2.	524	1634.2	.86	.85	.07	.09
3.	524	1614.3	.87	.86	.07	.08
4.	**521**	**1282.8**	**.91**	**.90**	**.05**	**.08**

Note: Model 4 had significantly better fit than Model 1, X^2 (5) = 176.04, $p < 0.01$; Model 2, X^2 (3) = 165.26, $p < 0.01$; and Model 3, X^2 (3) = 173.01, $p < 0.01$

Table 18

ADI-R CFA Model Fit for ID Verbal Group (IQ < 70; n = 558)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	**526**	**1657.63**	**.89**	**.89**	**.06**	**.08**
2.	**524**	**1535.88**	**.91**	**.90**	**.06**	**.08**
3.	**524**	**1546.46**	**.90**	**.90**	**.06**	**.08**
4.	**521**	**1312.90**	**.93**	**.92**	**.05**	**.07**

Note: Model 4 had significantly better fit than Model 1, X^2 (5) = 179.2, $p < 0.01$; Model 2, X^2 (3) = 111.92, $p < 0.01$; and Model 3, X^2 (3) = 146.71, $p < 0.01$

Table 19

ADI-R CFA Model Fit for ID Non-Verbal Group (IQ < 70; n = 312)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	**323**	**518.6**	**.95**	**.94**	**.04**	**.07**
2.	**321**	**481.9**	**.96**	**.95**	**.04**	**.07**
3.	**321**	**475.7**	**.96**	**.95**	**.04**	**.07**
4.	**318**	**423.2**	**.97**	**.97**	**.03**	**.07**

Note: Model 4 had significantly better fit than Model 1, X^2 (5) = 64.112, $p < 0.01$; Model 2, X^2 (3) = 42.928, $p < 0.01$; and Model 3, X^2 (3) = 44.24, $p < 0.01$

Table 20

ADI-R Standardized Factor Loadings for Model 4 (4-Factor Model)

	No ID	Borderline	ID Verbal	ID Non-Verbal
Social Factor				
31. Use of other's body	.17	.16	**.31**	.08
50. Direct gaze	**.51**	**.62**	**.58**	**.63**
51. Social smiling	**.63**	**.69**	**.71**	**.68**
52. Showing/directing attention	**.71**	**.74**	**.74**	**.71**
53. Offering to share	**.56**	**.62**	**.61**	**.67**
54. Seek to share enjoyment	**.71**	**.69**	**.74**	**.72**
55. Offering comfort	**.60**	**.60**	**.70**	**.65**
56. Quality of social overtures	**.63**	**.68**	**.66**	**.67**
57. Range of facial expressions	**.66**	**.60**	**.63**	**.70**
58. Inappropriate facial expressions	**.29**	**.34**	**.36**	**.31**
59. Appropriateness of social responses	**.58**	**.71**	**.67**	**.71**
Communication Factor				
34. Social chat (verbal item)	**.35**	**.28**	**.36**	--
35. Reciprocal conversation (verbal item)	**.45**	**.44**	**.47**	--
42. Pointing to express interests	**.69**	**.75**	**.79**	**.69**
43. Nodding	**.92**	**.89**	**.90**	**.76**
44. Head-shaking	**.93**	**.81**	**.85**	**.60**
45. Conventional instrumental gestures	**.79**	**.79**	**.79**	**.82**
Play/Peer Factor				
47. Spontaneous imitation of actions	**.64**	**.66**	**.64**	**.58**
48. Imaginative play	**.63**	**.57**	**.62**	**.65**
49. Imaginative peer play	**.71**	**.69**	**.67**	**.70**
61. Imitative social play	**.62**	**.55**	**.55**	**.67**
62. Interest in children	**.58**	**.64**	**.71**	**.69**
63. Response to children's approaches	**.65**	**.64**	**.68**	**.61**
64/65. Group play / Friendships	**.68**	**.61**	**.71**	**.64**
RRBI Factor				
33. Stereotyped utterances (verbal item)	**.54**	**.46**	**.79**	--
36. Inappropriate questions (verbal item)	**.36**	**.38**	-.11	--
37. Pronominal reversal (verbal item)	**.32**	**.32**	**.34**	--
38. Neologisms (verbal item)	**.29**	**.31**	.13	--
39. Verbal rituals (verbal item)	**.54**	**.42**	**.39**	--
67. Unusual preoccupations	**.39**	**.29**	**.24**	**.31**
68. Circumscribed interests	**.30**	**.29**	**.14**	.15
69/71. Repetitive use of objects/Sensory interests	**.55**	**.51**	**.68**	**.60**
70. Compulsions/Rituals	**.46**	**.53**	**.34**	**.30**
77/78. Hand Finger movements/ Complex Mannerisms	**.39**	**.45**	**.53**	**.38**

