A COMPARATIVE STUDY OF EXECUTIVE FUNCTIONING BEHAVIOURS IN BILINGUAL AND MONOLINGUAL CHILDREN WITH AUTISM SPECTRUM DISORDER

by

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Abstract

Weaker Executive Function (EF) abilities have been consistently noted in individuals with an Autism Spectrum Disorder (ASD) relative to typically-developing children, specifically with deficits in planning, mental flexibility or shifting, inhibition, and working memory. There have been mixed findings in terms of typically-developing bilingual individuals demonstrating a bilingual advantage compared to monolingual peers on tasks of EFs.

However, there is currently no research comparing the EF skills of bilingual and monolingual children with ASD. The current study compared the parent and teacher ratings of EF deficits and academic achievement in 42 8.5-to-9.0-year-old bilingual and monolingual children with ASD. Results indicated no significant differences in ratings of EF deficits or academic achievement scores. The results from this study support past research that indicates bilingualism does not have a negative impact on the cognitive development of children with ASD.

Preface

The topic and the design of this study were developed by the author, S. Macaro, and her thesis committee members, Dr. S. Marinova-Todd and Dr. P. Mirenda. This study utilized data collected for the "Autism Spectrum Disorders: Pathways to Better Outcomes (Phase II)" research project that was approved by UBC's Behavioural Research Ethics Board (BREB) on June 26, 2009 under certificate H09-01085-0. The Pathways research team approved Ms. Macaro's use of data for her thesis on March 26, 2015 and her name was added to the BREB ethics certificate on April 12, 2015 (H09-01085-A03). Ms. Macaro was responsible for all data analysis and is the sole author of this thesis.

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Dedication

I dedicate this thesis to my mom. Without you, none of this would have been possible. Thank you.

Chapter 1: Introduction

The number of children diagnosed with an Autism Spectrum Disorder (ASD) has increased almost 30% since 2008, with approximately one in every 68 children meeting the criteria for a diagnosis in 2010, compared to one in 88 just 2 years prior (Wingate, Kirby, & Pettygrove, 2014). With this number rising, and with more than half of the world's population identifying as bilingual or multilingual (Grosjean & Li, 2013), it is not surprising that many children with ASD are being raised in environments where they are exposed to more than one language (Kay-Raining Bird, Lamond, & Holden, 2012). It was once thought that learning more than one language was detrimental to one's cognitive development; however, that claim has been disproven since Peal and Lambert (1962) found equal to or advanced scores of cognition and school achievement in bilingual children when compared to monolingual children matched for age and socioeconomic status (SES). Since then, the Executive Functions (EFs) of bilingual individuals have been a topic of interest, with some research results indicating higher scores for bilinguals, or a “bilingual advantage” (see Bialystok, Craik, & Luk, 2012 for a review). Unfortunately, although it has been determined that bilingualism does not negatively affect language development in typically-developing children; parents of children with ASD are often advised to speak only one language to their child (Kremer-Sadlik, 2005). Recent research has examined this issue and, in a systematic review of ASD research, Drysdale, van der Meer, and Kagohara (2014) concluded that bilingualism does not have a negative effect on language development in children with ASD. However, the cognitive effects of bilingualism remain unclear, including the extent to which the bilingual advantage seen in typically-developing children is also present in children with ASD. Given the EF deficits often present in individuals with ASD, understanding the relationships between bilingualism and EFs is crucial in this population in terms of directing education goals and intervention advice (Buchwietz & Prat, 2013). Overall, as the number of individuals who are both bilingual and have a diagnosis of ASD increases, there is a need for more research to support evidence-based practice and decision making for recommendations in this field. The following sections of this chapter will review the current literature on the relationships between EFs, bilingualism, and school achievement in individuals with and without ASD. To my knowledge, there is currently no published research exploring EF skills in children with ASD who are also exposed to more than one language.

1.1 ASD and Executive Functions

ASD encompasses a continuum of mild to severe disorders that are characterized by impaired social-communicative interactions and restrictive, repetitive, or stereotyped behaviours, interests, and activities, as defined in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5; American Psychiatric Association, 2013). In general, EFs are needed to complete any goal-oriented task or activity; thus, they are critical for the development and maintenance of cognitive, social, psychological, physical, and emotional self-control (Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009; Diamond, 2014). EF research with samples of individuals with ASD has focused in four main areas: (a) cognitive flexibility (also referred to as mental flexibility, shifting, or switching), defined as the ability to switch between two perspectives or smoothly transition from one situation to another; (b) inhibition, defined as the ability to engage in self-control and suppress impulsive behaviour; (c) working memory, defined as is the ability to hold and manipulate information in one's mind while completing a task; and (d) planning, defined as the ability to generate and sequence thoughts and actions for a future-oriented task, as well as monitor and update steps depending on the situation (Blijd-Hoogewys, Bezemer, & van Geert, 2014; Diamond, 2014; Gioia, Isquith, Guy, & Kenworthy, 2000). EF deficits have been found in all four of these areas in individuals with ASD (e.g. Bliijd-Hoogewys et al., 2014; Corbett et al., 2009; Hill, 2004; Ozonoff, Pennington, & Rogers, 1991; South, Ozonoff, & McMahon, 2007).

1.1.1 Tasks Measuring Executive Functions

EFs are typically measured through a variety of laboratory-based tasks designed to target specific domains. However, as EFs skills are interconnected and not easily separated, it is often difficult to be sure which skill is being measured. For example, a few of the most common tests designed to measure EFs, including the Stroop test, Tower of London, and Wisconsin Card Sorting Task (WCST), all measure more than one EF skill. The Stroop test (variations include Day/Night and Go/NoGo tasks) measures attention and inhibition by assessing the ability to selectively attend to the correct component while inhibiting a dominant response by requiring a participant to respond by naming the colour of ink in which a word is printed, rather than the word itself (e.g., Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009). Another task that measures both inhibition and planning is the Tower of London (variations include Tower of Hanoi and Stockings of Cambridge), in which a participant is shown two sets of three pegs and three discs, with one arranged in a certain way; the participant must then match one set to look like the other by planning and sequencing a series of moves while inhibiting immediate responses and abiding by the constrains and rules (e.g., Corbett et al., 2009; Geurts, Verte, Oosterlaan, Roeyers, & Sergeant, 2004; Ozonoff et al., 1991; Robinson et al., 2009). Finally, the WCST (or its variation, the Intradimensional/ Extradimensional shift task) measures both flexibility and inhibition by assessing one's ability to modify rules throughout the task and to inhibit previously correct responses on a card sorting task. The cards are initially sorted on one dimension (e.g., shape) and then, after 10 consecutive correct sorting trials, the sorting rules switch without the participant's knowledge. This requires the participant to sort the remaining cards based on a different dimension (e.g., colour), as determined by either positive or negative feedback from the administrator (e.g., Corbett et al., 2009; Geurts et al., 2004; Ozonoff et al., 1991; Robinson et al., 2009). All of these tasks also require the use of working memory in order for a participant to succeed as they must remember the rules and constraints of the activity at hand and adjust them throughout the task.

1.1.2 Evidence of ASD and Executive Function Deficits

EF skills have been studied in monolingual individuals with ASD across a range of age and ability, using a variety of tasks, task presentations, and testing environments. After completing a study comparing individuals between 8 and 20 years of age both with and without a diagnosis of ASD, Ozonoff et al. (1991) suggested that weaker EFs may be a primary deficit of ASD. The participants in this study with high functioning ASD performed more poorly than typically-developing individuals on tasks involving planning, cognitive flexibility/shifting, and verbal working memory. However, there were no differences in their conceptual understanding of the task, suggesting that the deficit is reflective of weaker EFs rather than a simple misunderstanding. Corbett and colleagues (2009) found similar results when comparing typically-developing children with children with ASD and attention deficit hyperactivity disorder (ADHD) between the ages of 7 and 12 years. Results reflected significantly poorer performance for children with ASD in the domains of inhibition, working memory, cognitive flexibility/shifting and vigilance, but no difference for planning or fluency. Additional studies have revealed deficits in inhibition, planning, mental flexibility, and verbal fluency, with no difference in working memory (Geurts et al., 2004), or deficits in planning and inhibition while mental flexibility and verbal fluency were relatively spared (Robinson et al., 2009). Overall, the results are similar in that they all support a general deficit in EF but are also somewhat inconclusive as they differ in terms of the exact domains that are consistently impaired. This inconsistency may reflect the heterogeneity of individuals with ASD, preventing the generalizability of a definite set of specific deficits (Hughes, 2001).

