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A Longitudinal Examination of Repetitive Behaviours in Young Children with Autism Spectrum Disorder

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Abstract

Restricted, repetitive patterns of behavior, interests, or activities (RRBs) comprise one of the main clusters of symptoms of autism spectrum disorder (ASD). Though diagnoses of ASD have been found to remain relatively stable over time, identifying the developmental trajectories of individual symptoms within the spectrum can help clinicians and researchers understand the evolution of the disorder and create more focused intervention programs. This study consisted of an examination of the developmental trajectories of RRBs in children with ASD from diagnosis to age 6 years. Data were extracted from the database of the national Pathways in ASD study and included information accrued from the Autism Diagnostic Interview (ADI-R), the Autism Diagnostic Observation Scale (ADOS), and the Repetitive Behaviour Scale (RBS-R). Language ability, adaptive skills, and parenting stress were also examined as predictors of RRB trajectories. Improvement over time was found for overall RRBs, as well as for most subcategories of RRBs on all measures. Predictors, however, varied across measures and subtypes of RRBs.

Résumé

Les comportements stéréotypés et intérêts restreints représentent l'un des principaux groupes de symptômes du trouble du spectre de l'autisme (TSA). Bien que le diagnostic du TSA soit démontré comme étant relativement stable dans le temps, l'identification des trajectoires développementales axées sur les symptômes individuels à l'intérieur du spectre peut permettre aux cliniciens et aux chercheurs de mieux comprendre l'évolution du TSA, et de mettre en place des programmes d'intervention mieux ciblés. Cette étude est basée sur l'observation des trajectoires développementales des comportements stéréotypés et intérêts restreints chez les enfants ayant un TSA à partir du moment du diagnostic jusqu'à l'âge de 6 ans. Les données recueillies ont été obtenues à partir de la base de données de l'étude nationale Pathways in ASD et inclut des éléments provenant de l'ADI-R (entretien semi-structuré pour le diagnostic de l'autisme), de l'ADOS (échelle d'observation diagnostique pour l'autisme), et du RBS-R (échelle des comportements répétitifs). Les habiletés langagières, le fonctionnement adaptif, et les niveaux de stress parentaux ont également été examinés comme prédicteurs des trajectoires des comportements stéréotypés et intérêts restreints. Une amélioration au fil du temps a été constatée à la fois pour l'ensemble des comportements stéréotypés et intérêts restreints et pour la majorité des sous-catégories sur toutes les mesures. Cependant, des différences au niveau des prédicteurs ont été constatées, selon les mesures et les sous-types de comportements stéréotypés et intérêts restreints.

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Winnie, Maddie, Tigger, Cooper, and Toby, for all of your love and support throughout this process, all of graduate school, and for my entire life. I could not ask for a better family or support system and I am so lucky to have each and every one of you in my life. I am also so grateful for your accommodation and understanding, especially during these past few months.

Preface and Contribution of Authors

The following dissertation is submitted in partial fulfillment of the degree of Doctor of Philosophy in School/Applied Psychology, in the department of Educational and Counselling Psychology at McGill University. Research was conducted under the supervision of Professor Jacob A. Burack, Ph.D. and was approved by the Research Ethics Board III of McGill University.

All data described in this dissertation were drawn from the database of the Pathways in ASD study, a national study of developmental trajectories in autism spectrum disorder. The use of this data was approved by Dr. Eric Fombonne, MD, a member of my thesis advisory committee, as a representative of the principal investigators of the Pathways in ASD study. While the data were drawn from an existing database, I was involved in data collection, though at the time it was not yet part of my dissertation. Although I was not involved in the project at the onset of the Pathways in ASD study, and therefore was not involved in the design of the Pathways study, recruitment of participants, or testing at the early time points, I worked as a research assistant in the autism spectrum disorder clinic at the Montreal Children's Hospital, one of the Pathways in ASD sites, from 2010-2012. As a clinical research assistant, I was involved in collecting some of the data used in this dissertation, particularly at the final time point.

This dissertation provides an original contribution to knowledge as it is the first study, to my knowledge, to examine the developmental trajectories of restricted, repetitive patterns of behavior, interests, or activities (RRBs) from diagnosis to age 6 years, using multiple sources of information. Specifically, RRBs were examined using parent interviews, parent questionnaires, and direct observation. As data accrued from parent report and direct observation methods each have strengths and weaknesses, using both methods should provide a more comprehensive

understanding of behaviour. In addition, this dissertation is focused on developmental trajectories of RRBs in early childhood, which is a critical age range in ASD.

A Longitudinal Examination of Repetitive Behaviours in Young Children with Autism Spectrum Disorders

Diagnoses of autism spectrum disorders (ASDs) have been found to be relatively stable over time (eg. Chawarska et al., 2007; Cox et al., 1999; Kleinman et al., 2008; Lord et al., 2006) as individuals diagnosed with an ASD before the age of 3 years will also often receive a diagnosis on the autism spectrum at follow-up evaluations up to six years later. Despite this broad diagnostic stability, variability within the spectrum has been found. As most studies examining the stability of ASD and related symptoms were conducted in the era of the 4th edition of the Diagnostic and Statistical Manual for Mental Disorders (DSM-IV, TR; American Psychiatric Association, 2000), wherein the autism spectrum consisted of multiple diagnoses (autistic disorder, childhood disintegrative disorder, pervasive developmental disorder not otherwise specified, Asperger's disorder), variability within the spectrum was examined by assessing whether a child was assigned a different diagnosis on the spectrum at follow-up evaluations or whether the initial diagnosis was upheld. In support of temporal variability within the autism spectrum, Lord et al. (2006) found that some individuals diagnosed with a milder form of ASD, pervasive developmental disorder not otherwise specified (PDD-NOS), in early childhood were later assigned a diagnosis of the more severe autistic disorder (Lord et al., 2006). Despite the amalgamation of the multiple autism spectrum disorders into a single diagnosis with multiple severity levels, known as autism spectrum disorder (ASD), with the introduction of the 5th edition of the DSM (American Psychiatric Association, 2013), variability within the spectrum can continue to be examined. Specifically, evolution along the autism spectrum can be re-contextualized into the framework of the DSM-V by understanding this change as movement between severity levels or examining the trajectories of individual symptoms.

Identifying the developmental trajectories of the individual symptoms of ASD can extend our understanding of the progression of ASD at the diagnostic level, since diagnoses of ASDs are based on a constellation of symptoms including difficulties with social communication, impairments in social interaction, and restricted, repetitive and stereotyped patterns of behaviours and interests (American Psychiatric Association, 2013). Severity levels that represent the extent to which a child requires support are also assigned to the social communication and interaction deficits and the repetitive and stereotyped patterns of behaviours and interests. Since variability within the autism spectrum has been found despite broader diagnostic stability (Lord et al., 2006), further understanding the ways in which each of these clusters of symptoms evolves over time, and how they relate to one another highlights both the specific contribution of each symptom to the development of ASD, and the risk factors in the development of a more severe form of ASD. According to the DSM-V (American Psychiatric Association, 2013), the category of behaviours known as restricted and repetitive patterns of interests and behaviours (RRBs) is defined as (1) stereotyped or repetitive motor movements, use of objects, or speech; (2) insistence on sameness, inflexible adherence to routines, or ritualized patterns or verbal nonverbal behavior ; (3) highly restricted, fixated interests that are abnormal in intensity or focus; and (4) hyper- or hyporeactivity to sensory input or unusual interests in sensory aspects of the environment. RRBs are not only a defining characteristic of ASD, but these patterns of behaviours and interests can also negatively impact other areas of ASD, such as socialization. For example, individuals whose time is mostly spent engaged in RRBs often miss social cues as a result of their intense focus on the RRBs. As such, the developmental trajectories of RRBs throughout childhood can inform the progression of ASD at the diagnostic level.

In addition to enhancing the understanding of the contributing factors to the development of ASD throughout childhood, identifying the developmental trajectories of RRBs has clinical significance for individuals working on intervention strategies for children with ASD. Research in this area can help inform and apply to intervention, since the most common interventions for children with ASD (e.g., Applied Behavioural Analysis) are often aimed at specific symptoms, rather than at the diagnosis as a whole (Leekam et al., 2011). Understanding the natural development of clusters of symptoms can help identify the specific symptoms that improve with maturity, and the symptoms that tend to worsen over time. Furthermore, knowledge in the area of the trajectories of these symptoms could allow researchers to highlight specific time periods when behaviours are more susceptible to change. Since behavioural interventions in early childhood have shown some positive results for improving RRBs, and more fine-tuned strategies are needed to ameliorate specific behaviours at an appropriate age or time period (Leekam et al., 2011), research examining the developmental trajectories of RRBs can provide valuable theoretical and practical knowledge in the area of ASD. Furthermore, RRBs can also be found in typically developing children, and the factors that differentiate atypical RRBs from those found in typical development, should contribute to understanding the disorder as whole. The primary objective of the present dissertation is, therefore, to extend our understanding of the specific developmental trajectories of RRBs in early childhood and the factors that promote or inhibit these changes.

The specific definition of RRBs was slightly modified from the DSM-IV-TR (American Psychiatric Association, 2000) to the DSM-5 (American Psychiatric Association, 2013). While the majority of studies of RRBs in children with ASD were conducted under the DSM-IV-TR framework, the concept of RRBs remains constant, as the DSM-5 definition of RRBs

encompasses and expands on the categories of RRBs listed in the previous edition. The DSM-IV-TR definition of RRBs includes the four categories of (1) excessive interest in restricted topics unusual in either nature or intensity; (2) insistence on specific rituals or routines; (3) hand, finger or whole body movements or mannerisms that are stereotyped or repetitive; and (4) excessive interest in parts, rather than whole, objects (American Psychiatric Association, 2000). The two main instruments used to diagnose ASD, the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003) and the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000), both include sections devoted to assessing symptoms within these four categories of RRBs. For example, the RRB section of the ADI-R includes questions related to unusual preoccupations, circumscribed interests, sensory behaviours, repetitive activities and play, rituals and mannerisms, each of which falls into at least one of the aforementioned four categories. Similarly, the administration of the ADOS also involves the observation of behaviours such as excessive interest in specific topics, mannerisms, repetitive play, and sensory behaviours. While second edition of the ADOS (ADOS-2; Lord, Rutter, DiLavore, Risi, Gotham, & Bishop, 2012) was released with the aim of corresponding to the DSM-5 diagnostic criteria for ASD and measurement of severity levels, most studies of RRBs have involved the use of the original ADOS, as they were conducted prior to the release of the latter edition. Ratings of RRBs on the ADI-R and ADOS concurrently encompass both frequency and severity of RRBs, in that higher scores on either measure indicate both higher frequencies and severity of RRBs. In order to broaden the scope of RRB assessment, specialized questionnaires have also been developed to expand upon the RRB sections of diagnostic instruments (Leekam et al., 2011). For example, the Repetitive Behaviour Scale Revised (RBS-R; Bodfish, Symons, & Lewis, 1999) includes 43 items divided among six dimensions of RRBs. The development of these instruments has

therefore allowed for comprehensive assessment of RRBs in children with ASD and application of observed and reported symptoms to DSM criteria.

When examining the categories of RRBs, Mooney, Gray, Tonge, Sweeney, and Taffe (2009) analyzed repetitive behaviour items on the Autism Diagnostic Interview (ADI-R; Rutter, LeCouteur, & Lord, 2003), and combined the four DSM categories of RRBs into two categories of RRBs. The first category, referred to as insistence on sameness (IS) behaviours, includes an extreme adherence to specific routines, insistence of specific clothing, foods, and resistance to change, as well as circumscribed interests, which involve an all-encompassing interest or fixation on a specific topic (Leekam et al., 2011). Across the range of levels of functioning, IS behaviours are most commonly found among children with ASD who exhibit more developed cognitive and language abilities (i.e., those who do not have a comorbid intellectual disability). The second category, known as repetitive and sensory motor (RSM) behaviours, includes behaviours such as hand or finger flicking, tapping, rocking, and repetitively spinning wheels of toys, or lining up objects. These behaviours are less complex than IS behaviours, and are most commonly found among lower functioning children (Leekam et al., 2011). This division between IS and RSM behaviors is consistent with the findings of other factor analytical studies of RRBs (e.g., Bishop et al., 2013; Szatmari et al., 2006).

Despite these seemingly discrete categorical distinctions, Leekam et al. (2011) postulate that a two category model of RRBs does not sufficiently or accurately consider all RRBs, as some RRBs commonly found among children with ASD can be concurrently classified in both categories. These behaviours often involve a number of components, some of which might be considered sensory while others might be considered ritualistic (Leekam et al., 2011). For example, a complex ritual involving a sensory element, such as sniffing a group of objects in a

specific manner and sequence, can be classified in both categories, as the sensory aspect of the ritual can be considered an RSM behaviour, while the rigidity of the ritual itself can be considered an IS behaviour. This overlap between categories highlights the potential complexity of RRBs in children with ASD. As a result, a two-factor model of RRBs does not fully encompass the complexity of RRBs and further breaking down RRBs can provide a more comprehensive understanding of this symptom. As RRBs have also been found to increase in complexity as children age, breaking down each RRB into specific components should provide more nuanced information regarding the evolution of RRBs over time and maturity.