Note. significant loadings (p < .05) are bold

Table 21

ADOS Module 3 Polychoric Correlations for the No ID Group (IQ: ≥ 85; n = 1170)

Item	A4	A7	A8	A9	B1	B2	B4	B5	B6	B7	B9	B10	B11	C1	D1	D2
A4	-															
A7	.06	-														
A8	.23	.37	-													
A9	-.05	.34	.18	-												
B1	-.05	-.07	.17	.08	-											
B2	.03	.12	.24	.28	.22	-										
B4	-.03	.20	.24	.25	.17	.57	-									
B5	.01	.38	.23	.24	.06	.35	.20	-								
B6	.22	.40	.41	.17	.01	.21	.19	.42	-							
B7	.32	.16	.44	.15	.26	.32	.37	.10	.23	-						
B9	.24	.24	.52	.14	-.03	.25	.34	.25	.37	.37	-					
B10	.10	.34	.62	.31	.24	.33	.56	.27	.32	.30	.53	-				
B11	.17	.19	.46	.15	.12	.21	.43	.22	.35	.45	.57	.50	-			
C1	-.04	.22	.31	.32	.24	.24	.49	.21	.25	.21	.23	.30	.32	-		
D1	.10	.21	.07	.04	-.24	.09	.04	.16	.27	.10	.14	.13	.17	.12	-	
D2	.13	.24	.11	-.02	-.03	.00	-.01	.08	.19	.05	.24	.12	.24	.04	.24	-
D4	.32	.05	.09	-.06	.02	.00	.15	.01	.05	.09	.19	-.04	.09	.06	.17	.24

Table 22

ADOS Module 3 Polychoric Correlations for the Borderline Group (IQ 70 – 84; n = 290)

Item	A4	A7	A8	A9	B1	B2	B4	B5	B6	B7	B9	B10	B11	C1	D1	D2
A4	-															
A7	.21	-														
A8	.30	.41	-													
A9	.05	.23	.18	-												
B1	.20	-.03	.09	-.12	-											
B2	-.03	.10	.20	.37	-.18	-										
B4	.24	.32	.40	.27	.18	.56	-									
B5	.08	.32	.26	.27	.02	-.20	.22	-								
B6	.21	.27	.33	.06	.13	.17	.23	.28	-							
B7	.30	.32	.50	.21	.20	.23	.53	.21	.25	-						
B9	.39	.26	.53	-.06	.40	.07	.44	.24	.50	.30	-					
B10	.42	.44	.58	-.14	.27	.15	.51	.24	.30	.45	.57	-				
B11	.23	.37	.47	.21	-.10	.33	.54	.22	.40	.53	.34	.40	-			
C1	.08	.22	.36	.18	-.07	-.18	.29	.20	.36	.34	.36	.42	.40	-		
D1	.22	.06	.12	-.05	-.42	.11	.05	.10	.23	.19	.29	-.20	.18	.09	-	
D2	.25	-.22	-.03	.09	.09	.05	-.08	.00	.23	.29	.12	.07	.22	.07	.18	-
D4	.37	.12	.15	.02	-.20	-.21	.16	.17	.09	.22	.20	.02	.22	.09	.26	.24

Table 23

ADOS Module 2 Polychoric Correlations for the Verbal ID Group (IQ < 70; n = 227)

Item	A4	A6	A7	B1	B2	B3	B5	B6	B8	B11	B12	C1	C2	D1	D2
A4	-														
A6	.25	-													
A7	.08	.19	-												
B1	-.07	.13	.10	-											
B2	.38	-.07	.00	.18	-										
B3	.22	.21	.23	.26	.58	-									
B5	.11	.44	.43	-.01	.20	.46	-								
B6	.06	.20	.43	.16	-.12	.38	.66	-							
B8	.03	.38	.26	.24	.40	.55	.54	.11	-						
B11	.25	.52	.27	.41	.39	.54	.53	.33	.55	-					
B12	.05	.41	.26	.19	.30	.43	.42	.26	.52	.49	-				
C1	.10	.28	.25	.24	.33	.37	.20	.06	.38	.38	.36	-			
C2	.06	.41	.09	.20	-.16	.12	.22	.13	.35	.36	.35	.58	-		
D1	.06	.02	.25	.50	.26	.53	.41	.18	.41	.31	.22	.22	.24	-	
D2	.16	.11	.09	.20	.11	-.12	.43	.21	.00	.06	.12	.12	.37	.28	-
D4	-.06	-.06	.00	.39	-.18	.05	-.12	.00	.04	-.09	.13	-.06	-.01	-.24	.15