There are many other possible reasons that may underlie the variability in the results among studies. The differences may be attributed to inconsistent operational definitions of EF terms or the tasks used to measures the EF domains, as no one task is available to measure just one skill, making it difficult to reliably separate and consistently target the same domain across studies (Geurts et al., 2004). Another possible explanation for the differing results may be due to the nature of task instructions or administration; for example, performance may vary depending on whether the task is computer-based or human-administered. A computerized task may be more sensitive to subtle responses than a human is, thus revealing a greater deficit; but a computerized task may also mask an EF deficit that would otherwise be inflated through the social aspect of the same human-administered task (Robinson et al., 2009). Alternatively, one factor that might contribute to the variability of EF research results is the range of ASD severity among the participants. In a study comparing EF deficits across the autism spectrum, Verte, Geurts, Roeyers, Oosterlaan, & Sergeant (2006) found that the high functioning ASD and Asperger's groups' performance did not significantly differ; both groups experienced deficits in cognitive flexibility, visual working memory, planning, verbal fluency, and inhibition. However, in a group of participants with pervasive development disorder not otherwise specified (PDD-NOS), visual working memory and planning were spared, although the other domains were similarly affected. Additionally, weaker EFs are typically associated with ASD, but also a number of different populations as well. For example, results of Liss and colleagues (2001) revealed similar EF performance between a group of 9-year-old children with high functioning autism and a group with a developmental language disorder. The overlap in deficits between populations stresses the importance of controlling for co-morbidities in participants, especially the presence of ADHD (Geurts et al., 2004), as these similar deficits across groups may prevent reliable results. Nonetheless, despite the somewhat inconsistent findings regarding specific EF domains, there is general agreement that cognitive flexibility, inhibition, working memory, and planning are weaker in individuals with ASD than in typically-developing individuals, at least when studied in a controlled setting.

Most of the research on EFs in ASD has been conducted in highly controlled environments within a structured laboratory setting, reducing the face validity of the findings (Dollaghan, 2012). In an attempt to address this limitation, researchers have investigated EFs outside of laboratory settings and in more natural environments. For example, the Behaviour Rating Inventory of Executive Functions (BRIEF; Gioia et al., 2000) is a commonly used tool in research that measures teacher and parent ratings of children's behaviours and problem solving in natural, everyday situations, representing different EFs. The BRIEF measures the same EF domains as do performance-based lab tasks, in addition to the ability to organize materials and to initiate and monitor tasks. Rosenthal and colleagues (2013) completed a study using the BRIEF to examine cross-sectional age effects of EFs of 185 children with ASD from 5-to-18-years old. Overall mean scores from the BRIEF indicated significant EF deficits among all ages in the ASD group when compared to the normative sample. The ability to shift attention was consistently rated as the greatest deficit and all EF impairments were found to increase with age. Age effects revealed the ability to shift and monitor to be the most significantly impaired in the younger groups, whereas initiation, working memory, and organization of materials were rated as the most problematic within the older groups. In a similar study, Blijd-Hoogewys and colleagues (2014) found EF deficits in more than half of their sample of children with ASD, reflected through significantly poorer scores on all subscales with notable impairments in shift, inhibit, initiate, and monitor. Overall, the results of the parent and teacher ratings of EFs coincide with the previous literature in that deficits of EFs are present in individuals with ASD, not only in controlled settings but also in situations of less structured, everyday life demands.

1.2 Bilingualism and Executive Functions: The Bilingual Advantage

EF skills improve, change, and are influenced over time by many individual and environmental factors (Diamond, 2014), one such factor being the language environment in which one is raised (Stocco, Yamasaki, Natalenko, & Prat, 2014). Bilingual individuals appear to demonstrate better cognitive performance, known as a bilingual advantage that may stem from the mental control needed for switching back and forth between languages, selectively attending to the appropriate language, and inhibiting one language in the context of the other (Bialystok, Barac, Blaye, & Poulin-Dubois, 2010; Peal & Lambert, 1962). Bilingual cognitive advantages have been noted across the lifespan, ranging from improved information processing in 6-month-old bilingual infants as measured through visual habituation (Singh et al., 2015), to the delayed onset of dementia and Alzheimer disease and better coping strategies in bilingual elderly participants (Woumans et al., 2015). Furthermore, typically-developing bilingual children have been shown to perform better than monolingual children on laboratory-based EF tasks (e.g., Bialystok et al., 2010; Morales, Calvo, & Bialystok, 2013). In addition to the performance differences noted in the laboratory between monolingual and bilingual individuals, research has also focused on neuroimaging of the brain to establish which areas are responsible for multiple language use. A recent review by Buckweitz and Prat (2013) discussed the involvement of both lateral prefrontal cortices and the basal ganglia and how these strengthened networks in bilingual individuals have also been known to support EFs and cognition.

The bilingual advantage has been attributed to strengthened brain networks that result from the mental coordination that is required to shift between two languages (Bialystok et al., 2012). This advantage has been observed in typically-developing children of different ages, from different language backgrounds, and on a variety of tasks (Bialystok et al., 2010; Bialystok & Viswanathan, 2009; Morales et al., 2013). Bialystok and colleagues (2010) studied typically-developing monolingual and bilingual children aged 2.5-to-5-years old on EF tasks requiring inhibition, shift, and attention. The bilingual group performed better on the tasks requiring inhibition and shift, but there was no difference was found on the task measuring attention. Inhibition and shift were also found to be improved in a group of 8-year-old bilingual children compared to a monolingual group, while controlling for cultural differences (Bialystok & Viswanathan, 2009). Beyond investigating single components of EFs, studies have used tasks that require coordination of more than one EF, such as spatial perspective taking, requiring both inhibition and attention (Greenberg, Bellana, & Bialystok, 2013); or a dual modality classification task requiring coordination of working memory, inhibition, and shift (Bialystok, 2011). Results of both of these studies of 8-year-old bilingual and monolingual children revealed a bilingual advantage in terms of task completion efficiency and overall accuracy. Similar advantages with regard to time-sensitive shifting, inhibitory control, and resistance to distraction were noted in older bilingual individuals attending college (Pelham & Abrams, 2014; Prior & MacWhinney, 2010), supporting the notion that the bilingual advantage is present in individuals across the lifespan.

As previously mentioned, EFs and individual performance tends to be influenced by external factors, including the tasks used to measure EFs. Two studies by Morales et al. (2013) revealed that the bilingual advantage may be greater when the task increases in difficulty. The first study of 56 monolingual and bilingual 5-year-old children resulted in both groups performing equally with regard to accuracy but not response time, on a task requiring shifting when EF demands were low. The bilingual group responded faster in both the simple and difficult trials and also showed an advantage in accuracy for the difficult trials. The second study compared measures of visuospatial working memory in the same bilingual group from the first study to a new sample of 69 7-year-old monolingual and bilingual children. Results indicated equal performance between the 5-year-old bilingual group and the 7-year-old monolingual group in the simple conditions, while the older bilingual group achieved higher scores than the age-matched monolingual group on the difficult condition. Given these results altogether, it appears that a bilingual advantage is most commonly present in the EF domains of inhibition and shifting among all age groups.