Repetitive and Stereotyped Behaviours in Typical Development and among Children with ASD

The identification of RRBs as a core symptom of ASD does not mean that these behaviours are unique to the disorder. While RRBs are intrinsic to the diagnosis of ASD, they are also found among individuals without ASD, including young typically developing children (Evans et al., 1997; Leekam et al., 2011). For example, in typical development, young children often engage in RRBs through the incorporation of rituals in play, such as repetitive rhyming games (Zohar & Bruno, 1997). Studies designed to examine the developmental trajectories of these behaviours in both ASD and typical development can help identify whether there is a point at which typical behaviours become atypical, and differentiating RRBs displayed by individuals with ASD from those seen in typical development can also help identify the characteristics of these behaviours that are unique to children with ASD. This can help researchers and clinicians create more focused interventions that target specific RRBs rather than the category in its entirety. Differences in RRBs found among children with ASD and typically developing

children include frequency, quality, age of onset, and developmental trajectories of RRBs (Leekam et al., 2011)

Frequency and quality of RRBs in children with ASD. In an attempt to differentiate between typical and atypical RRBs, Watt, Wetherby, Barber, and Morgan (2008) found that a group of young children with ASD displayed a higher frequency of RRBs than either children with other developmental disabilities or typically developing children. In a follow-up study, Barber, Wetherby, and Chambers (2012) found that, in coded videotapes of young children, children with ASD showed higher frequencies of specific RRBs than typically developing children with a mean age of 14 months matched on non-verbal developmental level, including rocking, swiping, spinning, rolling, moving, clutching and rubbing objects. Matching children based on developmental level allows for elimination of the hypothesis that group differences can be attributed to differences in mental age (Barber et al., 2012), allowing them to conclude that the frequency and pattern of RRBs shown by children with ASD are distinct from those displayed by typically developing children. Similarly, infant siblings of children with ASD have been found to exhibit higher rates of RRBs than infant siblings of typically developing children (Damiano, Nahmias, Hogan-Brown, & Stone, 2013). Specifically, infants with a mean age of 15 months who had a sibling diagnosed with ASD showed more repetitive and sensorimotor behaviours (e.g., flapping, stiffening, rubbing, spinning, rocking, lining, and clutching) than matched infants with a typically developing sibling (Damiano et al., 2013).

Along with a higher frequency of RRBs among children with ASD, the ways in which they are exhibited can be used to distinguish those seen among children with ASD from those seen in typically developing children. Play has been found to correlate with RRBs in children with ASD but not in typically developing children. Specifically, typically developing children

were found to engage in play activities regardless of RRBs, whereas children with ASD who displayed more RRBs engaged in fewer play activities than those children with ASD who displayed fewer repetitive behaviours (Honey, Leekam, Turner, & McConachie, 2007). This indicates that levels of engagement in RRBs have more of an impact on other aspects of the lives of children with ASD than on those of typically developing children. As play activities are an important source of learning and development in early childhood, RRBs have an important impact on early development in children with ASD, but not in typical development. If children with ASD do not engage is as many play activities as typically developing children because they are focused on RRBs, they may miss out on many of the social and language skills that are typically learned through play activities as well as on the opportunities to interact with other children that are essential to the development of appropriate social cues and abilities.

The onset of RRBs in typical development and in individuals with ASD. Repetitive and stereotyped behaviours appear to be present early in development among both typically developing children and children with ASD (e.g,. Arnott et al. 2010; Loh et al., 2007), though there are some differences between older and more recent studies. For example, Zohar and Felz (2001) found that the onset of ritualistic behaviour in typically developing children was between 19 and 28 months, whereas Arnott et al. (2010) noted that some typically developing infants exhibit RRBs as early as 15 months of age. When differentiating between typical and atypical RRBs, Cox et al. (1999) found that the emergence of distinct RRBs in children with ASD, as compared to typically developing children, was around the age of 4 years, although evidence from more recent studies based on direct observation rather than parent reports indicates that the age of onset of atypical repetitive behaviours appeared to be earlier than the age of 2 years (e.g., MacDonald et al., 2007; Ozonoff et al., 2008; Watt, Wetherby, Barber, & Morgan, 2008).

Differences in RRBs between children with ASD and typically developing children have also been noted even earlier in development, as early as 12 months of age (e.g., Ozonoff et al., 2008). Distinct patterns of RRBs were detected in infants as young as 12 months during an object exploration task, and these early differences in RRBs predicted later diagnosis of ASD (Ozonoff et al., 2008). Similarly, infant siblings of children with ASD who were later diagnosed with ASD displayed repetitive behaviours as early as 12 to 18 months of age (Loh et al., 2007), suggesting that the onset of distinct RRBs in children with ASD can be found as early as the first year of life. This discrepancy has been shown to increase with age, as Watt et al. (2008) found that a group of children with ASD between the ages of 18 and 24 months showed more repetitive and stereotyped behaviours in terms of both frequency and duration than groups of same-aged typically developing children and of same-aged children with other developmental delays.

Developmental trajectories of RRBs among individuals with ASD and TD individuals. One of the main differences between RRBs in ASD and RRBs in typical development is the way in which they develop over time. RRBs are a significant part of ASD throughout childhood, and often beyond, while in typically developing children, RRBs are exhibited in early childhood, but these behaviours do not continue to form a significant part of behaviour as they develop. Evans et al. (1997) found that RRBs were most frequent among typically developing children between the ages of 2 and 4, and then seemed to dissipate with increasing age as compared to older children. Similarly, stereotyped behaviours, such as rocking, and self-injurious behaviours have been found to peak around the age of 2 years and then slowly decrease (Berkson & Tupa, 2000). More complex RRBs, including obsessions and compulsions, appear to follow a similar developmental trajectory in typical development, despite a later age of onset. Specifically, complex RRBs tend to appear later in development, but also

tend to reduce in frequency and severity over time, as children in grade 8 showed fewer obsessions and compulsive behaviour than children in grade 4 or 6 (Zohar & Bruno, 1997). These findings indicate that RRBs are present in typical development, but decrease over time in childhood.

When comparing RRBs in children with ASD and typically developing children, MacDonald et al. (2007) found that 2-, 3-, and 4-year old children with ASD showed more RRBs than their typically developing peers, and that the differences in RRBs between the groups were most pronounced in the 3- and 4-year old children. In typically developing children, the levels of RRBs were highest among the 2-year old children, with similar but lower levels among the 3- and 4-year old children. In the ASD group, the 3- and 4-year old children showed more RRBs than the 2 year old children. This suggests an opposite pattern of development of RRBs between ASD and typical development, as the number of RRBs slowly decreased over time among the typically developing children and increased over time among children with autism. Thus, while both children with ASD and typically developing children display RRBs in early childhood, children with ASD both display more RRBs than typically developing children at all ages and show an increase, rather than a decrease, in numbers of RRBs over time.

In most of the studies of the development of RRBs in children with ASD, changes from childhood through adolescence and adulthood have been examined using retrospective or cross-sectional designs (Leekam et al., 2011). The findings from these studies suggest a pattern in which RRBs tend to improve over time from childhood through adulthood, though less is understood regarding the precise trajectory of the change (e.g., Fecteau, Mottron, Berthiaume, & Burack, 2003). For example, improvements in symptoms across all symptoms of ASD, including RRBs, were found when parents of older children and adolescents, ranging from 7 to

20 years, with ASD, were administered the ADI-R (Fecteau et al., 2003). Questions were asked to evaluate symptoms of ASD at the time of the interview and retrospectively, when the child was between the ages of 4 and 5 years, and the comparison of the current and retrospective scores suggested improvement across ASD symptoms (Fecteau et al., 2003). This is consistent with retrospective parent reports of changes in RRBs among high functioning adults with ASD in which overall RRBs were reduced from childhood through adulthood. Compulsive behaviours were also found to decrease more than repetitive and sensorimotor behaviours (Chowdhury, Benson, & Hillier, 2010). Cross-sectional studies of groups of individuals with ASD of different ages, yielded similar results, as adults with ASD exhibited fewer and less severe RRBs than younger children with ASD (e.g., Esbensen, Seltzer, Lam, & Bodfish, 2009). However, this overall improvement from childhood through adulthood does not necessarily imply a direct linear path of RRBs in ASD, as little information is known about levels of RRBs in between these two time points, such as throughout adolescence. In another study of RRBs throughout childhood, RRBs were found to remain relatively stable in children with ASD from ages 2 to 14 years, though RRBs worsened over time in a small proportion of participants (Fountain, Winter, & Bearman, 2012). These findings differ from those of RRBs later in adolescence or adulthood, introducing the possibility that RRBs might develop one way in late childhood and early adolescence, and then change again between early adolescence and adulthood.

The retrospective or cross-sectional methodologies used in the aforementioned studies contain a number of limitations that can impact the understanding of the developmental trajectories of RRBs in ASD. For example, retrospective reports can yield inaccurate recall years later of the behaviour in childhood and differences among the children in each sample are not always accounted for by cross-sectional designs (Leekam et al., 2011). Accordingly, researchers

have started to study developmental trajectories of RRBs in ASD using longitudinal studies as the same sample of children would be followed over a period of time, eliminating confounds associated with using different samples and retrospective bias. RRBs in children with ASD in earlier childhood have been examined longitudinally in four studies (Harrop, McConachie, Emsley, Leadbitter, & Green, 2013; Honey, McConachie, Randle, Shearer, & Le Couteur, 2008; Richler, Huerta, Bishop, & Lord 2010; Wolff et al., 2014), although only Richler et al. (2010) longitudinally assess RRBs over a large age span. In a study of changes in RRBs among 24- to 28-month old children diagnosed with either ASD or autistic disorder, and typically developing children, Honey et al. (2008) found an increase in parent reports of repetitive behaviours among the children with a broader ASD diagnosis, but not the children diagnosed with autistic disorder over a span of 13 months, based on scores on the ADI-R. This suggests both differences in RRBs between children with ASD and typically developing children, as well as considerable variation within the autism spectrum. Variation among RRBs has also been found, whereby IS behaviours have been found to change over time while RSM behaviours remained relatively stable. When RRBs were observed during free play in young children with and without ASD between the ages of 2 and 4 years, the rates of RSM behaviours did not significantly change for either group over the span of 13 months. However, sub-threshold increases in the rates of RSM behaviours were observed for the ASD group, whereas sub-threshold decreases were observed for the typically developing group (Harrop et al., 2013). In contrast, Wolff et al. (2014) found that compulsive and ritualistic/sameness RRBs increased over time in a sample of children assessed at 12 and 24 months of age, as measured by the RBS-R. However, they acknowledged that the children were too young to exhibit complex RRBs at the initial assessment, and that this finding might reflect a later age of onset rather than an increase over time.

In a longitudinal study of RRBs across a larger age span throughout childhood, Richler et al. (2010) examined the stability of repetitive sensorimotor (RSM) and insistence on sameness (IS) categories of RRBs among children with ASD at ages 3, 5, and 9 years. As these results were based on ADI-R scores, which encompass both severity and frequency of RRBs, an increase in frequency and severity over time was found for IS behaviours, whereas RSM behaviours remained consistent over time. The ages of the children in this study suggest that this does not merely reflect a later age of onset of IS behaviours, as questioned by Wolff et al. (2014). Although these four longitudinal studies (Harrop et al., 2013; Honey et al., 2008; Richleret al., 2010; Wolff et al., 2014) provide valuable information regarding the developmental trajectories of RRBs in children with ASD, the data regarding RRBs were based exclusively on parent reports, which are more subjective than direct observation methods (Richler et al., 2010).

Correlates of RRBs in Children with ASD

The frequency and severity of RRBs in children with ASD have been correlated with a variety of factors, including those directly related to the child, such as adaptive skills and language ability, and environmental ones, such as parenting stress. Adaptive skills refer to an individual's ability to perform daily tasks in an autonomous way, and include categories such as communication, daily living skills, socialization, practical and community skills (Sparrow, Cicchetti, & Balla, 2005). Gabriels, Cuccaro, Hill, Ivers, and Goldson (2005) found that adaptive skills were negatively correlated with the presence of RRBs in a group of children with ASD with a mean age of 10 years. Specifically, children with lower scores on a measure of adaptive skills often had higher scores on the RBS-R. This finding was replicated with younger children, as higher RRB scores on the ADI-R were linked to lower levels of adaptive skills in children between the ages of 24 and 48 months (Honey et al., 2008), indicating that the relation

between adaptive skills and RRBs is evident at a range of ages. Despite these findings, information regarding directionality and the predictive nature of these relationships remains unclear, as correlations merely indicate the presence of a relationship. Understanding whether changes in adaptive skills predict changes in RRBs, or whether engagement in RRBs inhibit the development of adaptive skills, rendering RRBs predictive of adaptive skills, poses a number of theoretical and practical implications. For example, if improvements in adaptive skills predict improvements in RRBs, initiating intervention programs aimed at adaptive skills should likely incur benefits in terms of RRBs, as well.