Table 24

ADOS Module 1 Polychoric Correlations for the ID Non-Verbal Group (IQ < 70; n = 303)

Item	A2	A3	A5	A7	A8	B1	B3	B4	B5	B9	B10	B11	C1	D1	D2
A2	-														
A3	-.23	-													
A5	-.35	.32	-												
A7	.40	-.46	-.16	-											
A8	.26	-.23	-.12	.23	-										
B1	.11	-.19	-.22	.30	-.18	-									
B3	.37	-.18	.04	.08	-.07	.27	-								
B4	.53	-.22	-.10	.37	.23	.22	.34	-							
B5	.38	.09	-.03	.36	.16	.22	.34	.25	-						
B9	.40	.16	-.04	.34	.20	.16	.45	.47	.32	-					
B10	.29	-.43	-.03	.45	.21	.10	.37	.25	.27	.52	-				
B11	.30	-.10	-.20	.46	-.15	-.18	-.13	.27	.26	.12	.26	-			
C1	.44	-.05	-.01	.31	.28	.01	.57	.44	.45	.32	.45	.22	-		
D1	.30	-.03	-.23	.34	.18	-.18	-.19	.23	.22	.2	.19	.28	.24	-	
D2	.38	.03	-.19	.40	.16	.29	.08	.24	.33	.24	.24	.34	.33	.45	-
D4	.20	.11	-.02	-.19	.11	-.22	-.10	.12	.45	-.17	.21	.19	.16	.18	.21

Table 25

ADOS CFA Model Fit for No ID Group (Module 3; *n* = 1179)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	76	447.66	.88	.86	.07	.08
2.	74	488.87	.87	.84	.07	.08
3.	116	739.17	.86	.83	.07	.08
4.	113	667.67	.87	.85	.07	.07

Table 26

ADOS CFA Model Fit for the Borderline Group (Module 3; *n* = 290*)*

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	**76**	**116.01**	**.98**	**.97**	**.04**	**.07**
2.	**74**	**163.84**	**.95**	**.94**	**.07**	**.08**
3.	**116**	**169.55**	**.98**	**.97**	**.04**	**.07**
4.	**113**	**168.56**	**.97**	**.97**	**.04**	**.07**

Note. models with good fit statistics are bold

Table 27

ADOS CFA Model Fit for ID Verbal Group (Module 2; n = 227)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	**74**	**135.11**	**.95**	**.94**	**.06**	**.09**
2.	**76**	**147.35**	**.94**	**.93**	**.06**	**.09**
3.	**101**	**172.82**	**.96**	**.94**	**.06**	**.09**
4.	**98**	**166.89**	**.95**	**.94**	**.06**	**.09**

Table 28

ADOS CFA Model Fit for ID Non-Verbal Group (Module 1; n = 303)

Model	df	X^2	CFI	TLI	RMSEA	SRMR
1.	**96**	**62**	**.95**	**.96**	**.04**	**.08**
2.	**96**	**64**	**.95**	**.96**	**.04**	**.08**
3.	**101**	**178.76**	**.93**	**.92**	**.05**	**.09**
4.	**84**	**134.64**	**.95**	**.94**	**.05**	**.08**

Note. models with good fit statistics are bold

Table 29

ADOS (Module 3) Standardized Factor Loadings for the 4-Factor Model

	No ID	Borderline
Social Factor		
B1. Unusual eye contact	**.24**	**.23**
B2. Facial expressions directed to others	**.49**	**.60**
B4. Shared enjoyment in interaction	**.65**	**.69**
B7. Quality of social overtures	**.60**	**.75**
B8. Quality of social response	**.74**	**.80**
B10. Amount of reciprocal social communication	**.82**	**.85**
B11. Quality of rapport	**.69**	**.78**
Communication Factor		
A7. Reporting of events	**.52**	**.55**
A8. Conversation	**.73**	**.78**
A9. Gestures	**.41**	**.35**
Play/Peer Factor		
C1. Imagination/Creativity	**.54**	**.63**
B5. Comments on other’s emotions/empathy	**.51**	**.45**
B6. Insight into typical social situations/relationships	**.65**	**.63**
RRBI Factor		
A4. Stereotyped/idiosyncratic use of words/phrases	**.40**	**.81**
D1. Unusual sensory interests	**.57**	**.45**
D2. Hand/finger and other complex mannerisms	**.44**	**.44**
D4. Repetitive interests and/or behaviours	**.29**	**.51**

Note. *significant loadings (p < .05) are bold*

Table 30

ADOS (Module 2) Standardized Factor Loadings for the 4-Factor Model

	ID Verbal
Social Factor	
B1. Unusual eye contact	**.45**
B2. Facial expressions directed to others	**.71**
B4. Shared enjoyment in interaction	**.75**
B5. Showing	**.66**
B6. Spontaneous initiation of joint attention	**.43**
B8. Quality of social overtures	**.78**
B11. Amount of reciprocal social communication	**.83**
B12. Quality of rapport	**.68**
Communication Factor	
A6. Conversation	**.56**
A7. Pointing	**.39**
Play/Peer Factor	
C1. Functional play with objects	**.83**
C2. Imagination	**.78**
RRBI Factor	
A4. Immediate echolalia	**.37**
D1. Unusual sensory behaviours	**.74**
D2. Hand/finger and other complex mannerisms	**.39**
D4. Repetitive interests and/or behaviours	**.23**

Note. *significant loadings (p < .05) are bold*

Table 31

ADOS (Module 1) Standardized Factor Loadings for the 4-Factor Model

	ID Non -Verbal
Social Factor	
B1. Unusual eye contact	**.50**
B3. Facial expressions directed to others	**.61**
B4. Integration of gaze and other behaviours	**.68**
B5. Shared enjoyment in interaction	**.59**
B9. Showing	**.80**
B10. Spontaneous initiation of joint attention	**.54**
B11. Response to joint attention	**.52**
B12. Quality of social overtures	**.78**
Communication Factor	
A1. Overall level of non-echoed spoken language	**.68**
A8. Gestures	**.40**
Play/Peer Factor	
C1. Functional play with objects	**.61**
C2. Imagination/creativity	**.81**
RRBI Factor	
D1. Unusual sensory interests	**.57**
D2. Hand/finger and other complex mannerisms	**.36**
D4. Repetitive interests and/or behaviours	**.25**

Note. significant loadings (p < .05) are bold

Appendix

ADI-R Diagnostic Algorithm Items

Domain A: Qualitative Abnormalities in Reciprocal Social Interaction

A1: Failure to use nonverbal behaviors to regulate social interaction

- Direct gaze (item 50)
- Social Smiling (item 51)
- Range of Facial Expressions Used to Communicate (item 57)

A2: Failure to develop peer relationships

- Imaginative Play With Peers (item 49)
- Interest in Children (item 62)
- Response to Approaches of Other Children (item 63)
- Group Play with Peers OR Friendships (item 64 or 65 depending on age)

A3: Lack of shared enjoyment

- Showing and Directing Attention (item 52)
- Offering to Share (item 53)
- Seeking to Share Enjoyment With Others (item 54)

A4: Lack of socioemotional reciprocity

- Use of Other's Body to Communicate (item 31)
- Offering Comfort (item 55)
- Quality of Social Overtures (item 56)
- Inappropriate Facial Expressions (item 58)
- Appropriateness of Social Responses (item 59)

A Total = A1 + A2 + A3 + A4

Domain B: Qualitative Abnormalities in Communication

B1: Lack of, or delay in, spoken language and failure to compensate through gesture

- Pointing to Express Interest (item 42)
- Nodding (item 43)
- Head Shaking (item 44)
- Conventional/Instrumental Gestures (item 45)

B4: Lack of varied spontaneous make-believe or social imitative play

- Spontaneous Imitation of Actions (item 47)
- Imaginative Play (item 48)
- Imitative Social Play (item 61)

Verbal Participants Only:

B2 (V): Relative failure to initiate or sustain conversational interchange

- Social Verbalization/Chat (item 34)
- Reciprocal Conversation (item 35)

B3 (V): Stereotyped, repetitive or idiosyncratic speech

- Stereotyped Utterances and Delayed Echolalia (item 33)
- Inappropriate Questions or Statements (item 36)
- Pronominal Reversal (item 37)
- Neologisms/Idiosyncratic Language (item 38)

Verbal Total = B1 + B2 (V) + B3 (V) + B4

Nonverbal Total = B1 + B4

Domain C: Restricted, Repetitive, and Stereotyped Patterns of Behavior

C1: Encompassing preoccupation or circumscribed pattern of interest

- Unusual Preoccupations (item 67)
- Circumscribed Interests (item 68)

C2: Apparently compulsive adherence to nonfunctional routines or rituals

- Verbal Rituals (item 39)
- Compulsions/Rituals (item 70)

C3: Stereotyped and repetitive motor mannerisms

- Hand and Finger Mannerisms OR Other Complex Mannerisms or Stereotyped Body Movements (item 77 or 78; score the higher of the two)

C4: Preoccupations with part of objects or non-functional elements of material

- Repetitive Use of Objects OR Interest in Parts of Objects (item 69 or 71; score the higher of the two)
- Unusual Sensory Interests (item 71)

C Total = C1 + C2 + C3 + C4