Although the cognitive advantage in bilingual individuals has been established by Bialystok and her colleagues, replicating the results has proven to be somewhat difficult. For example, Morton and Harper (2007) compared monolingual and bilingual children aged 6-to-

7-years old, controlling for ethnicity and SES, and their results indicated no difference in inhibitory control across the two groups. In a more recent study, Ladas, Carroll, and Vivas (2015) found no advantage in performance on tasks requiring attention, working memory, or shift in 6-to-12-year-old monolingual and bilingual children. Additionally, Kalia, Wilbourn, and Ghio (2014) compared 105 18-to-20-year-old students who identified as either monolingual, early bilingual (i.e., acquired a second language before age 6), or late bilingual (i.e., acquired a second language after age 6). Measurements of accuracy and inhibition revealed that the late bilingual students performed the poorest, while the early bilingual and monolinguals students performed similarly. Other studies of monolingual and bilingual young adults also found no bilingual advantage on computer-based tasks measuring reaction times to distinguish inhibition, shifting, and monitoring (Paap & Greenberg, 2013), or working memory (Ratiu & Azuma, 2015). One possible explanation for the lack of bilingual advantage in these studies is that the young adults reached the scoring ceiling on all tasks, which would have limited the measurable effects (Bialystok et al., 2012). Further explanations that may inform the results are the type(s) of bilinguals included in the studies, the tasks used to measure EFs, and/or the amount of time and number of trials included (Bialystok et al., 2012; Kalia et al., 2014). Table 1.1 summarizes the studies on EFs and bilingualism that were discussed in this section.

Table 1.1 Summary of research on bilingualism and EF

Author, Year	Participant Age (yr; mo)	N	EF Task(s)	EF Skill(s) Measured	Bilingual Advantage?
Morton & Harper, 2007	6;0 – 7;0	34	Simon	Attention	No
Bialystok & Viswanathan, 2009	8;0	90	Faces	Inhibitory Control Shifting	Yes
Bialystok, Barac, Blaye, & Poulin-Dubois, 2010	2;5 – 5;0	162	Luria's Tapping Opposite Worlds ANT Flanker Reverse Categorization	Inhibitory Control Shifting	Yes
Prior & MacWhinney, 2010	18;0 – 19;5	88	Task Switching Paradigm	Shifting	Yes
Bialystok, 2011	8;0	63	Dual-Modality Classification	Coordinating Working Memory, Inhibition, and Shifting	Yes
Greenberg, Bellana, & Bialystok, 2013	8;0	82	Spatial Perspective Taking	Coordinating Inhibition and Attention	Yes

Table 1.1 Summary of research on bilingualism and EF cont'd

Author, Year	Participant Age (yr; mo)	N	EF Task(s)	EF Skill(s) Measured	Bilingual Advantage?
Morales, Calvo, & Bialystok, 2013	5;0 – 7;0	125	Pictures (Simon-type) Visual Pattern Span	Working Memory Monitor/ Update	Yes
Paap & Greenberg, 2013	3rd and 4th year University students	90	Simon Colour-Shape Flanker Antisaccade	Inhibitory Control Shifting	No
Kalia, Wilbourn, & Ghio, 2014	18;0 – 22;0	105	ACNNT	Working Memory Inhibition Switching	No
Pelham & Abrams, 2014	19;0 – 22;0	90	ANT Flanker	Inhibitory Control	Yes
Ladas, Carroll, & Vivas, 2015	6;0 – 12;0	110	ANT Flanker Scalar Implicature	Attention Working Memory Shifting	No
Ratiu & Azuma, 2015	19;5	105	Span	Working Memory	No

1.3 Bilingualism and ASD

Interestingly, inhibition and shifting are two of the EFs that appear to show the most consistent bilingual advantage and they are also two of the domains that are lacking in individuals with ASD (Buchwietz & Prat, 2013). However, the abilities in EFs of bilingual children with ASD has yet to be investigated. Recent research indicates that there are no significant differences between preschool bilingual and monolingual children with ASD in terms of expressive or receptive language, production and conceptual vocabulary, or the timing of language milestones (Hambly & Fombonne, 2012; Marinova-Todd & Mirenda, in press; Ohashi et al., 2012; Peterson, Marinova-Todd, & Mirenda, 2012). In fact, a recent systematic review of eight studies on children with ASD growing up in bilingual environments concluded that bilingualism does not have any negative impact on language development (Drysdale et al., 2014).

Nonetheless, bilingual parents of children with ASD are often counselled to expose their child to no more than one language (Kay-Raining Bird et al., 2012; Yu, 2013). Kay-Raining Bird et al. (2012) collected survey questionnaires that were completed by 49 parents of monolingual and multilingual children with ASD. Parents' ratings of their children's language abilities suggested that both monolingual and multilingual children, regardless of ASD severity, were similar in terms of language comprehension, production, reading, and writing. However, the researchers also found that advice to limit non-English language use was provided to 63% of the parents of children with ASD from a variety of professionals, including speech-language pathologists (SLPs), psychologists, social workers, and teachers. Another study that investigated multilingualism involved interviews with mothers of at least one child with ASD between the ages of 3 and 8 years (Yu, 2013). Results indicated, although most of the mothers initially believed a bilingual environment was ideal for their children, their beliefs were strongly influenced by the professionals with whom they interacted. The advice they most often received was to begin speaking only English to their children and to discontinue speaking their first language (in all cases, this was a Chinese language). These recommendations may actually have negative effects on an individual's cognition, given the research suggesting that bilingualism might have positive effects on cognitive processes or might naturally protect against cognitive impairments in individuals with ASD (Buckweitz & Prat, 2013). In light of this information, there is a need for more research in the area of bilingualism and ASD, in order to provide professionals with evidence-based information that can inform their recommendations and ensure that children and their families are being provided the best possible guidance (Drysdale et al., 2014).

1.4 Executive Functions and School Achievement

It is crucial to consider how EFs affect an individual's cognitive performance and behaviour in daily life and whether or not there are real, functional outcomes related to stronger or weaker EFs. Strong EF skills appear to be fundamental to successful academic performance (Bialystok et al., 2012; Diamond, 2014) and have been strongly linked to both math and reading achievement in typically-developing monolingual children (e.g. Bull, Espy, & Wiebe, 2008; St. Clair-Thompson & Gathercole, 2006). Bull and colleagues (2008) assessed EF skills in 124 preschool children at age 4.5-years and then measured math and reading outcomes of these children when they entered the third year of primary school at ages 7-to-8-years. They found that math outcomes were most strongly predicted by visual-spatial working memory, but were also correlated with inhibition, shifting, and planning. Reading was significantly correlated with working memory and switching. Similar relationships between EFs and school achievement have also been found in both younger and older age groups (Best, Miller, & Naglieri, 2011; Foy & Mann, 2013; St. Clair-Thompson & Gathercole, 2006). For example, inhibition and shift were found to predict early literacy skills in kindergartners (Foy & Mann, 2013), and working memory and inhibition were found to predict performance in math, English, and science in 11- and 12-year-olds (St. Clair-Thompson & Gathercole, 2006). Developmental correlations were also found across individuals ages 5-to-17-years between EF tasks and school achievement in the areas of math and reading (Best et al., 2011). Because EF skills are closely related to academic performance in typically-developing children, it would be fruitful to examine the relationship between school achievement and EF skills in clinical populations, such as individuals with ASD, who have been found to have EF deficits.

1.5 Current Study

There is currently research comparing EFs in individuals with and without ASD, EFs in bilingual and monolingual individuals, and language skills of bilingual and monolingual children with ASD. However, no research to date has compared the EF skills of bilingual and monolingual children with ASD to determine if bilingualism has the same advantage on EFs in this population as has been found in typically-developing bilingual children. The questions addressed in this study include: (a) Is there a difference in EF skills between monolingual and bilingual children with ASD? (b) Is there a difference in academic achievement between monolingual and bilingual children with ASD? and (c) Is there an association between EFs and academic achievement in either monolingual or bilingual children with ASD?

Chapter 2: Method

2.1 Participants

The data for the current study were retrieved from a database of participants involved in a Canada-wide, longitudinal research project following children with ASD and their families: “ASD: Pathways to Better Outcomes” (Szatmari et al., 2004). The Pathways research teams are located across five Canadian universities: University of British Columbia (Vancouver, British Columbia), University of Alberta (Edmonton, Alberta), McMaster University (Hamilton, Ontario), McGill University (Montreal, Quebec), and Dalhousie University (Halifax, Nova Scotia). The children, their families, and their teachers participate in a variety of measures assessing social competence, communication, mental health and well-being, ASD behaviours, and school achievement and adaptation every year during a three month period. Results from all participants across sites are compiled into one single database, which was accessed for this study.