A correlation has also been found between RRBs and language ability. Children between the ages of 24 and 48 months who had higher receptive and expressive language scores on a measure of cognitive functioning also had lower parent reports of RRBs on the ADI-R (Honey et al., 2008). Similarly, when children who were diagnosed with ASD between the ages of 15 months and 25 months were grouped based on expressive language ability upon follow-up 2 years later, those who showed impairments in expressive language also more frequently engaged in RRBs (Paul, Chawarska, Cicchetti, & Volkmar, 2008). In addition, children between the ages of 4 and 7 years who showed more difficulty with pragmatic language also engaged in higher frequencies of RRBs (Barrett, Prior, & Manjiviona, 2004). This nature of this relationship between language ability and RRBs was further elaborated by Ray-Subramanian and Weismer (2012), who found that expressive and receptive language abilities correlated with higher RRB scores on the ADOS in at ages 2 and 3 years, and that improvement in these skills also predicted a reduction in RRBs scores between the ages of 2 and 3 years.

Correlates of RRBs in children also include environmental factors that might serve as predictors of the developmental trajectories of RRBs, including factors related to parents, as

research in ASD is highly reliant on parent report. For example, RRBs have been linked to parenting stress, whereby high levels of parenting stress among parents of children with ASD correlate with higher frequencies of RRBs reported on the RBS-R (Gabriels et al., 2005). This should not be solely attributed to the finding that parents of children with ASD typically report higher levels of stress than the general population (Schieve, Blumberg, Rive, Visser, & Boyle, 2007), as Gabriels et al. (2005) found that RRBs and parent stress correlate even within a group of families with children with ASD. RRBs can be considered to be a characteristic of ASD that is especially stressful for parents or caregivers, as they pose a significant effect on family life, particularly when the RRB is in the sphere of insistence on sameness or leads to aggression (Gabriels et al., 2005). For example, children who have extreme tantrums due to resistance to slight changes in routine or who repeatedly hit themselves or others can cause severe disruption in the daily life and activities of their families. This disruption, along with unpredictability of behaviour, can lead to higher parent stress levels, which can in turn lead to higher reports of RRBs.

Objective and Hypotheses of the Present Study

The objective of the present study was to examine the temporal stability or change in RRBs in young children already diagnosed with an ASD, from diagnosis at age 2 or 4 years to age 6 years. Further elucidating the developmental trajectories of RRBs can provide insight as to the evolution of ASD in early childhood. As variation can occur within the autism spectrum despite broad diagnostic stability (e.g., Lord et al., 2006), understanding changes in RRBs over time might account for some of the variation. In an attempt to further understand the nature of the relationship between various correlates and RRBs, analyses of predictors of the changes in RRBs were also included, including adaptive skills, language ability and parenting stress. The

data were drawn from the database of the Pathways in ASD study (http://www.asdpathways.ca), a five-site cross-Canadian longitudinal study of young children with ASD, who were diagnosed between the ages of 2 and 4 years. The present project contributes to the literature on ASD, as it reflects an attempt to illuminate the developmental trajectories of RRBs, a core feature of ASD, in early childhood, and the factors that impact the progression of this cluster of symptoms. By examining RRBs, language ability, adaptive skills, and parent stress levels at different ages throughout early childhood, the nuanced development of these behaviours should be further understood. In contrast to previous longitudinal studies on the developmental trajectories of RRBs in children with ASD that were entirely based on one source of data collection, the data in the present study were accrued from both direct observation and parent interviews, in an attempt to obtain a more comprehensive image of RRBs in this population from diagnosis to age 6 years. The following hypotheses also reflect an attempt to identify specific predictors that influence the development RRBs and can therefore be used as tools to indirectly induce additional positive change in these behaviours.

As ASD, at the diagnostic level, is a spectrum rather than a singular construct, children with this diagnosis can show changes while remaining within that spectrum. The examination of how these symptoms, and specifically RRBs, change over time in the context of overall development will enhance the conceptual understanding of the evolution of ASD. Despite the inconsistencies in the directionality of changes in RRBs over time in the previous longitudinal studies of RRBs, a significant change in at least certain RRBs over time was found in three of the four studies (Honey et al., 2007; Richler et al., 2010; Wolff et al., 2014). Accordingly, in the present study, RRB scores were hypothesized to change over time, as measured by the ADI-R (Rutter et al., 2003), the ADOS (Lord et al., 2000), and the RBS-R (Bodfish et al., 1999). As

RRB scores on these measures encompass both frequency and severity of behaviour, a change in scores indicates a change in both frequency and severity from the time of diagnosis to the age of 6 years. Consistent with the findings of Richler et al. (2010) and Wolff et al. (2014), who found increases in IS behaviours, the level of change in RRBs was predicted to vary according to the type of RRB, with the most pronounced change on insistence on sameness (IS) behaviours.

Three factors were hypothesized to be significant predictors of the aforementioned change in RRBs over time, whereby improvements in these factors would predict decreases in the frequency and severity of RRBs over time, and further impairment in these factors would predict increases in the frequency and severity of RRBs over time. Further elaborating on the established relationship between adaptive skills and RRBs (Gabriels et al., 2005; Honey et al., 2008), adaptive skills were hypothesized to be a significant predictor of changes in RRBs over time. Accordingly, children who showed improvements in overall adaptive skills from diagnosis to age 6, as assessed by the VABS-II, were expected to show reduced frequency and severity of RRBs in general, as well as the specific types of RRBs, as shown by a reduction in ADI-R, ADOS, and RBS-R scores.

Based on Honey et al.'s (2008) finding of an association between lower levels of language abilities and higher levels of RRBs, and Ray-Subramanian and Weismer's (2012) finding of language ability as both a correlate and predictor of RRBs, language ability was hypothesized to be a significant predictor of the developmental trajectory of RRBs. The participants who showed improvements in language skills were predicted to also have shown reductions in the frequency and severity of RRBs from diagnosis to age 6, as assessed by the ADI-R, RBS-R, and ADOS.

In an attempt to extend predictors beyond child characteristics, parent stress levels, which have also been identified as a correlate of RRBs (Gabriels et al., 2005), were also examined as a potential predictor of changes in RRBs over time. Parents who reported improvements in their levels of stress on the Parenting Stress Index (PSI), a self-report measure of parenting stress, were predicted to have also reported reductions in the frequency and severity of their children's RRBs on the ADI-R and RBS-R from diagnosis to age 6. Overall, the aforementioned hypotheses reflect an attempt to identify specific predictors that influence the development RRBs and can therefore be used as tools to indirectly induce additional positive change in these behaviours.

Method

Participants

The data for the present project were drawn from the database of the cross-Canadian study Pathways in Autism Spectrum Disorders (e.g., Szatmari et al., 2004), a longitudinal study of developmental trajectories among persons with ASD conducted in sites in Quebec, Nova Scotia, Ontario, British Columbia, and Alberta. The participants were only included in the study if they were between the ages of 2 and 4 years at the start of the study, and had already received a clinical diagnosis of ASD in a clinical assessment in the 4 months prior to the start of the study, based on DSM-IV-TR criteria according to the ADI-R (Rutter et al., 2003) and ADOS (Lord et al., 2000). Children were excluded from the study if they had severe hearing or vision problems, genetic or chromosomal disorders, or neuromotor disorders. As seen in Table 1, the participants were followed up at six months after diagnosis (Time 2), one year after diagnosis (Time 3), and at 6 years of age (Time 4). 197 participants were included in the present study. The sample included 171 males and 26 females.

Measures

Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000). The ADOS (Lord et al., 2000) is a standardized, semi-structured instrument that can be administered to children with, or suspected of, ASD and provides direct observation data regarding ASD symptoms. Since its inception, the Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2000) has been considered to be a primary tool for diagnosing ASD (Gray, Tonge, & Sweeny, 2008; Kleinman et al., 2008). An updated version of the ADOS, the ADOS-2 (Lord et al., 2012) was developed in accordance with the revised ASD criteria outlined in the DSM-V (American Psychiatric Association, 2013). However, the original ADOS (Lord et al., 2000) was used in the present study, as assessments were conducted prior to the release of the ADOS-2 (Lord et al., 2012) and the DSM-V (American Psychiatric Association, 2013).

The objective of the ADOS administration is to establish situations designed to evoke and assess behaviours related to interaction, imagination and communication, deficits that are commonly found among individuals with ASD (Lord et al., 2000). The ADOS includes 4 modules, each of which is appropriate for a different level of functioning, ranging from children who are non-verbal through adolescents who are verbally fluent (Lord et al., 2000). An improvement in ADOS module over time is indicative of an improvement in expressive language level. Module 1, administered to children who are non-verbal or who speak in single words, includes activities such as bubble play, symbolic imitation, anticipation of routine with an object, and free play. Module 2, administered to children with phrase speech, includes a number of activities from Module 1 with the addition of make believe play, a construction task, a demonstration task, looking at a picture, and telling a story from a book. Module 3, administered to verbally fluent children, includes activities such as a construction task, make believe play,

telling a story from a book and a cartoon, looking at a picture, creating a story, and answering questions regarding emotions and relationships. Module 4 is similar to Module 3, but aimed at older individuals who are verbally fluent and includes more conversation rather than play activities. The scenarios established by the examiner throughout the ADOS (Lord et al., 2000) allow for the observation of characteristics and behaviours across the three areas of language and communication, social interaction, and RRBs, and include eye contact, joint attention, imaginative play, social overtures, gestures, repetitive behaviours, sensory interests, conversation and reciprocity, and insight.

Observations from the various ADOS activities are grouped into symptoms that are coded from 0 to 3. A score of 0 represents the absence of an ASD symptom or evidence of typically developing behaviour. A score of 1 represents that an ASD symptom was briefly observed or that it was observed to a lesser degree. A score of 2 represents the full presence of an ASD symptom or lack of evidence of typical age-appropriate behaviour. A score of 3 represents the presence of an ASD symptom that has a pervasive effect on the child or family life. When conducting an ASD assessment, the sum of scores on the items of each section is calculated, along with a total score for all sections, and it is noted whether the scores fall above the minimum ASD score. The items that are relevant to the present study are in the RRB section. Modules 1 through 4 involve four RRB items: (1) sensory interests; (2) hand and body mannerisms; (3) repetitive interests and behaviours; and (4) self-injurious behaviour. Modules 3 and 4 include an additional item related to compulsions and rituals.

The ADOS allows clinicians and researchers to be more structured in their behavioural observations, thus enhancing reliability across examiners, sites, and studies (Lord et al., 2000). With regard to diagnosing ASD, the ADOS (Lord et al., 2000) has been found to correlate well

with clinical impressions, specifically with regard to diagnoses of autism rather than those of Pervasive Developmental Disorder - Not Otherwise Specified (PDD-NOS) (Chawarska, et al., 2007). This agreement between clinical judgment and the ADOS (Lord et al., 2000) has also been found to be stronger than the agreement between clinical judgment and the ADI-R (Chawarska et al., 2007; Gray et al., 2008), further supporting its validity as a diagnostic and observational tool. Data accrued from the ADOS (Lord et al., 2000) is combined with parent report data from the Autism Diagnostic Interview Revised (ADI-R; Rutter, LeCouteur, & Lord, 2003), clinical judgment, and the criteria for ASDs listed in the Diagnostic and Statistical Manual of Mental Disorders (DSM IV-TR; American Psychiatric Association, 2000) in order to complete and ASD assessment and ascribe a diagnosis.

Autism Diagnostic Interview Revised (ADI-R; Rutter, LeCouteur, & Lord, 2003). The ADI-R is a semi-structured developmental history interview administered to parents of children with ASD or suspected of ASD. The ADI-R consists of 93 items divided into the three subsections of (1) language and communication; (2) social interaction; and (3) repetitive, restricted and stereotyped behaviour and interests. The interview includes a scale regarding current behaviour and a scale regarding past behaviour, when the child was between the ages of 4 and 5 years. Each item is coded with a score from 0 to 3 and is comprised of the clinician's interpretation of both the frequency and severity of the behaviour. A score of 0 represents the absence of an ASD symptom or the evidence of typical age-appropriate behaviour. A score of 1 represents that an ASD symptom was briefly observed or that it was observed to a lesser degree. A score of 2 represents the full presence of an ASD symptom or lack of evidence of typical age-appropriate behaviour. A score of 3 represents the presence of an ASD symptom that has a pervasive effect on the child or family life. Scores on items from each section are added to

calculate a summary score for each section, and a full score can be calculated using a diagnostic algorithm. The items that are most relevant to the current study are found in the RRB section.

The ADI-R (Rutter et al., 2003) is considered a reliable and valid tool for assessing symptoms of ASD. With regard to test-retest reliability and inter-rater reliability, most intra-class coefficients exceeded 0.9 (Rutter et al., 2003). Similarly, validity analyses supported the use of the ADI-R as a valid measure of ASD symptoms (Rutter et al., 2003). The ADI-R is one of the primary tools used to diagnose ASD and corresponds to both DSM-IV-TR (American Psychiatric Association, 2000) and DSM-V (American Psychiatric Association, 2013) criteria for ASD. Furthermore, the ADI-R is one of the most common tools used to assess RRBs in children with ASD across recent studies (Leekam, 2011).