Participants were included in the Pathways study if they met the following inclusion criteria: (i) a diagnosis of ASD based on scores from the Autism Diagnostic Interview-Revised (ADI-R; Lord et al., 1994), Autism Diagnostic Observation Schedule (ADOS; Lord et al., 2003), and clinical diagnosis from primary physician; (ii) chronological age between 2-to-4-years-11-months at time of entering the study; and (iii) the ability of at least one parent to read and understand the consent form in either English or French. Participants were excluded if they had any of the following: (i) cerebral palsy or other neuromotor disorder interfering with study assessments; (ii) any known genetic disorder or chromosomal abnormality; or (iii) a visual or hearing impairment more severe than “mild”. One child per family was recruited to be included in the Pathways study.

2.1.1 Procedure for Selecting and Matching Participants

The Pathways database included a total of 421 participants at the time of retrieval. To select the participants suitable for the present study, several steps were completed. First, only the participants between ages 8.5-9.0 years who had completed all of the measures required for this study were selected (n = 88). The bilingual group was selected out of these participants based on parent reports that (a) at least 20% of their language input at home from birth through to age 8.5-9.0 was in a second language (L2) and (b) they were able to understand the L2 but not necessarily speak it. The minimum cut-off of 20% exposure to at least two languages was chosen for this study as it has been observed that typically-developing children who are exposed to an L2 at least 20% of the time can still acquire vocabulary in that language (Pearson, Fernandez, Lewedeg, & Oller, 1997). In addition, previous research with young children with ASD has shown no differences in early language development between monolingual and bilingual toddlers when a 20% language exposure criterion was used (Ohashi et al, 2012). Participants were required to understand the L2 but not necessarily speak it because exposure and understanding appears to be sufficient to affect cognition, at least in young children (Kovacs & Mehler, 2009; Singh et al., 2015).

Twenty participants with ASD met both of the bilingual criteria. One additional participant had a reported language exposure of only 15% at age 8.5-9.0, which was slightly below the minimum; however, parent reports that were completed at younger ages confirmed that this participant had at least 30% L2 exposure since birth and understood the L2 at age 8.5-9.0, making him eligible for inclusion. Thus, data from 21 bilingual participants were used in the study. Next, a monolingual group was selected from the pool of 88 participants who completed all the necessary measures. Children were considered to be monolinguals based on the following criteria, by parent report: (a) ability to speak and understand one language only at age 8.5 – 9.0; (b) exposure to one language only at age 8.5 – 9.0; (c) no reports of exposure to an additional language from birth to 8.5 – 9.0. Each bilingual participant was matched to one monolingual participant based on the following variables from the Pathways database: (a) a non-verbal intelligence quotient (NVIQ), as represented by the Perceptual Reasoning Index (PRI) score of the Wechsler Intelligence Scale for Children (WISC IV; Wechsler, 2003) at the age of 8.5-9.0; and (b) language ability, based on the Core Language score of the Clinical Evaluation of Language Fundamentals (CELF-4; Semel, Wiig, & Secord, 2003) at the age of 8.5-9.0. Both tests were administered in English to the bilingual participants, as this was their dominant language.

2.1.2 Monolingual Group

The monolingual group (n = 21) consisted of 17 males and 4 females between 102 and 108-months-old (8.5-9.0-years) at the time of data collection (M = 103.95 mo, SD = 1.91). All participants understood and spoke English.

2.1.3 Bilingual Group

The bilingual participants (n = 21; 18 males and 3 females) were all between 102 and 108 months of age (8.5-9.0 years) at the time of assessment (M = 105.10 mo, SD = 2.78). All bilingual participants had English reported as their first language (L1). There was no restriction on the L2s and L3s that were included. Table 2.1 provides a summary of the L2s and L3s the children understood, according to parent report. L2 exposure ranged from 20 (with the one exception noted above) to 50 percent among bilingual participants. L3 exposure ranged from 5 to 30 percent.

Table 2.1 Languages understood by participants, by parent report on the FBIQ

Languages Understood at Age 8.5-9.0	n	Percent
English and French	11	52.40
English and one other language (Cantonese, Urdu, Serbian, Chinese, Japanese, Mandarin, Arabic, Polish, Spanish)	8	38.10
English, French, and one other language (Japanese, Croatian)	2	9.50

2.2 Measures

The independent variable in the present study was the participants' ability to understand one or more than one language at age 8.5-9.0, as described in the previous section. The dependent variables were participants' scores on a measure of Executive Functions (EFs), as measured with the Behaviour Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000); and scores on a measure of academic achievement, as measured by the Wechsler Individual Achievement Test- II Abbreviated (WIAT-II-A; Wechsler, 2001).

2.2.1 Behavior Rating Inventory of Executive Function

The Behaviour Rating Inventory of Executive Functions (BRIEF; Gioia et al., 2000) is an assessment of EFs as reported by parents or teachers through a questionnaire, targeting behaviours of children aged 5-to-18-years in home and school environments. The questionnaire is made of 86 items that are rated by the parent or teacher as "N" (never a problem), "S" (sometimes a problem), or "O" (often a problem). The clinical scales were developed to measure inhibition (e.g., "blurts things out"), shift (e.g., "acts upset by a change in plans"), emotional control (e.g., "mood changes frequently"), initiation (e.g., "is not a selfstarter"), working memory (e.g., "forgets what he/she was doing"), planning (e.g., "underestimates time needed to finish tasks"), organization of materials (e.g., "leaves a trail of belongings wherever he/she goes"), and monitoring (e.g., "does not check work for mistakes"). These subscales are grouped together to make two broader scales, the Behavior Regulation Index (BRI), which includes inhibit, shift, and emotional control; and the Metacognition Index (MI), which includes initiate, working memory, plan/organize, organization of materials, and monitor. Both scales together provide a Global Executive Composite (GEC) score. Two additional scales are also included in the BRIEF to measure inconsistent scoring (inconsistency scale) and unusually negative responses (negativity scale). In the current study, the GEC scores, both BRI and MI scales, and all of the individual clinical scales were compared, given the variability of which EFs may be affected. In this study, both parent- and teacher-completed BRIEF reports were included for all participants.

The BRIEF has high internal consistency for both parent and teacher forms with mean correlations ranging from .80-.98 (Gioia et al., 2000). Test-retest reliability was measured for the parent normative and clinical subsamples, as well as the teacher normative subsample. The mean test-retest correlation for the parent normative sample clinical scales was .81 (range = .76-.85); .79 (range = .72-.84) for the parent clinical sample; and .87 (range = .83-.92) for the teacher normative sample.

The BRIEF has strong content validity, as most of the items in the scales had high inter-rater agreement among 12 expert pediatric neuropsychologists and the authors. A multitrait-multimethod matrix was used to measure construct validity. Correlations between the BRIEF and the following measures of general behavioural functioning in children were examined: ADHD-Rating Scale-IV (ADHD-IV; DuPaul, Power, Anastopoulos, & Reid, 1998), Child Behaviour Checklist (CBCL; Achenbach, 1991a), Teacher's Report Form (TRF; Achenback, 1991b), Behavior Assessment System for Children (BASC; Reynolds & Kamphaus, 1992), and Connors' Rating Scale (CRS; Conners, 1989). Strong correlations between most of the BRIEF clinical scales and comparative measures were found, with only the CRS demonstrating moderate relationships.

2.2.2 Wechsler Individual Achievement Test- II Abbreviated

The Wechsler Individual Achievement Test- II Abbreviated (WIAT-II-A; Wechsler, 2001) is an abbreviated assessment of academic achievement that is comprised of three subtests, administered to individuals aged 6-to-85-years. The three subtests are: Word Reading, Numerical Operations, and Spelling. Word Reading targets areas of letter identification, phonological awareness, letter-sound correspondences, accuracy and automaticity of word recognition. Numerical Operations assesses the participant's counting, numeral identification and writing, calculations (add, subtract, multiply, divide), fractions, decimals, and algebra. Spelling involves sound-letter correspondence, written spelling of regular and irregular words, and written spelling of homonyms. The sum of these scores determines a composite score (M = 100, SD = 15). All of the subtests as well as the composite score were compared in this study.

The WIAT-II has strong inter-item reliability within subtests with mean average reliability coefficients ranging from .80-.98 and an overall total composite reliability of .98 (Wechsler, 2001). Test-retest reliability for the WAIT-II was adequate across time, ages, and grades (*r*s ranging from .85- .98).

Content validity for the WIAT-II was ensured through several steps, including item comparison with school curriculums, materials, and other achievement tests, and subtest reviews by experts in a variety of subjects. Construct validity was confirmed through intercorrelations of the WIAT-II subtest scores, as well as moderately high-to-high correlations between the WIAT-II subtest scores and the Wecshler IQ scales (WPSSI-R, WISC-III, WAIS-III). Moderate-to-high correlations between the WIAT-II and the following individual achievement assessments confirmed criterion-related validity of the WIAT-II: WIAT, the Process Assessment of the Learner- Test Battery for Reading and Writing (PAL-RW; Berninger, 2001), Wide Range Achievement Test- 3rd Edition (WART3; Wilkinson, 1993), Differential Ability Scales (DAS; Elliot, 1990), and the Peabody Picture Vocabulary Test- 3rd Edition (PPVT-III; Dunn & Dunn, 1997).

2.3 Procedure

Research staff involved in the Pathways study (i.e., psychometrists, speech-language pathologists, psychologists, and/or doctoral-level research assistants) began conducting assessments with all participants within 4 months of diagnosis, and continued collecting data from the participants approximately every 6 – 12 months thereafter. Participant data that matched the criteria for this study at Time 6 (i.e. age 8.5 – 9.0) were used. Scores from the BRIEF and the WIAT-II-A were available for all 42 participants in the present study.

2.3.1 Data Analysis

Normality was tested with the Kolmogorov-Smirnov test and variance was tested with Levene's test (Levene, 1960). Based on the results of these tests, a multivariate analysis of variance (MANOVA) was then used to compare the means between the two groups on the relevant variables.

Chapter 3: Results

The purpose of this study was to investigate group differences in and correlations between EF skills and academic achievement with matched samples of 8.5-to-9.0-year-old monolingual and bilingual children with ASD. Based on the published literature on EFs in bilingual, typically-developing children, I expected to find that the bilingual group would have less difficulty with inhibition and shifting.

3.1 Matching

Independent sample t-tests were used to confirm whether the two groups were well matched. CELF-4 scores were missing for two bilingual participants and therefore they were matched on NVIQ scores alone. The means and standard deviations for the two matching variables are presented in Table 3.1.

Table 3.1 Means and standard deviations of monolingual and bilingual participants' matching variables

	Monolingual Group (n = 21)		Bilingual Group (n = 21)		
Variable	***M***	***SD***	***M***	***SD***	***p***
WISC-IV	95.14	18.82	96.14	17.53	0.86
CELF-4	77.67	25.47	77.68	24.13	0.99

Results revealed no significant differences for either measure, indicating that the monolingual and bilingual groups were matched appropriately. There were also no significant differences between groups in terms of mean age (p = .11) or autism severity score on the ADOS (p = .93), although these variables were not used for matching purposes.

3.2 Executive Function Scores

The primary goal of this study was to examine how bilingualism affects EFs in children with ASD. When the BRIEF is scored, *T* scores are calculated (M = 50, SD = 10), with the higher number representing greater deficits in EFs. A MANOVA was used to compare the mean scores from the BRIEF parent and teacher reports of the monolingual and bilingual groups. Two bilingual participants were missing all BRIEF data for the teacher report, and one monolingual participant was missing data from the teacher GEC, MI, and plan/organize scale. Table 3.2 summarizes the results.

Table 3.2 Results of monolingual and bilingual comparison scores on the BRIEF
Boldface means represent better performance scores for the bilingual group.

	Monolingual				Bilingual			
BRIEF subscale/ composite	**Min.**	**Max.**	***M***	***SD***	**Min.**	**Max.**	***M***	***SD***
BRIEF Parent Report								
GEC	43	87	61.43	11.21	35	77	**58.38**	12.70
MI	33	78	61.05	12.10	35	79	**57.38**	13.73
BRI	43	81	60.24	9.91	37	78	**58.52**	10.39
Inhibit	40	84	62.24	10.98	42	80	**58.48**	12.26
Shift	4	81	59.48	11.10	40	84	60.19	10.82
Emotional Control	40	80	55.19	9.34	36	78	**54.43**	10.39
Initiate	38	84	57.81	10.82	38	81	**55.29**	11.98
Working Memory	36	81	61.76	10.75	38	83	**59.19**	12.06
Plan/Organize	33	77	60.29	12.56	33	82	**57.24**	14.43
Organization of Materials	39	71	58.71	10.67	33	71	**52.10**	12.34
Monitor	34	75	56.62	12.35	31	75	**54.90**	14.24

Table 3.2 Results of monolingual and bilingual comparison scores on the BRIEF cont'd
Boldface means represent better performance scores for the bilingual group.

	Monolingual				Bilingual			
BRIEF subscale/ composite	**Min.**	**Max.**	***M***	***SD***	**Min.**	**Max.**	***M***	***SD***
				BRIEF Teacher Report				
GEC	43	87	60.80	11.25	40	74	**58.84**	9.38
MI	42	84	59.55	11.48	40	78	59.68	10.40
BRI	43	85	61.38	10.67	42	70	**57.53**	7.82
Inhibit	42	67	56.71	8.24	42	69	**54.42**	7.73
Shift	44	92	64.76	12.97	44	82	**60.89**	10.34
Emotional Control	43	87	61.76	11.27	43	78	**56.53**	9.20
Initiate	41	85	62.43	10.53	43	75	63.21	11.31
Working Memory	38	79	58.19	10.79	40	81	58.95	10.07
Plan/Organize	40	87	59.85	13.97	40	70	**54.53**	9.47
Organization of Materials	42	76	53.48	11.76	42	77	**52.53**	9.58
Monitor	42	88	60.76	11.08	40	81	**58.89**	12.24

Results of the MANOVA indicated no significant differences between the monolingual and bilingual group on any of the BRIEF subscales or composites at the $p<.05$ level. Because of the small sample size, non-parametric Mann Whitney tests were also conducted with these data; again, no significant differences were evident for any of the subscales or composites. However, a review of the means revealed that the bilingual group had a tendency to perform better (i.e., they scored lower) on almost every EF scale, compared to the monolingual group (see means in boldface type in Table 3.2).

3.3 Academic Achievement

A secondary goal of this study was to examine the effects of bilingualism on academic achievement in children with ASD. A MANOVA was used to compare the monolingual and bilingual groups' mean standard scores from the WAIT-II-A. Composite scores were missing for two bilingual participants. Table 3.3 summarizes the results.

Table 3.3 Results of monolingual and bilingual comparison scores on the WIAT-II-A

	Monolingual				Bilingual			
Subtest/ composite	**Min.**	**Max.**	***M***	***SD***	**Min.**	**Max.**	***M***	***SD***
Composite Score	70	133	91.05	19.04	74	151	101.21	21.79
Word Reading	66	128	97.86	19.05	40	132	102.52	20.80
Numerical Operations	58	116	81.05	17.23	60	147	91.76	21.06
Spelling	66	142	97.43	20.87	40	144	102.00	24.62

The bilingual group achieved higher scores on the composite score and all three subtests; however, none of the differences were significant. The monolingual group's mean score for the numerical operations subtest was more than 1 standard deviation below the mean of the WIAT-II-A (M = 100, SD = 15), whereas the bilingual group mean was within the 1 standard deviation cut-off.

3.4 Relationships between EF and Academic Achievement

The third purpose of this study was to examine the relationship between EF and academic achievement in both bilingual and monolingual participants. Pearson correlations were conducted for all subtests of the BRIEF and the WIAT-II-A for both groups. Table 3.4 summarizes the results for the bilingual group.