Repetitive Behaviour Scale-Revised (RBS-R; Bodfish et al., 1999). The RBS-R is a questionnaire designed to assess restricted and repetitive patterns of behaviours and interests. The RBS-R consists of 43 items, each of which represents a repetitive or stereotyped behaviour or interest. Parents complete the questionnaire and are instructed to rate the applicability of each item to their child, ranging from 0 (behaviour does not occur) to 4 (behaviour occurs and is a severe problem). Items are grouped according to the six categories of (1) Stereotyped Behaviour Subscale; (2) Self-Injurious Behaviour Subscale; (3) Compulsive Behaviour Subscale; (4) Ritualistic Behaviour Subscale; (5) Sameness Behaviour Subscale; and (6) Restricted Behaviour Scale. The first category, stereotyped behaviours, is defined as "apparently purposeless movements or actions that are repeated in a similar manner" (Bodfish, 1999, p. 1), and includes behaviours such as repetitive physical movements or actions, stereotyped object usage, and sensory behaviours. The second category, self-injurious behaviour, is defined as "movement or actions that have the potential to cause redness, bruising or other injury to the body, and are

repeated in a similar manner" (Bodfish, 1999, p. 2), and includes behaviours such as hitting, biting, or scratching the self. The third category, compulsive behaviour, is defined as "behaviour that is repeated and is performed according to a rule, or involves things being done just so" (Bodfish, 1999, p. 2), and includes behaviours such as arranging, touching, and counting. The fourth category, ritualistic behaviour, is defined as "performing activities of daily living in a similar manner" (Bodfish, 1999, p. 3), and includes activities such as bedtime, mealtime, and social interaction rituals. The fifth category, sameness behaviour, is defined as "resistance to change, insisting things stay the same" (Bodfish, 1999, p. 3), and includes behaviours such as insistence on routines, becoming upset when interrupted, and objecting to visiting new places. The final category, restricted behaviour, is defined as "limited range of focus, interest, or activity" (Bodfish, 1999, p. 4), and includes behaviours such as circumscribed interests, unusual preoccupations, and interest in parts rather than whole objects. Using this framework, individual section scores can be calculated in order to assess the presence or absence of particular types of RRBs, and a total RRB score can be calculated in order to evaluate the pervasiveness and severity of RRBs in a particular child. The RBS-R correlates well with corresponding items on the ADI-R, and has been found to accurately represent repetitive behaviours in children with ASD (Mirenda et al., 2010). Reliability and validity was evaluated with a sample of 320 caregivers of individuals with ASD (Lam & Aman, 2007), and the finding of high internal consistency and inter-rater reliability suggests that the RBS-R is an appropriate tool for assessing RRBs in individuals with ASD.

Vineland Adaptive Behaviour Scale-Second Edition (VABS-II; Sparrow, Cicchetti, & Balla, 2005). The VABS-II is a survey interview administered to parents that is designed to assess a child or adolescent's adaptive skills, the abilities necessary for navigating everyday life,

including language, self-care, social skills, and community functioning and understanding. The VABS-II is used with a variety of populations and is often used to support diagnoses of ASD and other developmental disorders, as these diagnoses are often based on impairments in functioning in multiple areas, including adaptive skills. It can be used for individuals from birth through adulthood and is divided into four domains: (1) Communication; (2) Daily Living Skills; (3) Socialization; and (4) Motor Skills, although the Motor Skills section is only administered when assessing children under the age of 7 years. The Communication domain is further subdivided into three sections: (1) Receptive; (2) Expressive; and (3) Written. The Daily Living Skills domain is further subdivided into three sections: (1) Personal; (2) Domestic; (3) Community. The Socialization domain is further subdivided into three sections: (1) Interpersonal Relationships; (2) Play and Leisure Time; and (3) Coping Skills. The Motor Skills domain in further subdivided into two sections: (1) Gross Motor; and (2) Fine Motor. Clinicians administer the interview to parents and rate each item based on a Likert scale ranging from 0 (behaviour is not present) to 3 (child independently engages in the behaviour). Results are interpreted by calculating sum scores for each domain, as well as an overall score of global adaptive skills. The VABS-II has shown high test-retest reliability, high inter-rater reliability, high internal consistency, and high validity (Sparrow et al., 2005).

Parenting Stress Index (PSI-SF, Abidin, 1995). The PSI-SF is a 36-item self-report measure administered to parents that is designed to assess parental stress It is divided into three subscales: (1) Parental Distress; (2) Parent-Child Dysfunctional Interaction; and (3) Difficult Child and items are rated on a 5-point Likert scale ranging from Strongly Agree to Strongly Disagree. Sums of scores provide section scores as well as an overall score of parenting stress, in order to determine the general level of stress as well as the areas of stress that are particularly

difficult for the responders. The PSI-SF is a common measure of parenting stress among caregivers of individuals with ASD (e.g. Lecavalier, Leone, & Wiltz, 2006). Reliability and validity analyses indicated high internal consistency, test-retest reliability, and validity (Lecavalier et al., 2006), suggesting that the PSI-SF is an appropriate measure of parenting stress in caregivers of individuals with ASD.

Procedure

The participants joined the Pathways in ASD study no more than four months after receiving an ASD diagnosis, when they were between the ages of 2 and 4 years of age. Following the baseline (Time 1) assessment, follow-up evaluations were conducted at three subsequent time points, ending when the child reached 6 years of age. The schedule of time points and measures administered at each point are presented in Table 1. While the Pathways in ASD study included evaluations in multiple areas of ASD, only the measures that are relevant to the current study will discussed. The measures administered at Time 1 included (1) the ADI-R (Rutter et al., 2003); (2) the ADOS (Lord et al., 2000); (3) the RBS-R (Bodfish et al., 1999); (4) the VABS-II (Sparrow et al., 2005); and (5) the PSI-SF (Abidin, 1995). The second time period (Time 2) occurred six months following the Time 1, and included (1) the RBS-R (Bodfish et al., 1999); and (2) the VABS-II (Sparrow et al., 2005). The third time point (Time 3) occurred 12 months following Time 1, and the measures administered at this time included (1) the ADOS (Lord et al., 2000); (2) the RBS-R (Bodfish et al., 1999); (3) the VABS-II (Sparrow et al., 2005); and (4) the PSI-SF (Abidin, 1995). The fourth time point (Time 4) was administered when the participants reached 6 years of age, and the measures included (1) the ADI-R (Rutter et al., 2003); (2) the ADOS (Lord et al., 2000); (3) the RBS-R (Bodfish et al., 1999); (4) the VABS-II (Sparrow et al., 2005); and (5) the PSI-SF (Abidin, 1995). Accordingly, for the participants who

entered the study at the age of 2 years, Time 4 occurred 48 months following Time 1. For the participants who entered the study at the age of 3 years, Time 4 occurred 36 months after Time 1. For the participants who entered the study at the age of 4 years, Time 4 occurred 24 months after Time 1. The measures administered at Time 4 included (1) the ADI-R (Rutter et al., 2003); (2) the ADOS (Lord et al., 2000); (3) the VABS-II (Sparrow et al., 2005); and (4) the PSI (Abidin, 1995). All the assessments were conducted at the Pathways in ASD site nearest to the family's home. The sessions were conducted in either English or French, depending on which was the first language of the family. All the individuals who administered the ADI-R and ADOS were trained and research reliable on the appropriate measure.

Results

General Linear Model (GLM) measures Analyses of Covariance (ANCOVAs) were conducted in order to assess the potential changes over time of RRBs, as measured by the relevant items on the ADI-R, ADOS, and RBS-R. Further analyses of the subsets of RRBs, including RSM behaviours and IS behaviours, were conducted for the ADI-R and RBS-R analyses. This was not done for the ADOS analyses, as the ADOS only includes four RRB items in modules 1 and 2, and five RRB items in module 3. In all of the analyses, within-subject effects were examined for RRB scores, and adaptive skills, language ability, and parenting stress were included in the model as predictors by including them in the model as covariates. Change scores were calculated by subtracting scores at Time 1 from scores at Time 4. In all analyses, improvement in RRBs refers to both severity and frequency, as scores on the measures encompass both of those facets of RRBs.

The participants entered the study between the ages of 2 and 4 years of age, and were divided into two cohorts according to age at baseline. In order to determine whether analyses in

the present study could be conducted for the sample as a whole, or whether separate analyses were required for each cohort, cohort was assessed as a between subjects predictor. Specifically, between-subject effects were first calculated for the variable known as cohort. This effect was not significant across all of the analyses, $p > .05$, thereby indicating no differences between the two cohorts on any of the measures. Accordingly all of the results will be presented across both groups ($n = 197$).

A second preliminary analysis was conducted for each analysis of predictors in the present study. Although language ability has been found to be a significant correlate of RRBs (Barrett et al., 2004; Honey et al., 2008), this correlation is often not significant when overall level of functioning is considered (e.g., Honey et al., 2008). For example, while Honey et al. (2008) found that language ability was significantly correlated with RRBs, this was no longer the case when IQ was considered. Thus, in this study, stepwise regression analyses were performed for each RRB measure at each time point in order to examine whether changes in language ability significantly predicted changes in RRBs, independent of overall level of functioning. In these stepwise regression analyses, both language ability and overall adaptive skills were included in the model, which identified the predictor that accounted for more of the variance. Specifically, the effects of the overall adaptive and communication skills as measured by the VABS-II were included in the model for each analysis, and the most appropriate predictor was identified by the regression model. Thus, the decision whether to include language ability as a separate predictor from overall adaptive skills was made individually, for each analysis, based on the results of each stepwise regression analysis.

Autism Diagnostic Interview-Revised Results

Overall restricted, repetitive and stereotyped patterns of interests and behaviours. Means and standard deviations for overall RRB and subscale scores on the ADI-R at each time point are presented in Table 2. The ADI-R was administered at Time 1 and Time 4, and GLM repeated measures ANCOVAs were used to examine changes in the RRB items on the ADI-R between these two time points. A total score was calculated for all RRB items on the ADI-R and used as the dependent variable. With regard to predictors, the preliminary stepwise regression analyses showed that language ability accounted for more of the variance than overall adaptive skills at Time 1 ($R^2 = 0.22$, $\beta = -0.46$). At Time 4, preliminary stepwise regression analyses showed that overall adaptive skills accounted for more of the variance than language ability ($R^2 = 0.41$, $\beta = -0.64$). This indicates a stronger correlation between language ability and RRBs at Time 1, and a stronger correlation between overall adaptive skills and RRBs at Time 4. Since both language ability and overall adaptive skills were significant predictors of RRBs in the stepwise regression models, the communication score and the adaptive composite score on the VABS-II were both included in the model as predictors of overall RRBs.

In the overall GLM ANCOVA model, significant differences were found in RRB scores on the ADI-R from Time 1 to Time 4, $F(1, 189) = 46.47$, $p < .001$. As demonstrated in Figure 1, the RRB scores significantly decreased over time, suggesting that according to parent reports on the ADI-R, overall RRBs improved from diagnosis at age 2 or 4 years to age 6 years.

The changes in RRBs from Time 1 to Time 4, as assessed by the ADI-R, were associated with changes in both communication and overall adaptive skills, as assessed by the VABS-II. Specifically, changes in communication scores on the VABS-II were found to be a predictor of changes in RRB scores over time, $F(1, 189) = 27.60$, $p = .00$, and changes in the adaptive

composite scores on the VABS-II were found to be a predictor of change in RRB scores over time, $F(1, 189) = 5.85$, $p < .05$. As such, based on ADI-R parent interviews and standard scores on the VABS-II, improvement in overall adaptive skills significantly predicted improvement in RRBs from diagnosis to age 6. In terms of parenting stress, changes in PSI scores were not found to be a significant predictor of changes in RRB scores, $F(1, 189) = 0.44$, $p > .05$

Repetitive sensorimotor behaviour (RSM) scores. General Linear Model repeated measures ANCOVAs were used to examine changes in RSM items on the ADI-R from baseline to Time 4. A total score was calculated for all of the RSM items on the ADI-R and included as the dependent variable at two time points, Time 1 and Time 4. As the communication scores on the VABS-II were excluded from both stepwise models, preliminary stepwise regression analyses indicated that the overall adaptive skills score was a stronger correlate of RRBs than language ability at both Time 1 ($R^2 = 0.10$, $\beta = -0.32$) and Time 4 ($R^2 = 0.28$, $\beta = -0.53$). As a result, only the adaptive behaviour composite score on the VABS-II was included in the model as a predictor of RSM behaviours.

In the overall model, as presented in Figure 2, RSM scores on the ADI-R decreased over time $F(1, 190) = 12.44$, $p < .01$from age 2 and 4 at Time 1 to Time 4. This suggests that, according to parent reports on the ADI-R, overall RSM behaviours improved from diagnosis at age 2 or 4 to age 6.