Table 3.4 Pearson Correlations for BRIEF and WIAT-II-A scores for the bilingual group

WIAT-II-A	Composite Score	Word Reading	Numerical Operations	Spelling
BRIEF Parent Report				
GEC	.124	-.045	.029	-.077
MI	.130	-.065	.070	-.107
BRI	.081	-.009	-.065	-.031
Inhibit	.184	.044	.072	.060
Shift	-.151	-.171	-.227	-.221
Emotional Control	.067	.034	-.101	.011
Initiate	-.078	-.170	-.100	-.214
Working Memory	-.056	-.198	.002	-.271
Plan/Organize	.132	-.028	.048	.071
Organization of Materials	.494*	.171	.325	.182
Monitor	.072	-.019	.013	-.049
BRIEF Teacher Report				
GEC	.157	.278	.092	.103
MI	-.002	.048	.013	.187
BRI	.159	.291	.019	-.075
Inhibit	.362	.435*	.223	.331
Shift	-.001	.015	-.063	.076
Emotional Control	.020	.202	-.089	.024
Initiate	.031	.210	-.085	.050
Working Memory	-.090	-.046	-.005	-.169
Plan/Organize	.095	.257	.010	.054
Organization of Materials	.137	.130	.198	.025
Monitor	.076	.184	.055	.040

*p<.05

Results for the bilingual group revealed that there were only two significant relationships between EF scores and academic achievement. The BRIEF parent organization of materials score was significantly correlated with the WIAT-II-A composite score, $r = .494$, $p = .016$, and the BRIEF teacher inhibit score was significantly correlated with the WIAT-II-A reading score, $r = .435$, $p = .031$.

Results for the monolingual group are summarized in Table 3.5.

Table 3.5 Pearson Correlations for BRIEF and WIAT-II-A scores for the monolingual group

WIAT-II-A	Composite Score	Word Reading	Numerical Operations	Spelling
BRIEF Parent Report				
GEC	-.451*	-.256	-.517**	-.366
MI	-.526**	-.318	-.562**	-.439*
BRI	-.268	-.132	-.363	-.207
Inhibit	-.221	-.144	-.315	-.123
Shift	-.181	-.107	-.409*	.055
Emotional Control	-.250	-.192	-.190	-.277
Initiate	-.446*	-.291	-.444*	-.356
Working Memory	-.525**	-.336	-.528**	-.449*
Plan/Organize	-.498*	-.330	-.534**	-.386*
Organization of Materials	-.290	-.086	-.390*	-.259
Monitor	-.552**	-.347	-.549**	-.497*
BRIEF Teacher Report				
GEC	-.503*	-.453*	-.338	-.526**
MI	-.540**	-.444*	-.408*	-.542**
BRI	-.363	-.377*	-.197	-.398*
Inhibit	-.311	-.283	-.218	-.354
Shift	-.315	-.353	-.147	-.344
Emotional Control	-.413*	-.426*	-.217	-.442*
Initiate	-.557**	-.514**	-.354	-.556**
Working Memory	-.493*	-.468*	-.576**	-.603**
Plan/Organize	-.406*	-.426*	-.224	-.435*
Organization of Materials	-.277	-.107	-.371*	-.246
Monitor	-.465*	-.419*	-.321	-.491*

**p<.01 *p<.05

Many statistically significant medium strength correlations were found between the WIAT-II-A and BRIEF subscales in the monolingual group. The strongest correlation was between the WIAT-II-A spelling subtest and the BRIEF teacher working memory scale, $r = -.603$, $p = .003$.

3.5 Summary

In summary, no significant differences were found between the monolingual and bilingual groups in terms of either EF deficits or academic achievement. However, the bilingual group consistently scored lower on measures of EF deficits and higher on measures of academic achievement. In terms of relationships between EFs and academic achievement, medium strength correlations were found on almost all variables for the monolingual group, but only on two for the bilingual group.

Chapter 4: Discussion

The main goals of this study were to investigate the possible influences of growing up in a bilingual environment on the EF skills, academic achievement, and the relationships between them, in children with ASD. Scores of teacher and parent reports and student academic assessments were expected to reflect the research on typically-developing bilingual children and show an advantage in EFs, specifically shift and inhibit, when compared to the monolingual group.

4.1 Executive Functions

The first goal of this study was to examine what effects, if any, bilingualism has on EFs in children with ASD. Counter to what was expected, and what has been previously observed with typically-developing children, no significant differences between the monolingual and bilingual group on any of the BRIEF subscales or composites were found. The results of the current study are in line with the research that has found no differences on laboratory-based tasks requiring inhibitory control (Morton & Harper, 2007), attention, working memory, or shifting (Ladas et al., 2015) in typically-developing, bilingual children of a similar age. Interestingly, although not statistically significant, the bilingual group had a tendency to score lower (i.e. perform better) on almost every EF scale, compared to the monolingual group. The only scores that did not follow this pattern were the parent rated shift scale, and the teacher rated MI, initiate, and working memory scales. These findings contradict the results of previous studies that have demonstrated a bilingual advantage in typically-developing children on lab tasks that require shifting (Bialystok et al., 2010; Bialystok & Viswanathan, 2009). This difference may be a result of the different populations being studied, as shifting has been found to be the most significantly impaired in monolingual children with ASD (Blijd-Hoogewys et al., 2014; Granader et al., 2014; Rosenthal et al., 2013). Initiating and working memory have also been notably more impaired in the ASD population in the past (Blijd-Hoogewys et al., 2014; Rosenthal et al., 2013). Therefore, as these scales tend to be the most impaired in children with ASD, it is possible that bilingualism alone is not sufficient to impact the underlying EF domains that have previously been found to show an advantage in typically-developing populations.

4.2 Academic Achievement

A secondary goal of this study was to examine the effects of bilingualism on academic achievement, specifically math and reading, in children with ASD. Similar to the EF scores on the BRIEF, the bilingual group achieved higher standard scores on the composite and all three subtests of the WIAT-II-A, yet all of the differences were non-significant. As it has been suggested that academic achievement is closely correlated with EF skills in typically-developing children (e.g., Best et al., 2011), it is not surprising that the WIAT-II-A results mirror the performance scores of the BRIEF. However, as these differences were not statistically significant, an alternate explanation may be that because individuals with ASD tend to learn differently than typically-developing children (Hughes, 2001), they rely less on EF skills for academic abilities than other individuals typically would and therefore no advantages were observed. A study by Estes, Rivera, Bryan, Cali, and Dawson (2011) found that academic achievement (i.e. spelling, word reading, and basic number skills) of 9-year-old children with ASD was not able to be consistently predicted based on overall IQ scores or problem behaviours, as has been found for typically-developing children; rather, there was a relationship between academic achievement and social functioning. As the current study did not investigate social functioning as a variable, it cannot be determined what influence it may have had on these results. Nevertheless, these results reinforce that bilingualism does not have a negative impact on individuals with ASD in terms of academic abilities, when compared to their monolingual peers.

4.3 Relationships between Executive Functions and Academic Achievement

The third purpose of study was to examine potential relationships between EF scores and academic achievement scores. Results for the bilingual group revealed that there were only two significant relationships between EF scores and academic achievement: the BRIEF parent organization of materials score with the WIAT-II-A composite score, and the BRIEF teacher inhibit score with the WIAT-II-A reading score. In contrast, many correlations were found between the WIAT-II-A and BRIEF subscales in the monolingual group. The relationships revealed for the monolingual group are consistent with what previous research has found in terms of EFs and academic achievement. For example, both math and reading outcomes have previously been found to be correlated with working memory, inhibition, shifting, and planning in typically-developing, monolingual children (e.g., Bull et al, 2008; Bull & Lee, 2014; St. Clair-Thompson & Gathercole, 2006). The strongest correlations noted for the monolingual group in the current study were the BRIEF parent MI, working memory, and monitor scales with the WIAT-II-A composite score, numerical operations, and spelling. Interestingly, the parent reported scores did not significantly correlate with the word reading subscale. In addition, the BRIEF teacher-rated shift and inhibit scales did not have a significant relationship with any of the academic achievement outcomes for the monolingual group, which is not in line with the findings of studies looking at typically-developing children. These interesting relationships between EF skills and academic achievement are difficult to explain using results from previous research as this is the first study to compare the relationship between EFs and academic achievement in monolingual and bilingual individuals, as well as in individuals who are both bilingual and have ASD. As it is unclear why these differences in EFs and academic achievement correlations between the monolingual and bilingual groups are present, it is something that needs to be addressed in future research.