The change in RSM behaviours from Time 1 to Time 4, as assessed by the ADI-R was correlated with both overall adaptive skills and parenting stress. Specifically, changes in the adaptive skill composite scores on the VABS-II predicted changes in RSM scores over time, $F(1, 190) = 9.20$, $p < .01$. Changes in PSI scores were also found to predict changes in RSM scores,

$F(1, 190) = 6.58$, $p < .05$. These findings indicate that both overall adaptive skills and parenting stress predict changes in RSM behaviours from diagnosis at age 2 or 4 years to age 6 years.

Insistence on sameness (IS) behaviour scores. General Linear Model repeated measures ANCOVAs were used to examine changes in IS items on the ADI-R from Time 1 to Time 4. A total score was calculated for all of the IS items on the ADI-R and included as the dependent variable at Time 1 and Time 4. The preliminary stepwise regression analyses excluded the VABS-II adaptive behaviour composite scores at both Time 1 and Time 4, indicating a stronger correlation between communication and IS behaviours was found at both Time 1 ($R^2 = 0.18$, $\beta = -0.42$) and at Time 4 ($R^2 = 0.38$, $\beta = -0.61$). As a result, the communication score on the VABS-II was included in the model as predictors of IS behaviours.

In the overall model, as presented in Figure 2, significant differences were found in the IS scores on the ADI-R from Time 1 to Time 4, $F(1, 189) = 48.17$, $p = .00$. As the IS behaviour scores significantly decreased over time according to parent reports on the ADI-R, overall IS behaviours improved from diagnosis at age 2 or 4 to age 6.

The changes in IS behaviours from Time 1 to Time 4, as assessed by the ADI-R, were associated with changes in communication and parenting stress. Specifically, changes in the communication scores on the VABS-II predicted changes in IS scores over time $F(1, 189) = 22.79$, $p = .00$. In terms of parenting stress, changes in PSI-SF scores did not predict changes in IS scores $F(1, 189) = .53$, $p > .05$.

Repetitive Behaviour Scale-Revised Results

The RBS-R provides scores for different types of RRBs, as well as an overall RRB score. This allows for further detail when analyzing results, as researchers can examine whether overall RRBs change over time and whether there are patterns of specific RRBs that change in different

ways, independent of the trajectory of overall RRBs. Accordingly, the analyses with the RBS-R involved overall RRB scores, as well individual analyses for each subsection of the RBS-R, including the stereotyped behaviour scale, the self-injurious behaviour scale, the compulsive behaviour scale, the ritualistic behaviour scale, the sameness behaviour scale, and the restricted behaviour scale. The results of each analysis will be discussed in separate sections. Means and standard deviations for overall RRB and subscale scores on the RBS-R at each time point are presented in Table 3.

Overall repetitive behaviour (RRB) scores. General Linear Model repeated measures ANCOVAs were used to examine changes in RRB items on the RBS-R from Time 1 through Time 4. The total score for all of the RRB items on the RBS-R was included as the dependent variable at all four time points in the study. The preliminary stepwise regression analyses excluded the VABS-II communication scores at all four time points. This indicates that overall adaptive skills are stronger correlates of RRBs, as assessed by the RBS-R, at baseline ($R^2 = 0.05$, $\beta = -0.22$), Time 2 ($R^2 = 0.03$, $\beta = -0.18$), Time 3 ($R^2 = 0.07$, $\beta = -0.26$), and Time 4 ($R^2 = 0.26$, $\beta = -0.51$). As a result, only the adaptive composite score on the VABS-II was included in the ANCOVA model as a predictor of RRBs.

In the overall GLM ANCOVA model, as presented in Figure 3, the total RRB scores on the RBS-R significantly decreased over time from T1 to Time 4, in both the linear model $F(1, 168) = 3.96$, $p < .05$, and the quadratic model, $F(1, 168) = 4.58$, $p < .05$. This suggests that, according to the parent reports on the RBS-R, the overall RRBs improved from the time of diagnosis at age 2 or 4 years to age 6 years.

The changes in total RRB scores from Time 1 to Time 4, as assessed by the RBS-R, were associated with changes in overall adaptive skills and parenting stress. Specifically, changes in

the adaptive composite score on the VABS-II predicted changes in the RRB scores from T1 to T4, in both the linear model, $F(1, 168) = 5.08$, $p < .05$, and the quadratic model, $F(1, 168) = 5.39$, $p < .05$. In terms of parenting stress, changes in PSI-SF scores were found to predict changes in the RRB scores in the linear model, $F(1, 168) = 28.71$, $p = .00$.

Stereotyped behaviour scale. General Linear Model repeated measures ANCOVAs were used to examine changes in items from the RBS-R stereotyped behaviour subscale, from T1 through Time 4. The total score for this subscale was included as the dependent variable at all four time points in the study. The preliminary stepwise regression analyses excluded the VABS-II communication scores at all four time points. This indicates that overall adaptive skills are stronger correlates of RRBs, as assessed by the RBS-R, at baseline ($R^2 = 0.10$, $\beta = -0.33$), Time 2 ($R^2 = 0.15$, $\beta = -0.38$), Time 3 ($R^2 = 0.19$, $\beta = -0.43$), and Time 4 ($R^2 = 0.34$, $\beta = -0.59$). As a result, only the adaptive composite score on the VABS-II was included in the model as a predictor of stereotyped RRBs.

In the overall GLM ANCOVA model, no differences were found in RRB scores on the RBS-R stereotyped behaviour scale from Time 1 to Time 4, $F(1, 168) = 3.73$, $p > .05$. While the plot of the scores, as demonstrated in Figure 4, appears to indicate that stereotyped RRB scores on the RBS-R decreased over time from baseline through Time 3 then leveled off between Time 3 and Time 4, these differences were not significant. This suggests that, according to parent reports on the RBS-R, stereotyped behaviours decreased, but not significantly, between each of the time points from diagnosis at age 2 or 4 years to age 6 years.

Self-injurious behaviour scale. General Linear Model repeated measures ANCOVAs were used to examine changes in self-injurious behaviour items on the RBS-R from baseline through Time 4. The total score for this subscale of the RBS-R was included as the dependent

variable at all four time points in the study. The preliminary stepwise regression analyses excluded the VABS-II communication scores at all four time points. This indicates that overall adaptive skills are stronger correlates of RRBs, as assessed by the RBS-R, at baseline ($R^2 = 0.04$, $\beta = -0.20$), Time 2 ($R^2 = 0.02$, $\beta = -0.15$), Time 3 ($R^2 = 0.06$, $\beta = -0.24$), and Time 4 ($R^2 = 0.14$, $\beta = -0.37$). As a result, only the adaptive composite score on the VABS-II was included in the ANCOVA model as a predictor of self-injurious behaviours.

In the overall GLM ANCOVA model, significant differences were found in self-injurious behaviour scores on the RBS-R from baseline to Time 4, in the quadratic model $F(1, 169) = 6.16$, $p < .05$. As demonstrated in Figure 4, the self-injurious behaviour scores on the RBS-R significantly decreased from baseline through Time 3 then increased between Time 3 and Time 4. This suggests that, according to parent reports on the RBS-R, self-injurious behaviours improved from diagnosis at age 2 or 4 years to one year post-diagnosis, then worsened by the age of 6 years.

The changes in self-injurious behaviour, as measured by the RBS-R, were not associated with changes in overall adaptive skills or parenting stress. Specifically, changes in the adaptive composite score on the VABS-II did not predict changes in self-injurious behaviour scores over time, $F(1, 169) = .40$, $p > .05$, and changes in PSI-SF scores did not predict changes in self-injurious behaviour scores, $F(1, 169) = .54$, $p > .05$.

Compulsive behaviour scale of the RBS-R. General Linear Model repeated measures ANCOVAs were used to examine changes in the compulsive behaviour items on the RBS-R from baseline through Time 4. The total score for this subscale of the RBS-R was included as the dependent variable. Four levels of the factor Time were included, as the RBS-R was administered at all four time points in the study. The preliminary stepwise regression analyses

excluded the VABS-II communication scores at all four time points. This indicates that overall adaptive skills are stronger correlates of RRBs, as assessed by the RBS-R, at baseline ($R^2 = 0.02$, $\beta = -0.15$), Time 2 ($R^2 = 0.02$, $\beta = -0.13$), Time 3 ($R^2 = 0.03$, $\beta = -0.16$), and Time 4 ($R^2 = 0.17$, $\beta = -0.41$). As a result, only the adaptive composite score on the VABS-II was included in the model as a predictor of compulsive behaviour.

In the overall GLM ANCOVA model, significant differences were found in compulsive behaviour scores on the RBS-R from baseline to Time 4, in the linear model, $F(1, 168) = 10.53$, $p < .01$. As demonstrated in Figure 4, the compulsive behaviour scores on the RBS-R significantly decreased from baseline through Time 4, thereby suggesting that, according to parent reports on the RBS-R, compulsive behaviours improved between each of the time points from diagnosis at age 2 or 4 years to age 6 years.

With regard to predictors, changes in the adaptive composite score on the VABS-II were not found to be a significant predictor of changes in compulsive behaviour scores over time, $F(1, 168) = 1.05$, $p > .05$. Based on RBS-R parent interviews and standard scores on the VABS-II, improvements in language ability predicted the variation in stereotyped behaviour from diagnosis to age 6. In terms of parenting stress, changes in PSI scores were found to be a significant predictor of changes in compulsive behaviour scores, $F(1, 168) = 9.69$, $p < .01$, thereby suggesting that improvement in parenting stress is a significant predictor of improvements in compulsive behaviour over time, as assessed by the RBS-R.

Ritualistic behaviour scale. General Linear Model repeated measures ANCOVAs were used to examine changes in items from the RBS-R ritualistic behaviour subscale from baseline through Time 4. The total score for this subscale was included as the dependent variable at all four time points in the study. In the preliminary stepwise regression analyses, overall adaptive

skills were excluded from the stepwise model at Time 2, and communication scores were excluded from the stepwise model at Time 4, indicating that there was a stronger correlation between communication and ritualistic behaviours at Time 2 ($R^2 = 0.02$, $\beta = 0.12$), and between overall adaptive scores and ritualistic behaviour at Time 4 ($R^2 = 0.08$, $\beta = -0.29$). As a result, the communication score and the adaptive composite score on the VABS-II were both included in the model as predictors of ritualistic behaviour. In the overall GLM ANCOVA model, no significant differences were found in RRB scores on the ADI-R from baseline to Time 4, $F(1, 165) = .03$, $p > .05$.

Sameness behaviour scale. General Linear Model repeated measures ANCOVAs were used to examine changes in items from the RBS-R sameness behaviour subscale, from baseline through Time 4. The total score for this subscale was included as the dependent variable at all four time points in the study. The preliminary stepwise regression analyses excluded the VABS-II communication scores at all four time points. This indicates that overall adaptive skills are stronger correlates of RRBs, as assessed by the RBS-R, at baseline ($R^2 = 0.04$, $\beta = -0.21$), Time 2, Time 3 ($R^2 = 0.04$, $\beta = -0.20$), and Time 4 ($R^2 = 0.17$, $\beta = -0.41$). As a result, only the adaptive composite score on the VABS-II was included in the model as a predictor of sameness behaviours.

In the overall GLM ANCOVA model, no significant differences were found in RRB scores on the ADI-R from baseline to Time 4, $F(1, 168) = .09$, $p > .05$. While the plot of the scores, as demonstrated in Figure 4, gives the appearance that sameness behaviour scores on the RBS-R consistently decreased over time from Time 1 through Time 4, these differences were not significant. This suggests that in the present study, according to parent reports on the RBS-R,

sameness behaviours decreased, but not significantly, between each of the time points from diagnosis at age 2 or 4 years to age 6 years.

Restricted behaviour scale. General Linear Model repeated measures ANCOVAs were used to examine changes in items from the RBS-R restricted behaviour subscale, from baseline through Time 4. The total score for this subscale was included as the dependent variable at all four time points in the study. The preliminary stepwise regression analyses excluded the VABS-II communication scores at all four time points. This indicates that overall adaptive skills are stronger correlates of RRBs, as assessed by the RBS-R, at baseline ($R^2 = 0.02$, $\beta = -0.15$), Time 2 ($R^2 = 0.03$, $\beta = -0.18$), Time 3 ($R^2 = 0.06$, $\beta = -0.25$), and Time 4 ($R^2 = 0.17$, $\beta = -0.41$). As a result, only the adaptive composite score on the VABS-II was included in the model as a predictor of restricted behaviours.

In the overall GLM ANCOVA model, as presented in Figure 4, significant differences were found in restricted behaviour scores on the RBS-R from baseline to Time 4 in both the linear model $F(1, 168) = 16.89$, $p = .00$ and the quadratic model, $F(1, 168) = 4.36$, $p < .05$. Thus, according to parent reports on the RBS-R, overall RRBs improved between each of the time points from diagnosis at age 2 or 4 years to age 6 years.

The changes in restricted behaviours from Time 1 to Time 4, as assessed by the RBS-R, were associated with parenting stress but not overall adaptive skills. The changes in PSI-SF scores were found to predict changes in restricted behaviour scores in the linear model, $F(1, 168) = 9.58$, $p < .01$, whereas the changes in the adaptive composite score on the VABS-II did not predict changes in RRB scores over time, in either model, $F(1, 168) = .11$, $p > .05$; $F(1, 168) = 2.89$, $p > .05$.

Autism Diagnostic Observation Schedule Results

General Linear Model repeated measures ANCOVAs were used to examine changes in RRB items on the ADOS at three time points. As modules 1 and 2 includes four RRB items and module 3 includes five RRB items, scores on the ADOS were standardized for all of the participants. Specifically, a total score was calculated for all of the RRB items and divided by the total number of items to create a proportion that could be compared across time points. This standardized score was included as the dependent variable in the ADOS analysis at three time points, as the ADOS was administered at the first, third, and last time points in the study. The means for overall RRB scores on the ADOS at each time point are presented in Table 4.

In the preliminary stepwise regression analyses, the communication scores were excluded from the stepwise model at Time 1 and Time 3, and overall adaptive skills were excluded from the stepwise model at Time 4, indicating a stronger correlation between communication and RRBs at baseline ($R^2 = 0.03$, $\beta = -0.16$), and Time 3 ($R^2 = 0.10$, $\beta = -0.31$), and between overall adaptive skills and RRBs at Time 4 ($R^2 = 0.22$, $\beta = -0.47$). As a result, the communication score and the adaptive composite score on the VABS-II were both included in the model as predictors of overall RRBs on the ADOS.

In the overall GLM ANCOVA model, significant differences were found in the RRB scores on the ADOS from baseline to Time 4 in the linear model, $F(1, 182) = 4.22$, $p < .05$. As demonstrated in Figure 5, the RRB scores significantly decreased over time from baseline to Time 3, then stayed relatively stable from Time 3 to Time 4. This suggests that, according to direct observation using the ADOS, the overall RRBs improved from diagnosis at age 2 or 4 years to age 6 years.

The changes in RRBs from Time 1 to Time 4, as assessed by the ADOS, were associated with changes in overall adaptive skills, but not in communication or parenting stress. Changes in the adaptive composite scores on the VABS-II predicted changes in RRB scores over time, $F(1, 182) = 6.61$, $p < .05$, while changes in communication scores on the VABS-II, $F(1, 182) = .38$, $p > .05$, , and changes in parenting stress on the PSI-SF, $F(1, 182) = .51$, $p > .05$, did not.

Discussion

The focus of the present study was the developmental trajectories of RRBs over time in children with ASD. Potential predictors of changes in RRBs, including communication, adaptive skills, and parent stress levels, were also examined in the present study. Children with ASD were administered a variety of measures including the ADI-R, ADOS, RBS-R, VABS-II, and PSI at various time points from diagnosis at age 2 or 4 years to age 6 years. The use of multiple sources of information, including parent interviews, parent questionnaires, and direct observation provided for a more comprehensive assessment of these behaviours than used previously, as the exclusive use of parent report data has been noted as a limitation of previous studies of RRBs (e.g., Richler et al., 2010). The nuanced information provided by the multimodal method of data collection allows for a discussion of findings both in terms of individual measures and behaviours across measures. In addition, the lack of significant differences between the two cohorts allow for a discussion of the results for the sample as a whole, rather than separately for each cohort. The lack of significant differences between the cohorts means that the children in the present study demonstrated similar developmental trajectories of RRBs regardless of whether they were diagnosed at age 2 years, or at age 4 years. This suggests that the developmental level, rather than the actual age of the child, is important for RRB development. More specifically, the age at which ASD symptoms are first identified does not appear to affect the developmental

trajectory of RRBs as much as the length of time following diagnosis. This is an important finding for intervention, as early intervention is crucial for children with ASD, and the results of the present study contribute to the focus of the definition of early intervention from a specific age to a stage in relation to diagnosis.

Developmental Trajectories of Restricted, Repetitive, and Stereotyped Patterns of Interests and Behaviours (RRBs)

Consistent with the hypotheses of the study, levels of RRBs were found to change over time from diagnosis to age 6 years. However, contrary to the predictions that were based on previous research findings of increases in the frequency and severity of RRBs over time (e.g., Richler et al., 2010; Wolff et al., 2014), overall levels of RRBs were found to decrease from baseline to Time 4. This suggests that the severity and frequency of RRBs, as measured by the ADI-R, ADOS, and RBS-R improved with time from diagnosis to age 6 years. This finding is also contrary to previous findings that RSM behaviours remained relatively stable over time, while IS behaviours worsened over time (Richler et al., 2010; Wolff et al., 2014). The disparity between the findings might be attributed to two factors. One, Richler et al. (2010) considered only the RRB items included in the diagnostic algorithm of the ADI-R, whereas in the present study, all RRB items on the ADI-R were included in the analyses. Two, RRBs were examined from diagnosis to age 6 years in this study, but until the age of 9 years by Richler et al. (2010). Changes between the ages of 6 and 9 years could have led to differences between the findings of the two studies. The age of the children in the study might have also contributed to differences between the findings of this study and those of Wolff et al. (2014), as the children in the Wolff et al. (2014) study were significantly younger than the children in the current study, and were only followed for a brief period of time.

The results of the present study can be considered support for the notion that the clusters of symptoms that comprise ASD, such as RRBs, can each have individual developmental trajectories, although diagnoses of ASDs remain relatively stable over time (eg., Chawarska et al., 2007; Kleinman et al., 2008; Lord et al., 2006). Specifically, the decrease in the frequency and severity of RRBs over time that was found in the present study indicates more nuanced developmental trajectories within ASD, despite broad diagnostic stability. These changes in RRBs over time might account for some of the variability within the spectrum, contributing to our understanding of how children with ASD might evolve, in terms of both overall diagnosis and symptoms, over time. This finding also has implications for the focus of interventions in ASD, as RRBs appear to be susceptible to change, and should therefore be more amenable to intervention than if they were stable characteristic. If RRBs improve naturally over time, interventions aimed at these behaviours should be even more effective by targeting the natural course of development. This clinical implication also extends to other areas of ASD, since ASD affects multiples areas of functioning, including communication, social impairments, and RRBs, which are all interrelated with one another (Leekam et al., 2011). Since RRBs appear to improve naturally with time, children with ASD might benefit from more intensive interventions in the other spheres. This leads to a suggestion for future research examining the implications of intervening in the other clusters of ASD symptoms in the context of the natural improvement of RRBs over time.

Changes in Restricted, Repetitive, and Stereotyped Patterns of Interests and Behaviours (RRBs) Across Methods of Data Collection

Improvement in overall levels of RRBs was found across all three measures, suggesting consistency among direct observation, parent interviews and parent questionnaires of RRBs.

However, more nuanced differences between the three measures were noticed in the shapes of plots of the trajectories and differences were found between measures when RRBs were broken down into RRB subtypes. These findings suggest that each method of measurement might capture a slightly different aspect of RRBs, supporting the use of multiple sources of information in the present study. The use of multiple modes of data collection in the present study also allowed for elaboration of the finding of different developmental trajectories among the subtypes of RRBs through an examination of more specific subtypes of RRBs on the ADI-R and the RBS-R. Subtypes of RRBs were not examined using the ADOS, as the ADOS only contains four RRB items in Modules 1 and 2, and five RRB items in Module 3. The finding of differences between the trajectories of subtypes of RRBs is consistent with the findings of Richler et al. (2010), who also found differences among different subsets of RRBs. However, the findings of the two studies differed in terms of the direction of change, as Richler et al. (2010) found that a subset of RRBs (IS behaviours) increased over time, while the corresponding subset of RRBs were found to decrease in the present study.

The finding of a decrease in overall RRBs across measures suggests that in general, the frequency and severity of RRBs improved from diagnosis to age 6, though this change did not necessarily follow a linear trajectory from the first to the final time point. As the ADI-R was only administered at the first and final time points and a significant decrease was found, the impression is that of a linear decrease from Time 1 to Time 4, but scores on the other measures also administered at Times 2 and/or 3 suggest a more complex trajectory. Specifically, the scores on the RBS-R appeared to follow a trajectory of an initial sharp decline in RRBs, followed by a smaller decrease from Time 2 to Time 3, and the smallest decrease from Time 3 to Time 4. While scores on the ADOS showed an overall decrease from baseline to Time 4, the

shape of the trajectory indicates a linear decrease from Time 1 to Time 3, followed by relative stability from Time 3 to Time 4. This profile might be attributed to a child's increased ability to regulate behaviour in a structured setting as the child ages, which is why the stability toward the end of the study would be seen by the examiner, but the child's everyday behaviour would be captured in the parent reports, as parents have more opportunity to observe their children in more natural, unstructured, and less regulated, settings. These findings suggest that the trajectory of overall RRBs over time differs as a function of time point and measure. The differences across the various time points support the complexity of the developmental trajectories of RRBs, suggesting that these are not stable characteristics of children with ASD throughout childhood. Differences across measures suggest that parent interviews, questionnaires, and direct observation might each consist of individual sets of strengths and weaknesses for assessing RRBs in children with ASD, and should be considered in future research.

Subsets of Restricted, Repetitive, and Stereotyped Patterns of Interests and Behaviours (RRBs)

In terms of the subsets of RRBs, the findings varied according to the specific category of RRB. When the analyses were conducted based on the ADI-R, both the RSM and IS behaviours improved over time. This is different from Richler et al.'s (2010) findings that RSM behaviours remained relatively stable over time, while IS behaviours worsened over time. Further examination of the profile plots for both the RSM and the IS behaviours in the present study showed that the difference in the IS behaviours appears greater than the difference in RSM behaviours, although both types of behaviours diminished over time. Specifically, the scores on the IS behaviour items of the ADI-R were initially higher than scores on the RSM behaviour items on the ADI-R, but the scores were around the same level at the final time point. While the

difference in RSM scores from Time 1 to Time 4 was significant, the first and final scores did not differ by many points, indicating some similarity to the results of Richler et al. (2010). However, as the ADI-R was only administered at two time points in the present study, the interpretation of the current findings are limited, and future research should examine the precise trajectory of both IS and RSM behaviours between the first and final time points.

In order to examine more specific subsets of RRBs, the six subsets of RRBs measured by the RBS-R (Bodfish et al., 1999) were considered in the analyses of the present study. This allows for even more nuanced examinations of the developmental trajectories of RRBs than examinations of RSM and IS behaviours, as they further break down the categories into more specific behaviours. The subsets of RRBs on the RBS-R (Bodfish, 1999) include: (1) Stereotyped Behaviour Subscale, measuring repetitive physical movements or actions, stereotyped object usage, and sensory behaviours; (2) Self-Injurious Behaviour Subscale, measuring repetitive behaviours that are harmful to oneself; (3) Compulsive Behaviour Subscale, measuring behaviour conducted according to a rule, or behaviours that must be done in a very specific manner; (4) Ritualistic Behaviour Subscale, measuring behaviour repeatedly done in the same way; (5) Sameness Behaviour Subscale, measuring insistence on sameness and resistance to change; and (6) Restricted Behaviour Scale, measuring behaviours and interests that are limited in focus. The examination of these subsets of RRBs in the present study yielded both quantitative and qualitative differences among the subsets of RRBs. Whereas overall levels of RRBs, self-injurious behaviours, compulsive behaviours, and restricted behaviours changed over time, no significant change was found in sameness behaviours, ritualistic behaviours, or stereotyped behaviours. The lack of change in stereotyped behaviours is consistent with Richler et al.'s (2010) finding of stability in RSM behaviours on the ADI-R, as these subscales include

similar behaviours, and changes in the restricted and compulsive subsets are consistent with Richer et al.'s (2010) finding of changes in IS behaviours. However, the direction of these changes differ between studies, as Richler et al. (2010) found that IS behaviours worsen over time, whereas similar behaviours on the RBS-R were found to improve over time in the present study.

While self-injurious behaviours, compulsive behaviours, and restricted behaviours all changed over time, the developmental trajectories of each subscale were neither direct, nor linear. In terms of self-injurious behaviour, a quadratic trajectory was found, wherein these behaviours initially improved from baseline to Time 3, followed by a worsening of behaviour, almost to the initial level of the behaviour at Time 4. In contrast, an overall improvement was found in compulsive behaviours, though the profile plot suggests that more change occurred between baseline and Time 2, and between Time 3 and Time 4, than between Times 2 and 3. A similar profile was found for restricted behaviour, where the sharpest decline in these behaviours was found between baseline and Time 2. Whereas significant changes were not found for the other three subsets of RRBs (stereotyped, ritualistic, and sameness behaviours), the profile plots for sameness and stereotyped behaviours suggested a slight improvement over time. While the change was not significant, the plot of ritualistic behaviour showed a decrease in the behaviours, followed by an increase, followed by another decrease, suggesting sub-threshold change over time. As certain subscales of RRBs do not appear to improve naturally with time, interventions designed to target these specific behaviours should be designed to help improve overall RRBs in children with ASD and also stimulate development in terms of those behaviours that do not improve over time. Furthermore, the identification of self-injurious, compulsive, and restricted

behaviours as amenable to change over time suggests a need for early intervention to further the natural course of improvement.