4.4 Limitations and Future Directions

The current study is not without its limitations. First of all, it is the first study of its kind to evaluate EF skills in bilingual children with ASD. It is important for future research to replicate the current findings to strengthen their validity. In addition, the current research could be expanded by comparing the same population on lab-based EF tasks to compliment the findings based on parent and teacher reports. Third, the current study did not control for certain confounding variables, such as SES, social functioning, or extent of therapy received by participants. Each of these could be investigated further to explore their potential relationships or effects on EF skills or academic measures. The results of the current study are unable to be generalized to the entire ASD population as only high functioning individuals were included. The participants of the current study were all capable of completing the IQ, language, and academic assessments. Therefore, including a greater range of severities of ASD in future studies may result in more generalizable outcomes. Similarly, participants were selected based on a minimum requirement of language exposure to be considered bilingual for the current study. As the degree of bilingualism or proficiency was not assessed, and thus may have varied in the present study, research including more balanced bilinguals with strong language proficiency skills in both languages, could have different results as well. For example, it is possible that children with ASD need more exposure to the second language than typically-developing children to see a measurable impact on EF performance, especially in the high demands of everyday life. Lastly, the sample size of the present study was relatively small. Perhaps the patterns that were revealed in the current EF data would be greater if there were more participants included in each group.

4.5 Clinical Implications

The clinical implications of the current findings stress the importance of providing families of children with ASD with the most current and up-to-date evidence-based advice with regard to what language environment to raise their children in. The results of this study add to the research that suggests a bilingual language environment is not detrimental to children's EF behaviours or school success, even when the child also has a diagnosis of ASD. It is crucial that professionals work with families and consider their preferences and values in terms of language use. Families should be encouraged to continue to speak their home language to their child with ASD, if that is best for their situation, to ensure optimal language input to support development.

4.6 Conclusion

The primary purposes of this exploratory study were to examine (a) EF skills in monolingual and bilingual children with ASD, (b) academic achievement in monolingual and bilingual children with ASD, and (c) associations between EFs and academic achievement in both monolingual or bilingual children with ASD. In summary, no significant differences were found between the monolingual and bilingual groups in terms of either measure of EF deficits or academic achievement. The results also expand on previous research in terms of investigating academic achievement of monolingual and bilingual children with ASD.

Furthermore, the relationships between academic achievement and EF skills varied among the two groups in the current study. This difference in relationships between the groups may be attributed to the heterogeneity of individuals with ASD and the underlying processes that are required for learning. Finally, it is important to note that, as is the case for language ability (e.g. Drysdale et al., 2015), although there was no bilingual advantage present in this study, there was no disadvantage to EF skills in the home or school environments, or to academic achievement scores, for children with ASD being raised in a bilingual environment.

Bibliography

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders, 5th Edition* (DSM-5). Washington, DC: American Psychiatric Association.

Best, J. R., Miller, P. H., & Naglieri, J. A. (2011). Relations between executive function and academic achievement from ages 5 to 17 in a large, representative national sample. *Learning and Individual Differences, 21*(4), 327-336.

Bialystok, E. (2011). Coordination of executive functions in monolingual and bilingual children. *Journal of Experimental Child Psychology 110*, 461-468..

Bialystok, E., Barac, R., Blaye, A., & Poulin-Dubois, D. (2010). Word mapping and executive functioning in young monolingual and bilingual children. *Journal of Cognition and Development*, *11*(4), 485-508.

Bialystok, E., Craik, F. I., & Luk, G. (2012). Bilingualism: consequences for mind and brain. *Trends in Cognitive Sciences*, *16*(4), 240-250.

Bialystok, E., & Viswanathan, M. (2009). Components of executive control with advantages for bilingual children in two cultures. *Cognition, 112*(3), 494-500.

Blijd-Hoogewys, E.M.A., Bezemer, M.L., & van Geert, P.L.C. (2014) Executive functioning in children with ASD: An analysis of the BRIEF. *Journal of Autism and Developmental Disorder, 44*(12), 3089-3100.

Buchweitz, A., & Prat, C. (2013). The bilingual brain: Flexibility and control in the human cortex. *Physics of Life Reviews, 10(*4), 428-443.

Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 years. *Developmental Neuropsychology, 33*(3), 205-228.

Bull, R., & Lee, K. (2014). Executive functioning and mathematics achievement. *Child Development Perspectives, 8*(1), 36-41.

Corbett, B. A., Constantine, L. J., Hendren, R., Rocke, D., & Ozonoff, S. (2009). Examining executive functioning in children with autism spectrum disorder, attention deficit hyperactivity disorder and typical development. *Psychiatry Research, 166*(2), 210-222.

Diamond, A. (2014) Want to optimize executive functions and academic outcomes? Simple, just nourish the human spirit. *Minnesota Symposia on Child Psychology, 37,* 203-230.

Dollaghan, C. A. (2012). *The Handbook for Evidence-Based Practice in Communication Disorders*. Baltimore, Maryland: Paul H. Brookes Publishing Co., Inc.

Drysdale, H., van der Meer, L., & Kagohara, D. (2014). Children with autism spectrum disorder from bilingual families: A systematic review. *Review Journal of Autism and Developmental Disorders, 2*(1), 26-38.

Estes, A., Rivera, V., Bryan, M., Cali, P., & Dawson, G. (2011). Discrepancies between academic achievement and intellectual ability in higher-functioning school-aged children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41,* 1044-1052.

Foy, J. G., & Mann, V. A. (2013). Executive function and early reading skills. *Reading and Writing, 26*(3), 453-472.

Geurts, H. M., Verte, S., Oosterlaan, J., Roeyers, H., & Sergeant, J. A. (2004). How specific are executive functioning deficits in attention deficit hyperactivity disorder and autism? *Journal of Child Psychology and Psychiatry, 45*(4), 836-854.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Behavior Rating Inventory of Executive Function: BRIEF. Odessa, FL: Psychological Assessment Resources.

Granader, Y., et al. (2014). Characterizing the factor structure of parent reported executive function in autism spectrum disorders:.The impact of cognitive inflexibility. *Journal of Autism and Developmental Disorders, 44,* 3056-3062.

Greenberg A., Bellana, B., & Bialystok, E. (2013). Perspective-taking ability in bilngual children: Extending advantages in executive control to spatial reasoning. *Cognitive Development 28*, 41-50.

Grosjean, F. & Li, P. (2013). *The Psycholinguistics of Bilingualism*. West Sussex, UK: Wiley-Blackwell.

Hambly, C., & Fombonne, E. (2012). The impact of bilingual environments on language development in children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 42*(7), 1342-1352.

Hill, E. L. (2004). Executive dysfunction in autism. *Trends in Cognitive Sciences, 8*(1), 26-32.

Hughes, C. (2001). Executive dysfunction in autism: Its nature and implications for the everyday problems experiences by individuals with autism i*n* Burack, J.A., Charman, T., Yirmiya, N., & Zelazo, P. R. (2001). *The Development of Autism: Perspectives from Theory and Research*. Mahwah, New Jersey: Lawrence Erlbaum Associates.

Kalia, V., Wilbourn, M. P., & Ghio, K. (2014). Better early or late? Examining the influence of age of exposure and language proficiency on executive function in early and late bilinguals. *Journal of Cognitive Psychology, 26*(7), 699-713.

Kay-Raining Bird, E., Lamond, E., & Holden, J. (2012). Survey of bilingualism in autism spectrum disorders. *International Journal of Language & Communication Disorders, 47*(1), 52-64.

Kovacs, A. M., & Mehler, J. (2009). Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Sciences, 106*(16), 6556-6560.

Kremer-Sadlik, T. (2005). To be or not to be bilingual: Autistic children from multilingual families. In Proceedings of the 4th International Symposium on Bilingualism. MA: Cascadilla Press Somerville.

Ladas, A. I., Carroll, D. J., & Vivas, A.B. (2015). Attentional processes in low-socioeconomic status bilingual children: Are they modulated by the amount of bilingual experience? *Child Development 00*(0), 1-22.

Levene, H. (1960). Robust tests for equality of variances. *Contributions to Probability and Statistics: Essays in Honor of Harold Hotelling*, *2*, 278-292.