Predictors of the Trajectories of Restricted, Repetitive, and Stereotyped Patterns of Interests and Behaviours (RRBs)

The finding of a general decrease in RRBs over time was consistent across all three measures. However, the effect of the predictors of this change differed among the RBS-R, ADOS, and ADI-R and among the subsets of RRBs. With regard to parent stress levels, change in parenting stress was found to be a significant predictor of change in overall RRBs on the RBS-R, but not on the ADI-R or the ADOS. This might be attributed to parents' response styles on an interview as compared to a questionnaire, as parents might feel more comfortable answering questions on a questionnaire, than orally in front of an examiner. Another possibility is that the wording of the RBS-R might be more sensitive to parenting stress. With regard to language ability as a predictor of RRBs, change in language ability was found to be significant on the ADI-R, but not on the ADOS or on the RBS-R. In contrast, changes in overall adaptive skills, however, were found to significantly predict changes in overall RRBs on all three measures. This suggests that the relationship between adaptive skills and RRBs is strong and consistent with previous cross-sectional research noting the correlation between RRBs and adaptive skills (e.g., Gabriels et al., 2005; Honey et al., 2008). Given the strong predictive nature of adaptive skills to RRBs, interventions aimed at improving overall adaptive skills should be encouraged in order to in turn promote improvement in RRBs.

These differences in predictors across measures might be related to differences in the predictors of the subsets of RRBs. On the ADI-R, language was only a significant predictor of the IS behaviours, but not the RSM behaviours. This might be attributed to the idea that RSM

behaviours inherently do not involve language, while many IS behaviours rely heavily on language. Moreover, IS behaviours are more commonly found in higher functioning children (Leekam et al., 2011), and communication is often associated with of level of functioning. In contrast, parenting stress was only a significant predictor of RSM, but not IS behaviours. This might be attributed to the idea that RSM behaviours are most commonly found in lower functioning children, and since stress levels are higher among parents of children with ASD, then stress levels would logically be even higher in parents of lower functioning children.

Although change in adaptive skills was found to predict change in overall RRBs on the RBS-R, neither change in overall adaptive skill change nor language ability were found to predict significant changes in any of the subsets of RRBs. However, parenting stress significantly predicted overall RRBs, compulsive behaviour, and restricted behaviour. As the RBS-R is a parent questionnaire that was administered at the same time as the PSI, it is possible that the parents may have been primed to think about their stress as they completed the RBS-R, or about their children's difficult behaviour when completing the PSI. If the completion of one questionnaire primed parents' responses as they completed the other questionnaire; higher levels of stress and higher levels of RRBs might be concurrently reported by the parents.

With regard to the unique contributions of language as compared to overall adaptive skills, overall adaptive skills appeared to be more strongly correlated to RRBs during the preliminary analyses than language skills, and to more strongly predict RRBs in the longitudinal analyses. While this might seem to indicate that overall adaptive skills are more relevant to RRBs than language skills, this is not the entire story. Language skills superseded overall adaptive skills in some of the preliminary stepwise regression analyses, suggesting that language skills play a role with specific RRBs above and beyond the role of overall adaptive skills. As such, language

skills should be considered to have a unique contribution to certain RRBs, and should not be consistently excluded from future analyses. In sum, adaptive skills, language ability, and parenting stress each contribute to the developmental trajectories of RRBs and are therefore important factors when considering the context of changes in RRBs over time.

Limitations

The present study was constrained by a number of limitations that should be noted and considered when interpreting the results of the study and planning future research. One, the present study did not take into account any interventions or services the children received during the course of the study. As such, levels of RRBs could have been influenced by factors other than those considered as predictors. Early intervention has been shown to be important in reducing the impact of ASD symptoms (Leekam et al., 2011), and it is therefore possible that the varying levels of interventions received by different children in this study impacted the results. In addition, more details regarding demographic factors (e.g., gender, ethnicity, and dominant language) should be further explored as potential predictors. Two, the possibly varying levels of severity of RRBs across participants at baseline were not considered in this study. As ASD is a spectrum comprised of varying levels of severity (American Psychiatric Association, 2013), the developmental trajectories of RRBs might differ according to the initial severity of RRBs. Three, the ADI-R was only administered at the first and last time points in the present study, showing the overall trend from diagnosis to age 6, but lacking the specific developmental trajectory shown by the ADOS and the RBS-R. Similarly, the questionnaires and interviews given at each time point were not all administered to a family on the same day. As such, other factors might have allowed parents to answer different measures differently. Specifically, since parenting stress impacts responses, parents who were more stressed on the day they were given

the ADI-R than the RBS-R might have answered differently than the day they answered the RBS-R. Four, as the children in the study varied in terms of levels of functioning, different modules of the ADOS were administered to different children. Similarly, some children in the study improved in terms of level of functioning during the course of the study and were therefore administered different ADOS modules at different points in the study. Since the RRB sections of Modules 1 and 2, and Module 3 contain different numbers of RRB items (4 and 5, respectively), the results had to be standardized in order to compare scores across modules. As a result, proportion scores were calculated for each RRB total, whereby the total score was divided by the total possible score, and the proportions were used as the unit of analysis.

Directions for Future Research

While the present study examined changes in RRBs using multiple sources of information, a number of questions remain to be answered by future research. One, in the present study, the findings indicated whether there was a significant change in RRBs and subsets of RRBs over time, but the precise change between each individual time point was approximated using the shapes of the profile plots. In the future, researchers could more precisely measure this specific change at each time point. In addition, the ADOS was the direct observation measure used the present study, and while it is the gold standard for ASD diagnoses, it only contains four or five RRB items, depending on the module. Future studies in this area might benefit from the use of a direct observation measure that contains more RRB items.

With regard to predictors of changes in RRBs over time, future research should be conducted to elucidate the relationship further between adaptive skills and language skills in the context of RRBs. Similarly, future research should be conducted with regard to the relationship between parent stress levels and RRBs. As the relationship between parenting stress and RRBs

appeared to be present, but not entirely clear in the present study, future studies could be focused on the nature of relationship between parenting stress and RRBs in order to understand more fully the impact and directionality of the relationship. This should also be examined in the context of level of functioning of the child and subset of RRBs, as well as RRBs as a broad category.

In the present study, the RRBs tended to improve with time, a finding that is inconsistent with the evidence from two previous studies of similar behaviours (Richler et al., 2010; Wolff et al., 2014). Thus, replications and extensions of this study might be undertaken in order to clarify the discrepancies among the studies. An examination of whether improvement in RRBs over time means that other clusters of ASD symptoms will also improve would further illuminate the relationship among the clusters of ASD symptoms.

Overall, the findings of the present study revealed that, despite previous evidence of diagnostic stability among children diagnosed with ASD, improvement can be found within at least one specific cluster of symptoms of the disorder. This change over time might account for some of the variability found within the spectrum and enhances our understanding of how children with ASD develop throughout early childhood. Understanding this development in turn contributes to knowledge regarding the evolution of ASD, which is a prevalent and complex diagnostic category. The directionality of this change also reflects an encouraging finding for children with ASD and their families, as children showed improvement in both the frequency and severity of RRBs from diagnosis to age 6 years. Moreover, the present study provides further identification of areas to be targeted by early intervention, an important implication for research in this area.

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Table 1

Schedule of Measures Across Time Points

	ADI-R[a]	ADOS[b]	RBS-R[c]	VABS[d]	PSI[e]
Baseline (T1)	x	x	x	x	x
T2: 6 months after T1			x	x	
T3: 1 year after T1		x	x	x	x
T4: Age 6 years	x	x	x	x	x

[a]Refers to the Autism Diagnostic Interview-Revised

[b]Refers to the Autism Diagnostic Observation Schedule

[c]Refers to the Repetitive Behavior Scale-Revised

[d]Refers to the Vineland Adaptive Behavior Scale

[e]PSI refers to the parenting stress

Table 2

ADI-R[a] *Scores Across Time Points*

	Time 1		Time 4	
Scale	*M*	*SD*	*M*	*SD*
Total RRB[b] Score	17.15	7.8	10.26	6.86
IS[c] Behaviour Score	10.64	6.35	5.13	4.34
RSM[d] Behaviour Score	6.52	3.39	5.13	3.29

[a]Refers to the Autism Diagnostic Interview-Revised

[b]Refers to restricted, repetitive and stereotyped patterns of behaviours and interests

[c]Refers to insistence on sameness behaviours

[d]Refers to repetitive sensorimotor behaviours

Table 3

RBS-R[a] *Scores across Time Points*

	Time 1		Time 2		Time 3		Time 4	
Scale	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Total RRB[b] Score	23.42	17.15	20.75	15.68	19.83	14.60	18.86	17.96
Stereotyped Behaviour	4.66	3.08	4.17	3.03	3.83	2.91	3.73	3.72
Self-Injurious Behaviour	2.02	3.02	1.73	2.57	1.59	2.72	1.82	3.09
Compulsive Behaviour	4.05	3.55	3.55	3.34	3.36	3.38	2.87	3.24
Ritualistic Behaviour	3.69	3.43	3.43	3.19	3.61	3.13	3.26	3.34
Sameness Behaviour	5.49	5.29	5.39	4.95	5.16	4.59	4.94	4.95
Restricted Behaviour	3.74	3.01	3.01	2.73	2.84	2.44	2.55	2.70

[a]Refers to the Repetitive Behavior Scale-Revised

[b]Refers to restricted, repetitive and stereotyped patterns of behaviours and interests

Table 4

ADOS[a] *Scores across Time Points*

	M	*SD*
Total RRB[b] Score at Time 1	0.45	0.21
Total RRB Score at Time 2	0.39	0.22
Total RRB Score at Time 3	0.39	0.24

[a]Refers to the Autism Diagnostic Observation Schedule

[b]Refers to restricted, repetitive and stereotyped patterns of behaviours and interests

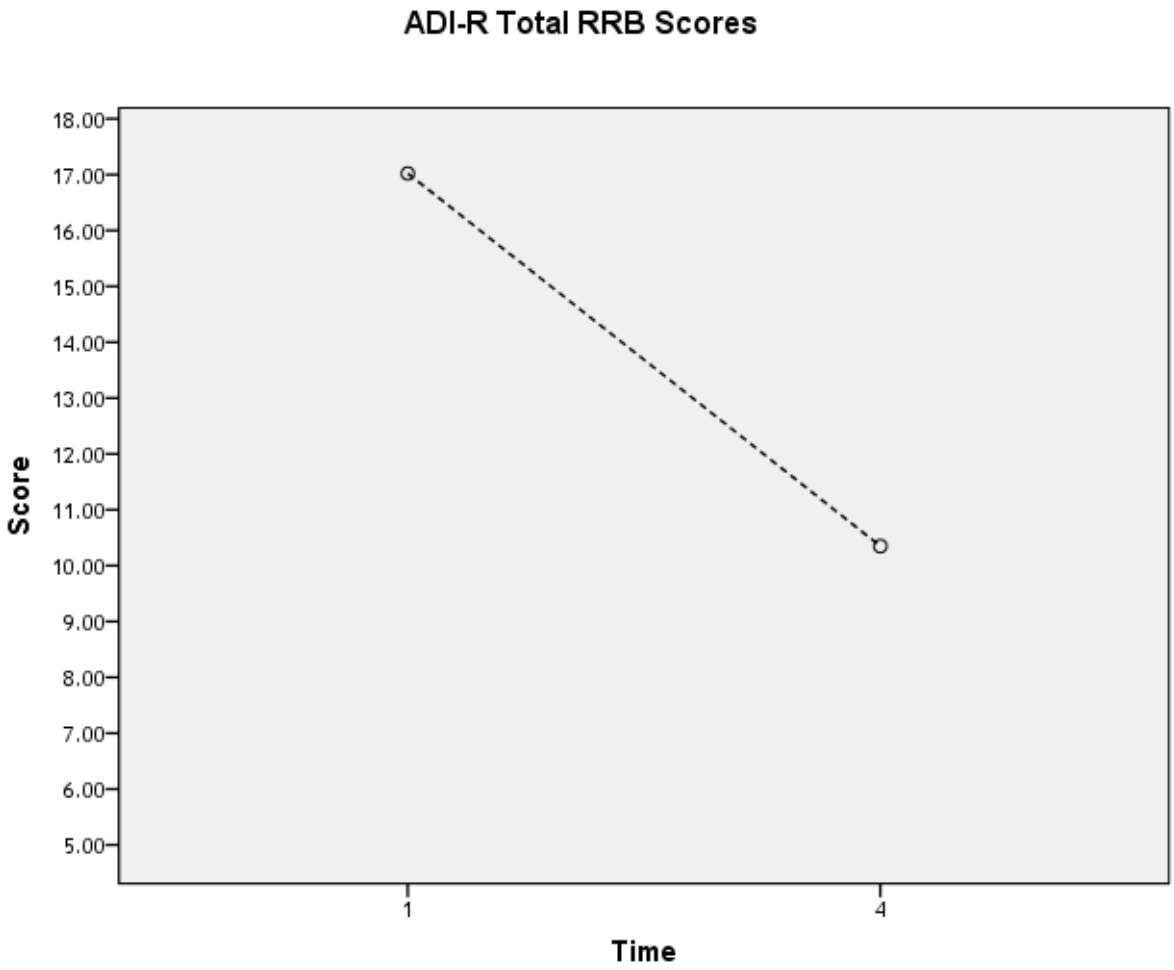

Figure 1. Change in overall RRB scores across time periods, as measured by the Autism Diagnostic Interview-Revised (ADI-R).

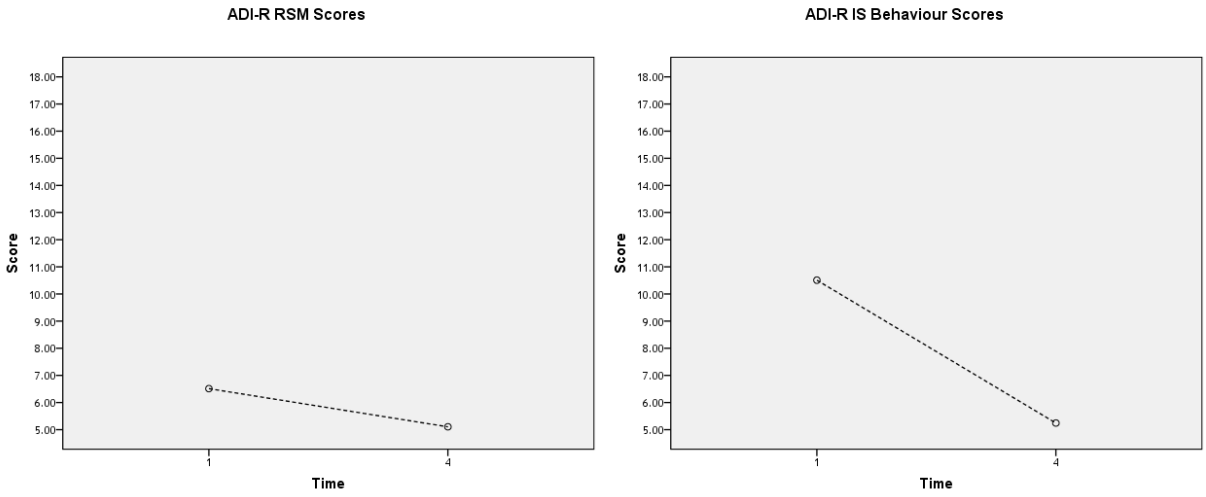

Figure 2. Changes in RRB subtype scores across time periods, as measured by the Autism Diagnostic Interview-Revised (ADI-R).

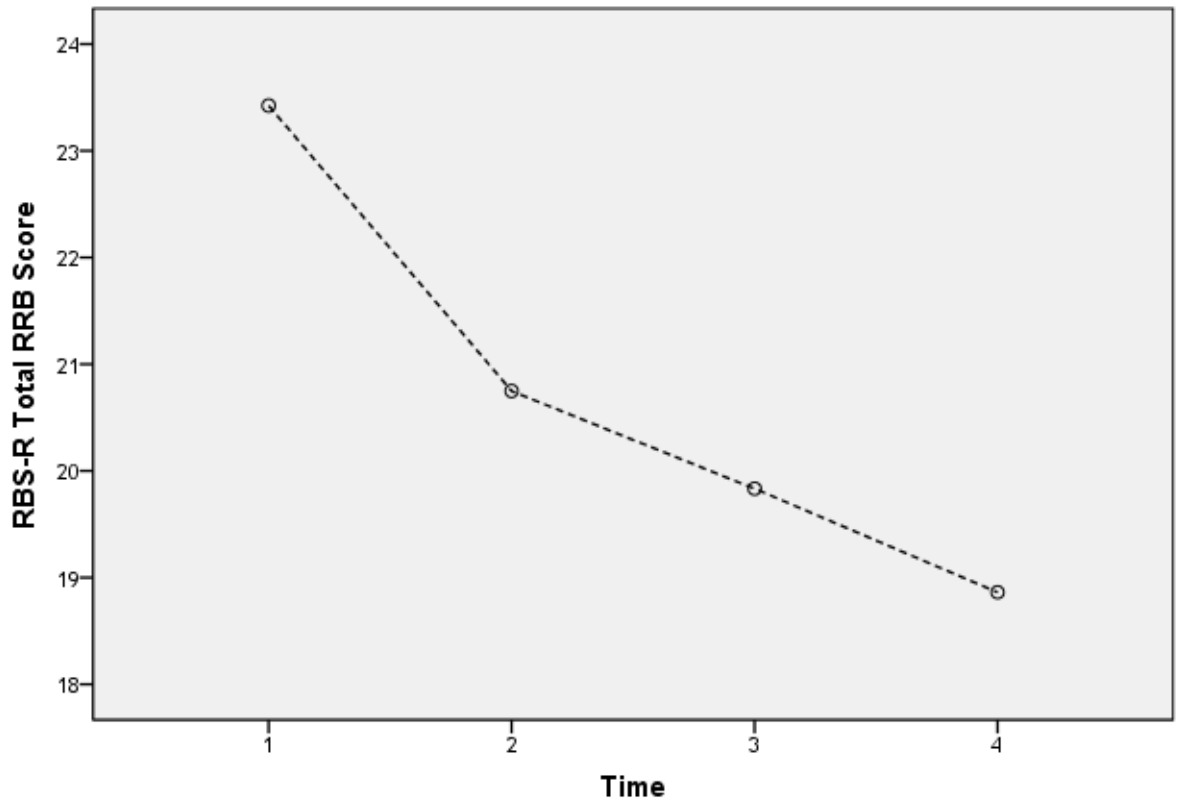

Figure 3. Changes in overall RRB scores across time periods, as measured by the Repetitive Behaviour Scale-Revised (RBS-R).

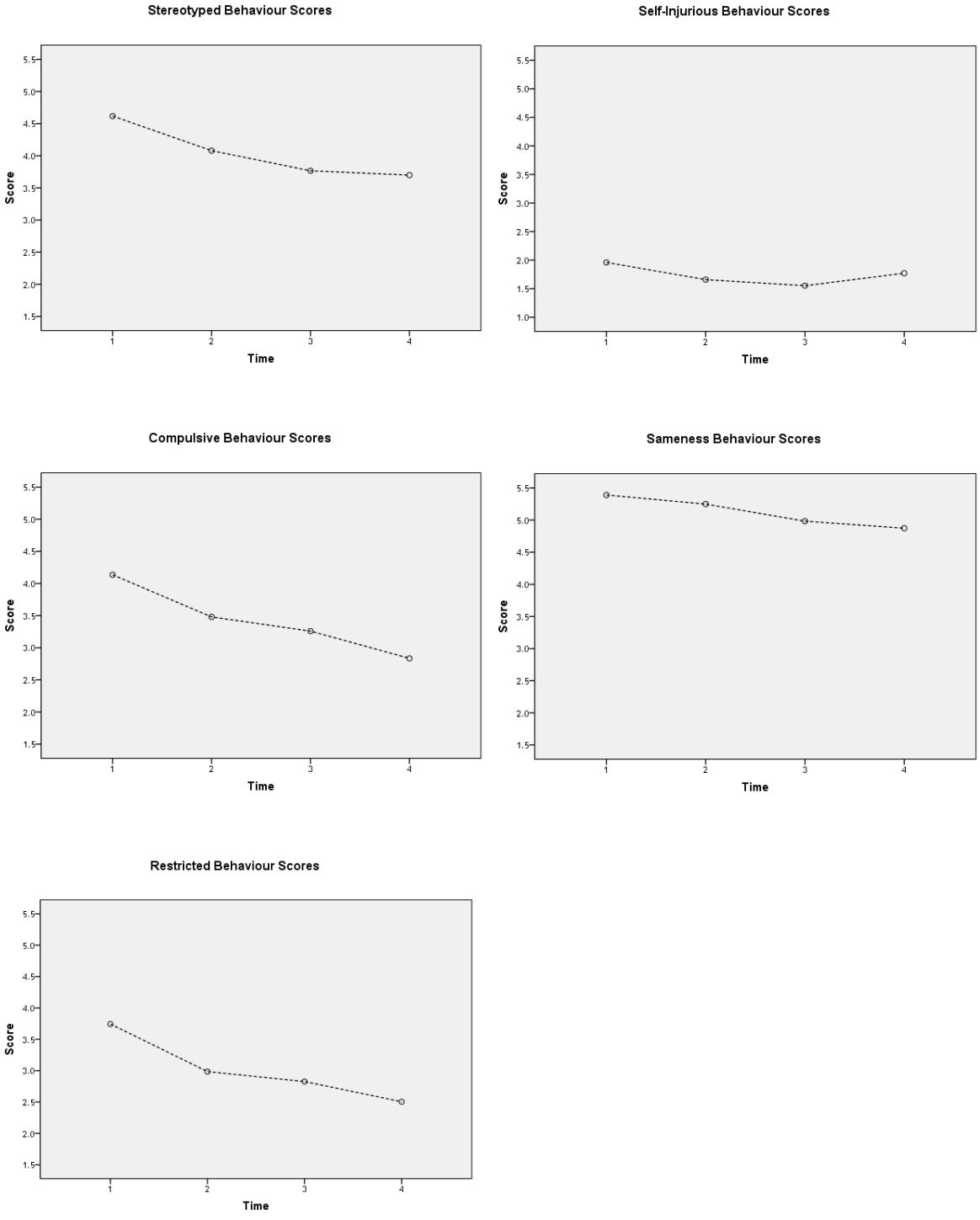

Figure 4. Changes in RRB subtype scores across time periods, as measured by the Repetitive Behaviour Scale-Revised (RBS-R).

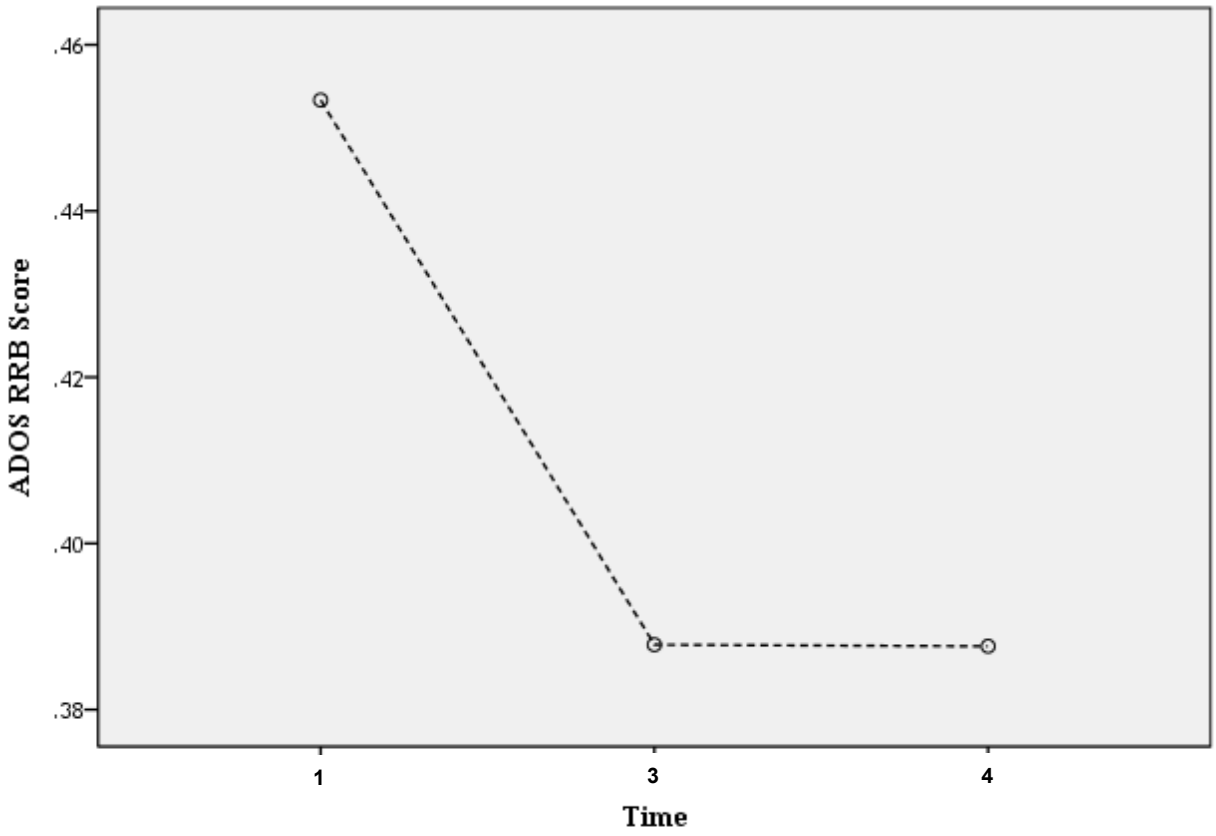

Figure 5. Changes in Autism Diagnostic Observation Schedule total RRB scores across time periods.