Liss, M., Fein, D., Allen, D., Dunn, M., Feinstein, C., Morris, R., ... & Rapin, I. (2001). Executive functioning in high-functioning children with autism. *Journal of Child Psychology and Psychiatry 42*(02), 261-270.

Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (2003). ADOS. Autism diagnostic observation schedule. Los Angeles, CA: Western Psychological Services.

Lord, C., Rutter, M., & Le Couteur, A. (1994). Autism Diagnostic Interview-Revised (ADI-R): A revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *Journal of autism and developmental disorders*, *24*(5), 659-685.

Marinova-Todd, S. H., & Mirenda, P. (in press). Language and communication abilities of bilingual children with ASD. *To appear in* J. Patterson & B. L. Rodriguez (Eds.), *Multilingual Perspectives on Child Language Disorders.* Bristol, UK: Multilingual Matters.

Morales, J., Calvo, A., & Bialystok, E. (2013). Working memory development in monolingual and bilingual children. *Journal of Experimental Child Psychology, 114*(2), 187-202.

Morton, J. B., & Harper, S. N. (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10*(6), 719-726.

Ohashi, J. K., et al. (2012). Comparing early language development in monolingual-and bilingual-exposed young children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 6*(2), 890-897.

Ozonoff, S., Pennington, B.F., & Rogers, S. (1991). Executive function deficits in high-functioning autistic individuals: Relationship to theory of mind. *Journal of Child Psychology and Psychiatry 32*(7), 1081–1105.

Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology, 66*(2), 232-258.

Peal, E., & Lambert, W. E. (1962). The relation of bilingualism to intelligence. *Psychological Monographs: General and Applied, 76*(27), 1-23.

Pearson, B. Z., Fernandez, S. C., Lewedeg, V., & Oller, D. K. (1997). The relation of input factors to lexical learning by bilingual infants. *Applied Psycholinguistics*, *18*(01), 41-58.

Pelham, S. D., & Abrams, L. (2014). Cognitive advantages and disadvantages in early and late bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition 40*(2), 313-325.

Petersen, J. M., Marinova-Todd, S. H., & Mirenda, P. (2012). Brief report: An exploratory study of lexical skills in bilingual children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 42*(7), 1499-1503.

Prior, A., & MacWhinney, B. (2010). A bilingual advantage in task switching. *Bilingualism: Language and Cognition, 13*(02), 253-262.

Ratiu, I., & Azuma, T. (2015). Working memory capacity: Is there a bilingual advantage? *Journal of Cognitive Psychology 27*(1), 1-11.

Robinson, S., Goddard, L., Dritschel, B., Wisley, M., & Howlin, P. (2009). Executive functions in children with autism spectrum disorders. *Brain and Cognition, 71*(3), 362-368.

Rosenthal, M., Wallace, G. L., Lawson, R., Wills, M. C., Dixon, E., Yerys, B. E., & Kenworthy, L. (2013). Impairments in real-world executive function increase from childhood to adolescence in autism spectrum disorders. *Neuropsychology, 27*(1), 13.

Semel, E., Wiig, E. H., & Secord, W. A. (2003). *Clinical evaluation of language fundamentals*, fourth edition (CELF-4). Toronto, Canada: The Psychological Corporation/A Harcourt Assessment Company.

Singh, L., Fu, C.S.L., Rahman, A.A., Hameed, W.B., Sanmugam, S., Agarwal, P., ... & Rifkin-Graboi, A. (2015). Back to basics: A bilingual advantage in infant visual habituation. *Child Development, 86*(1), 294-302.

South, M., Ozonoff, S., & Mcmahon, W. M. (2007). The relationship between executive functioning, central coherence, and repetitive behaviors in the high-functioning autism spectrum. *Autism, 11*(5), 437-451.

St. Clair-Thompson, H. L., & Gathercole, S. E. (2006). Executive functions and achievements in school: Shifting, updating, inhibition, and working memory. *The Quarterly Journal of Experimental Psychology, 59*(4), 745-759.

Stocco, A., Yamasaki, B., Natalenko, R., & Prat, C. S. (2014). Bilingual brain training: A neurobiological framework of how bilingual experience improves executive function. *International Journal of Bilingualism, 18*(1), 67-92.

Szatmari, P., Fombonne, E., Bryson, S., Mirenda, P., Roberts, W., Smith, I., ... & Zwaigenbaum, L. (2004). *Autism Spectrum Disorders: Pathways to Better Outcomes (Phase II).* Ottawa, ON: Canadian Institutes for Health Research.

Verte, S., Geurts, H. M., Roeyers, H., Oosterlaan, J., & Sergeant, J. A. (2006). Executive functioning in children with an autism spectrum disorder: Can we differentiate within the spectrum?. *Journal of Autism and Developmental Disorders, 36*(3), 351-372.

Wechsler, D. (2001). WIAT-II-A: Wechsler Individual Achievement Test- Second Edition-Abbreviated. San Antonio: The Psychological Corporation.

Wechsler, D. (2003). WISC-IV: Wechsler Intelligence Scale for Children-IV. San Antonio: The Psychological Corporation.

Wingate, M., Kirby, R. S., & Pettygrove, S. (2014). CDC: Prevalence of autism spectrum disorder among children aged 8 years- autism and developmental disabilities monitoring network, 11 sites, United States, 2010. *Morbidity and Mortality Weekly Report (Washington, DC: 2002), 63*(2).

Woumans, E., Santens, P., Sieben, A., Versijpt, J., Stevens, M., & Duyck, W. (2015). Bilingualism delays clinical manifestation of Alzheimer's disease. *Bilingualism: Language and Cognition, 18*(03), 568-574.

Yu, B. (2013). Issues in bilingualism and heritage language maintenance: Perspectives of minority-language mothers of children with autism spectrum disorders. *American Journal of Speech-Language Pathology, 22*(1), 10-24.

Appendix A

Note: Only the questions used for the purposes of this study are reported.

Family Background Information Questionnaire (FBIQ)

Instructions: We ask that the following questions be answered by the person most knowledgeable (PMK) about the child. The PMK is the person who knows the child the best. These Statistics Canada Census questions are asked because many psychological journals are now requiring that a description about participants' background is given so that the reader can make links to the populations they study and/or serve. For example, a study that includes only English speaking, African-Canadian children from wealthy homes may not represent the realities of children from other language or cultural groups. In order to see how the findings may relate to other groups of children we need to describe our participants' background which is why we are asking the following questions.

This information will only be used for descriptive purpose. No individual information will be shared. Further, should your personal circumstances place you in a small group in which there are not many people, we will combine your group with another one to ensure your confidentiality.

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1. a) What is the primary language spoken to your child at home? The primary language is the one you use most often when speaking to your child.

English ○	Cree ○	Italian ○	Portuguese ○	Ukrainian ○
French ○	German ○	Korean ○	Punjabi ○	Vietnamese ○
Arabic ○	Greek ○	Persian (Farsi) ○	Spanish ○	Other (please specify) ○
Chinese ○	Hungarian ○	Polish ○	Tagalog (Filipino) ○	

b) Are there any languages spoken regularly in your home other than the primary language you indicated above?

YES___________ NO ___________

If YES, please proceed to the next question. If NO, do not answer any more questions.

2. What language(s) did you family and other caregivers speak yo your child from?

Birth to age 1? PMK:____________ Partner: ___________ Other Caregivers: _________

Age 1 to age 2? PMK:___________ Partner: ___________ Other Caregivers: _________

Age 2 to present? PMK:__________ Partner: ___________ Other Caregivers: _________

3. Please list the language(s) the following people CURRENTLY speak to your child:

Circle “N/A” if not applicable.

		Primary Language	and	Other Language(s)
PMK				
Partner	N/A			
Child's siblings	N/A			
Relatives	N/A			
Educators/Therapists	N/A			
Daycare workers/Nannies	N/A			

4. During a typical week what PERCENT of time does your child hear each language:

Exclude time spent watching TV.

Example: 70% French, 20% English, 10% Greek

	Language	Percentage
Primary Language:		
Other (please specify)		
Other (please specify)		

5. What language(s) does your child currently UNDERSTAND?

Primary Language:

Other Languages:

6. What language(s) does your child currently SPEAK? N/A (not yet speaking)

Primary Language:

Other Languages: