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ORIGINAL PAPER

Second Language Exposure, Functional Communication, and Executive Function in Children With and Without Autism Spectrum Disorder (ASD)

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Abstract Parents and professionals are concerned that second language exposure may delay communication in children with ASD. In this study 174 youth (6–16 years) with and without ASD, exposed to a second language, were compared on executive function (EF) and functional communication (FC) with their peers without exposure. There were no significant differences between groups on age, IQ, and socioeconomic status. Parents reported on language exposure and rated EF and FC skills within everyday social contexts. The findings indicated that second language exposure in children with ASD is not associated with delay in cognitive and functional communication skills rather there was evidence of a reduced clinical impact as indexed by a lower percentage of children whose FC and EF ratings fell within the clinical range.

Keywords Autism spectrum disorder · Second language exposure · Executive function · Functional communication

Multilingual environments are common for many children in Canada and it is estimated that 1 in 5 children speak a foreign language at home (i.e., other than English or French, Statistics Canada 2011). However, when a child has autism spectrum disorder (ASD), multilingual environments pose a dilemma for parents and professionals (Hambly and Fombonne 2012). For many immigrant families, the use of a native language in the home is tied to cultural identity (Jegatheesan 2011) and facilitates communication and connectedness with their child (Y'Garcia et al. 2012; Yu 2013) yet exposure to more than one language may seem counterintuitive due to the marked language and communication deficits in children with ASD (Rogers 2006; Ohashi et al. 2012; Kay-Raining Bird et al. 2012; Yu 2013).

There is emerging evidence that exposure to a second language does not adversely affect certain aspects of language proficiency in preschool children with ASD (Hambly and Fombonne 2012; Ohashi et al. 2012; Petersen et al. 2012). In one study in Western Canada, vocabulary production and comprehension between 14 English-Chinese bilingual and 14 English monolingual children with ASD (mean age 59 months) were investigated (Petersen et al. 2012). The exposure to an additional language in the bilingual group of children with ASD did not disadvantage their English vocabulary production and comprehension performance as compared to their monolingual age matched peers. Bilingual children's vocabulary production and comprehension were also assessed in Mandarin and found to be comparable to their English proficiency. However, the group of bilingual children with ASD had a significantly higher estimated nonverbal IQ than their monolingual peers and demographic factors (e.g., family income) other than their bilingual status may have confounded results (Morton and Harper 2007; Morton and Carlson 2017).

In another study of 75 children with ASD age 36–78 months (mean 46 months) in Eastern Canada, there was no evidence of a disadvantage to exposing children with ASD to two languages (Hambly and Fombonne 2012). The researchers defined two paths to "bilingual" exposure: (1) simultaneous exposure to a second language before

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12 months of age and (2) sequential exposure to a second language after 12 months of age. Parent report measures were administered to assess English as well as second language vocabulary and communication skills. Results showed that regardless of when the child was exposed to a second language (before or after 12 months of age), they showed similar primary language (i.e., the language that the child most often uses and is exposed to) outcomes as their monolingual peers with ASD at approximately 4 years of age. Over half of the second language exposed children spoke words in their second language and a few had achieved phrase speech. However, the authors acknowledged that they had a relatively small sample size and did not assess verbal IQ or other independent measures of language.

In a follow up study the researchers examined whether the amount of parent reported second language spoken directly to the child and the child's primary language skills as indexed by standardized parent report measures would predict parent reported second language expressive vocabulary size (Hambly and Fombonne 2014). They grouped 56 children with ASD according to second language expressive vocabulary counts: 33 children had no second language vocabulary (Non-bilingual) and the remaining were subdivided according to the median second language vocabulary score of 70 words; 11 children had less than 70 words (Low bilingual) and 12 had more than 70 words (High bilingual). Cognitive functioning and autism symptoms were not significantly different across groups. The authors found that higher levels of direct second language exposure accounted for 69%, and primary language skills accounted for an additional 13% of the variance in second language vocabulary counts. The timing of second language exposure (before or after 12 months of age) did not influence primary language outcomes. The authors concluded that the child's primary language functioning, rather than ASD diagnosis, should be the critical factor to consider when deciding on second language learning for a child with ASD. Also, increasing the amount of direct language exposure the child receives may be the key to promoting their second language vocabulary.

The findings of no differences in language have held up with young children (24–60 months) assessed within months of their ASD diagnosis and prior to intensive intervention (Ohashi et al. 2012). In a Canada wide study of 20 bilingual children (mean age 40.87 months) and 40 age and nonverbal IQ matched monolingual peers (mean age 41.0 months), researchers assessed the child's age of first words and phrases, receptive and expressive language scores as indexed by the Preschool Language Scale (4th Edition), and communication scores as indexed by the Vineland Adaptive Behaviour Scales (2nd Edition). No significant differences in outcomes/performance were found between children with ASD who were and those that were not exposed to a second language. In summary, the available studies on second language exposure have focused mainly on language outcome measures such as speech acquisition, conceptual vocabulary, and expressive vocabulary in preschool age children with ASD and found no delays in their language outcomes compared to other children with ASD who were not exposed to a second language.

Although important, speech/language outcomes provide only one indicator within the broader context of communication development. The majority of children with ASD acquire fluent speech (Anderson et al. 2007; Wodka et al. 2013) and at least 30%, of severely language delayed (nonverbal) children achieve phrase speech later in life (Pickett et al. 2009) yet the ability to communicate remains impaired. For example, a subgroup of children with ASD may be verbose (e.g., have sophisticated vocabularies, provide many details on a topic of interest), but not functionally communicative (able to express when they need help or describe what happened at school, Norbury 2014). The functional aspects of communication may be especially relevant to educators and parents whose day-to-day interactions with children are task-oriented. Second language exposure may have a broader impact on communicative development beyond language specific outcomes in children with ASD. For example, when researchers studied non-linguistic communicative attempts such as facial expression, eye contact, gestures, pointing, and pretend play and assessed receptive language skills such as whether the child answered to his or her name, responded to "no", and followed commands with or without gestures, bilingual (English–Spanish) toddlers with ASD were found to more frequently use gestures and vocalizations as compared to their monolingual (English only) peers with ASD matched on developmental level and autism symptoms (Valicenti-McDermott et al. 2013). However, no differences emerged in another study that focused on language indices even when pragmatic language was included (Reetzke et al. 2015). Here, researchers used the Chinese version of the Children's Communication Checklist–2 to assess both structural (e.g., vocabulary, grammar, and pronunciation) and pragmatic language (the social use of language in the context of conversation). Competencies were assessed in 54 Chinese children with ASD (4–8 years) exposed to one or two Chinese languages. The findings indicated that the performance of the bilingually exposed children with ASD was not significantly different on any of the communication measures relative to their monolingual peers with ASD (Reetzke et al. 2015). The implication of these findings is that communication indices other than linguistic ones may be an important source of information on second language learning in children with ASD and need to be further assessed in order to fully understand the potential dis/advantages of second language exposure.

Functional communication (FC) is one index of communication that does not rely on language proficiency per se. FC is defined as a child's ability to communicate in a way that others can comprehend and reciprocate (Reynolds 2004) with purpose or intent relevant to the context (e.g., interaction with one's parent, teacher; Hartley 1990). For children with ASD, a functional communicative response may involve a variety of means including using words, picture exchange systems, gestures, or assistive technology devices (Brady and Halle 1997). When children with ASD use communication (regardless of method) to achieve a functional purpose, as in expressing what they need or want to others, it can decrease challenging behaviours (Mancil 2006). Bi/multilingual environments may be advantageous in providing more opportunities and situations to elicit communicative initiatives using a variety of means (e.g., speech, gestures, other behavioural attempts to communicate) with a specific purpose or directed intent (e.g., with parent, teacher, peer).

Executive Functions (EF), are also implicated in second language learning in TD children and in social communication and adaptation among children with ASD (Leung et al. 2016; Pugliese et al. 2015; Wallace et al. 2016). EF refers to higher order cognitive processes (e.g., working memory, inhibition, organization, planning, and flexibility or set-shifting) thought to regulate goal-directed thoughts and actions (Zelazo and Müller 2010). Previous research on second language exposure and EF focused on standardized or experimental measurements administered in controlled environments (Bialystok 2015). Although neuropsychological or performance-based measures provide good indicators of the fundamental cognitive components of EF, performance-based tests are often not predictive of real-world task performance and functional ability (Toplak et al. 2013). Similarly, ASD-specific EF deficits do not consistently emerge when assessed with highly structured performance-based tasks yet teacher and parent reports consistently identify that children with ASD demonstrate difficulties with cognitive as well as behavioural regulation aspects of executive control in their daily lives (Humphrey et al. 2011).

In contrast to traditional performance-based EF tasks, in which children solve problems in highly structured settings where the demands are clear and distractions are limited, behaviour ratings of EF assess how children are able to interpret competing information, discern between information that is relevant and distracting, and flexibly shift from one activity to the next across different contexts within their everyday activities (Toplak et al. 2013). In a recent study, parent reports of EF were associated with social impairment in 6–15 year old children with ASD without intellectual disability (ID) (Leung et al. 2016). The researchers assessed EF with the Behavior Rating Inventory of Executive Function (BRIEF) and social impairment with the Social Responsiveness scale (SRS). The Behavioral Regulation Index of the BRIEF taps into executive processes such as inhibition, shifting, and emotional control and parent ratings on this index were predictive of their social impairment ratings in both the children with and without ASD. However, the parent ratings on the Metacognition Index of the BRIEF that taps the cognitive aspects of EF such as the abilities to independently generate new ideas and to manipulate information in the mind while executing actions, were predictive of social impairment only in the children with ASD. The findings suggested that children with ASD as compared to their TD peers recruit a wider repertoire of EF skills to function competently in a social context.

In a longitudinal study of 3–14 year old children with ASD without ID, EF was found to be predictive of the development of adaptive behavior skills. EF was assessed using the BRIEF and adaptive behavior was measured with the Vineland Adaptive Behavior Scales (VABS), First and Second Edition. Overall, the results showed that the majority of children with ASD did not change in their adaptive behavior overtime. However, the majority of observations that did not change or that declined fell within the Low range on adaptive level (e.g., ''low'' vs. ''adequate'') at the subsequent observation suggesting that they required on-going support in their daily adaptive skills. With regard to the role of EF on their adaptive behavior, the BRIEF, Behavioural Regulation Index rating on impaired self-monitoring, the ability to monitor one's own actions and adjust one's behavior accordingly to reach a predefined goal, was the most robust predictor of the children's lower subsequent adaptive behavior on the VABS. Poorer ratings on Behavioural Inhibition were associated with lower scores on the Daily Living Skills and Socialization domains of the VABS. The results of this study also suggest that parent ratings of EF skills are important to adaptive behavior outcomes (Pugliese et al. 2015).

In a subsequent study, the researchers used the BRIEF and the Adaptive Behavior Assessment System-Second Edition Adult Informant versions to assess EF and adaptive behavior in 18–40 year old adults with ASD without ID. The results indicated that adaptive behavior problems persist in adults with ASD without ID and that EF ratings were strongly associated with adaptive functioning deficits and co-morbid symptoms of depression and anxiety above and beyond the influence of age, IQ, and co-morbid ADHD symptoms (Wallace et al. 2016). In sum, the studies on EF and ASD suggest that EF problems are evident early in development, persist over time and are associated with the social, adaptive and mental health outcomes of those with ASD.

In typically developing (TD) children, parent-reported EF difficulties generally decrease in older children as they better manage multistep directions such as transitioning between activities, keeping school materials organized, and initiating activities. However, in children with ASD, EF is particularly impaired (Hill 2004a, b; Kenworthy et al. 2008; Rajendran and Mitchell 2007) and problems are reported to increase with age, especially in the area of shifting flexibly (Rosenthal et al. 2013). According to parent reports of EF, flexibility remains impaired across ages in ASD whereas working memory, initiation, and organization become increasingly problematic over time (Rosenthal et al. 2013; Pugliese et al. 2015).

In TD children there is evidence of a "bilingual advantage" on performance-based indices of EF (Kroll and Bialystok 2013), referring to enhanced EF performance for bilinguals compared to monolinguals. These effects are thought to be due to added practice with flexibly coordinating between languages and have been found in TD preschoolers (e.g., Bialystok 2010), school age, and adolescent children (Bialystok and Barac 2012; Martin-Rhee and Bialystok 2008; de Abreu et al. 2012; Gathercole et al. 2010). However, researchers have also found that social variables (Duñabeitia et al. 2014; Gathercole et al. 2010) such as socioeconomic status (SES) can influence EF performance findings and need to be controlled to accurately assess whether the advantage is due to the language exposure (Morton and Harper 2007). SES was overlooked in previous studies on the EF bilingual advantage in TD children and has lead researchers to question whether the enhanced EF performance is due to the bilingual or SES environment (Morton and Carlson 2017).

Given the prevalence of EF in ASD and the significant impact that EF difficulties seem to have on the social and adaptive outcomes of children with ASD, it seems plausible that bi/multilingual environments that are more conducive to promoting EF development (at least with the preliminary evidence from the TD literature) may be advantageous for children with ASD. The added practice with flexibly coordinating between languages observed in TD children may also improve cognitive flexibility in children with ASD. Thus, second language exposure may confer benefits on parent reported EF, or at least, reduce the EF impairments commonly reported in children with ASD. An association between language exposure environment and parent reported EF would be clinically relevant in pointing to naturalistic intervention strategies to reduce the EF problems that so commonly interfere with the social adaption of children with ASD across contexts.

In this study, our goal was to extend previous research in three ways: (1) to examine parent ratings of FC and EF that are measures derived outside of the specific domain of language but within the broader context of communication outcomes; (2) to compare children with ASD to typically developing (TD) peers who are not significantly different on age, IQ, and SES, and (3) to focus on older school age children with ASD (6–16 years of age) who are exposed to a second language or English only in the home environment. Specifically, we examined whether parent ratings of FC and EF differed across groups and whether these differences were associated with second language exposure. Based on previous findings, we predicted that the TD children (regardless of second language exposure) would have better parent ratings on both FC and EF than children with ASD (regardless of second language exposure). For the second language exposure groups (ASD and TD) we expected better parent ratings on FC relative to those without second language exposure. With regard to parent ratings of EF, we did not make any predictions as these measures provide different information on EF than performance based measures. Whether an EF advantage to second language exposure in the TD or the ASD group would be found was an exploratory question.

Method

Participants

A sample of 174 children and adolescents with and without ASD aged 6 to 16 years of age were taken from a larger study on social attention in ASD. Children in the ASD groups received a standardized clinical diagnosis of ASD from a qualified pediatrician, psychologist, or psychiatrist associated with the provincial government-funded autism assessment network, or through a qualified private clinician. All diagnoses were based on the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; APA, 2000) using the Autism Diagnostic Interview–Revised (ADI-R; Rutter et al. 2008), and Autism Diagnostic Observation Schedule (ADOS; Lord et al. 1999). The English version of the WASI-II (WASI; Wechsler 2011) was used to assess cognitive ability (as indexed by the Full Scale IQ) and to ensure that there were no significant differences between groups on IQ (see Table 1 for full scale IQ scores). An additional 12 children with ASD were excluded due to an IQ standard score less than 75 because intellectual disability is a co-morbid condition that needs to be considered separately in children with ASD.

The Social Responsiveness Scale, Second Edition (SRS-2) was administered to all parents of participants in order to quantify the severity of autism symptoms (Constantino and Gruber 2005) and to ensure that (a) the ASD groups a greater number of autism traits than the TD groups, (b)

Table 1 ASD groups compared to TD groups on key demographic and dependent variables

Measure	NSE		SE		*F*-ratio	*p* value	η^2
	ASD ($n=52$)	TD ($n=24$)	ASD ($n=39$)	TD ($n=59$)			
Demographic variables							
Age							
M (SD)	10.08 (1.94)	9.27 (1.56)	10.21 (2.47)	9.71 (1.76)	1.47	0.23	0.02
Range	6.80– 15.71	6.86–12.50	5.92–16.67	6.94–13.40			
IQ							
M (SD)	103.12 (14.22)	110.08 (15.39)	104.54 (16.78)	108.76 (14.04)	2.01	0.11	0.03
Range	75–139	75–138	78–144	75–131			
SES							
M (SD)	3.81 (1.51)	4.25 (1.02)	3.50 (1.28)	3.44 (1.38)	1.84	0.14	0.04
Range	1–6	3–6	1–6	1–6			
SRS-2 TS[a]							
M (SD)	79.12 (14.43)	48.17 (4.00)	76.33 (11.30)	48.88 (5.50)	133.84	<0.001	0.68
Range	49–111	42–59	60–105	39–59			
Dependent variables							
BASC-2 EFCS TS[a]							
M (SD)	65.73 (11.68)	48.79 (7.28)	61.79 (8.13)	45.47 (8.14)	59.19	<0.001	0.49
Range	39–91	37–64	45–79	28–64			
BASC-2 FC TS							
M (SD)	33.73 (8.85)	50.04 (8.36)	34.85 (7.65)	53.41 (9.32)	64.47	<0.001	0.53
Range	10–53	37–65	19–51	30–68			

NSE No second language exposure, *SE* Second language exposure, *ASD* autism spectrum disorder, *M* mean, *SD* standard deviation, *IQ* intelligence quotient was measured using the WASI, full scale IQ scores are reported, *SES* socioeconomic status as indexed by total family income (1 ≤ $20,000, 2 = $20–49,999, 3 = $50–79,999, 4 = $80–109,999; 5 = 110–139,999, 6 ≥ 140,000); SRS-2 TS = Social Responsiveness Scale, Second Edition T Scores with higher scores indicating poorer social skills, *BASC-2* Behavior Assessment System for Children-Second Edition Parent Report Scale, *EFCS TS* executive function content scale T scores with higher scores indicating poorer EF skills, *FC TS* functional communication T scores with higher scores indicating better FC skills

[a]Due to a violation of homogeneity of variance and two extreme means between the four groups, Brown-Forsythe *F* is reported

there was a similar number of autism traits across the two ASD groups, and (c) there were few autism traits across the two TD groups. The SRS-2 is a 65-item, ordinally scaled measure of autism symptoms in 4- to 18-year-olds, with strong measurement properties in ASD and non-ASD samples. A SRS T score of 59 or less indicates a normal range of autism traits, 60–75 indicates mild to moderate severity, and 76 or higher indicates a severe range of autistic traits. An additional 18 TD children were excluded due to an SRS T score in the severe range ($n=3$) and the moderate range ($n=15$). One child with ASD had an SRS T score in the normal range; however, this child was retained in the sample because a recent study has shown that, even though the SRS is a good measure of autism traits, several children who were carefully diagnosed with ASD were not correctly classified by the SRS (Cholemkery et al. 2014; see also; Armstrong and Iarocci 2013).

To identify second language exposure, all parents were asked, "What is the primary language spoken at home (First Language)?". They were also asked, "What other languages are spoken (Second Language)?" and space was provided to list other languages. The sample was subdivided into four groups: (a) ASD No second language exposure (NSE) ($n=52$, 43 male); (b) Typically Developing (TD) No second language exposure NSE (i.e., absence of an ASD diagnosis; $n=24$, 10 male); (c) ASD second language exposure (SE) ($n=39$, 32 male); and (d) TD second language exposure SE ($n=59$, 35 male). There were no significant differences between groups on age, IQ, and family income (a proxy for socioeconomic status, see Table 1).

To examine whether there were significant differences on SRS-2 T scores between the ASD NSE and ASD SE groups and the TD NSE and TD SE groups, an analysis of variance (ANOVA) was conducted and yielded significant differences between groups, $F(3,170)=133.84$, $p<.001$ (see Table 1 for descriptive statistics). Due to a violation of homogeneity of variance and two extreme means between the four groups, Brown-Forsythe F is reported. As the sample size varied across groups and this ANOVA analysis was exploratory in nature, a post-hoc Hochberg's GT2 test showed that, as would be expected, the ASD NSE group had a significantly higher SRS-2 T score than the TD NSE group, $p<.001$, and the TD SE group,$p<.001$, suggesting that the ASD NSE group had more autism traits than the two TD groups. In addition, the ASD SE group had a significantly higher SRS-2 T score than the TD NSE group, $p<.001$, and the TD SE group, $p<.001$, suggesting that the ASD SE group had more autism traits than the two TD groups. There were no significant differences in SRS-2 T scores between the ASD NSE group and the ASD SE group, $p=.73$, suggesting that the two ASD groups had a similar number of autism traits. Also, there were no significant differences in SRS-2 T scores between the TD NSE group and the TD SE group, $p>.99$, suggesting that the two TD groups had a similar number of autism traits.

Parents reported that all children in the ASD NSE group and TD NSE group had English as the primary language and did not report any additional languages in the home. Parents reported that the children in the ASD SE group and TD SE group had one primary language and one or more additional languages spoken in the home. For the ASD SE group ($n=39$), 59% ($n=23$) had English as the primary language and 41% ($n=16$) had another primary language: Mandarin (3), Cantonese (3), Chinese (3), Spanish (2), Korean (2), Russian (1), Afrikaans (1), and Slovak (1). Secondary languages were: English (14), French (4), Tagalog (4) Arabic (2), Cantonese (2), Spanish (2), Chinese (1), Mandarin (1), Hindi (1), Japanese (1), Korean (1), Sinhalese (1), and Thai (1). There were also four participants who listed more than one second language: English and French (2), Cantonese and Mandarin (1), and French and Arabic (1) who were included in the SE group. As there is some evidence that individuals with exposure to three or more languages may have distinct cognitive and language performance compared to dual language exposure, we conducted a series of t-tests between children in the ASD SE group with exposure to two languages to children in the ASD SE group with exposure to three languages. Results showed that there were no significant differences between the two subgroups on IQ, $t(37)=-0.43$, $p=.67$, $r=.07$, BASC Functional Communication T scores, $t(37)=-0.73$, $p=.47$, $r=.11$, and BASC EFCS T Score, $t(37)=0.79$, $p=.44$, $r=.13$. Thus, it was appropriate to include children with ASD who had exposure to three languages ($n=4$) in the ASD SE group.

For the TD SE group ($n=59$), 49% ($n=29$) had English as the primary language and 51% ($n=30$) had another primary language: Mandarin (11), Cantonese (6), Spanish (7), Korean (4), Russian (1) and Slovak (1). Secondary languages were: English (26), Mandarin (6), French (5), Cantonese (4), Spanish (2), Chinese (2), Sinhalese (2), Korean (1), Arabic (1), Punjabi (1), Farsi (1), Tagalog (1), and Yoruba (1). There were also six participants who listed more than one second language: English and French (2), English and Cantonese (1), Spanish and French (1), Mandarin and Russian (1), and one participant who listed three "second" languages: French, Chinese, and Croatian (1) who were included in the SE group. We also conducted a series of t-tests between children in the TD SE group with exposure to two languages to children in the TD SE group with exposure to three or more languages. Results showed there were no significant differences between the two subgroups on IQ, $t(57)=-0.69$, $p=.50$, $r=.09$, BASC Functional Communication T scores, $t(57)$ = -1.72, $p=.09$, $r=.22$, and BASC EFCS T Score, $t(57)=0.26$, $p=.80$, $r=.03$. Thus, it was appropriate to include TD children who had exposure to three or more languages ($n=6$) in the TD SE group.

In a second round of data collection, we refined the questionnaire to include a question about the child's age at second language exposure. A subset of parents of the ASD SE participants ($n=12$) and the TD SE participants ($n=22$) were also asked "How old was your child when he/she started hearing two or more languages on a regular basis?" and estimated the daily number of hours their child: (a) listens to conversations in the first language, (b) listens to first language through TV or radio, (c) listens to conversations in the second language, and (d) listens to second language through TV or radio. For the ASD SE group the average age was 1.04 years (range = 0- 7.50 years), for the TD SE group the average age was 2.64 years (range = 0-8.50 years), and there was no significant difference between groups, $t(32)$ = -1.89, $p=.07$, $r=.32$.

For the ASD SE group ($n=12$), parents reported an average of 5.29 h (range = 1.50–12.00 h) of listening to conversations in their first language, 2.54 h (range = 0.00–10.00 h) of listening in the first language through TV or radio, 4.38 h (range = 1.00–10.00 h) of listening to conversations in their second language, and 2.42 h (range 0.00–10.00 h) of listening in the second language through TV or radio. For the TD SE group ($n=22$), parents reported an average of: 6.14 h (range = 0.50–14.50 h) of listening to conversations in their first language, 2.84 h (range = 0.00–11.00 h) of listening in the first language through TV or radio, 4.80 h (range = 0.50–10.00 h) of listening to conversations in their second language, and 2.13 h (range 0.00–10.00 h) of listening in the second language through TV or radio. A series of t-tests revealed there were no significant differences between groups on the number of hours of: listening to conversations in their first language, $t(32)=-0.61$, $p=.55$, $r=.11$; listening in the first language through TV or radio, $t(32)=-0.27$, $p=.79$, $r=.05$; listening to conversations in their second language, $t(32)=-0.36$, $p=.72$, $r=.06$; and listening in the second language through TV or radio, $t(32)=0.34$, $p=.74$, $r=.06$.

Procedures

Human ethics approval was received from the University Research Ethics Board (ID #1257). Parents gave informed written consent before filling in the SRS-2, the Behavior Assessment System for Children-Second Edition, Parent Rating Scales (BASC-2 PRS), and a demographic form that included a measure of language exposure. Children and adolescents provided verbal assent and were administered the Wechsler Abbreviated Scale of Intelligence 2nd Edition (WASI-II).

Measures

BASC-2 PRS

The BASC-2 (Reynolds and Kamphaus 2002) is a multidimensional assessment system that evaluates both clinical and adaptive aspects of behavior. The Parent Rating Scale (PRS) child (PRS-C; 160 items; age 6–11 years) and adolescent (PRS-A; 150 items; age 12–21 years) forms were used in this study. Each PRS item is rated on a four-point scale and item raw scores are converted into standardized T scores for interpretation. The BASC-2 PRS psychometric properties are strong (Reynolds and Kamphaus 2002). For the BASC-2 PRS-C and PRS-A forms, internal consistency reliability coefficients for the major composite scores ranged from 0.90 to 0.95 (Median = .94), and alpha coefficients for the individual scales ranged from 0.72 to 0.88 (Median = .84). Concurrent validity studies have yielded moderate to high correlations with other measures (e.g., ASEBA, Child Behavior Checklist).

Functional Communication

The BASC-2 also provided a measure of functional English communication. The FC subscale is part of the BASC-2 Adaptive Skills Subdomain and includes items such as "provides own phone number when asked" and "is able to describe feelings accurately". High scores on this scale indicate better FC skills. Raw scores are converted into standardized T scores for interpretation. An average T score is 50 and scores that fall within the 30–40 range are considered at risk and those that fall below 30 are considered to be clinically significant.

Executive Function

The BASC-2 executive function content scale (EFCS) is an index of the ability to control behavior by planning, anticipating, inhibiting or maintaining goal-directed activity, and by reacting appropriately to environmental feedback. Example items of the EFCS include: "is easily distracted" and "organizes chores or other tasks well". High scores on the EFCS indicate difficulties with self-regulation and EF. Raw scores are converted into standardized T scores for interpretation. An average T score is 50, thus scores that fall within the 60–70 range are considered at risk and those that fall above 70 are considered to be clinically significant. This scale is internally consistent (alpha = 0.84), and reliably differentiates groups with and without frontal lobe impairment (Reynolds and Kamphaus 2002; Sullivan and Riccio 2006). The EFCS is significantly correlated with other validated measures of EF including the BRIEF and Conners' Parent Rating Scales Revised (CPRS; Conners 1997; Sullivan and Riccio 2006). (Sullivan and Riccio 2006), and has been used to measure EF in various populations (Iarocci and Gardiner 2017; Linebarger et al. 2014; Piotrowski et al. 2013; Volker et al. 2010).

Results

All data analyses were conducted using SPSS Statistics, Version 19. In the present study, only one univariate outlier (data point with a standardized score in excess of 3.29, $p < .001$) from the ASD SE group was found in the BASC Functional Communication score. The indices for validity were in the acceptable range; thus, the score was changed to one unit above than the next most extreme score in the distribution (from 35 to 29; Tabachnick and Fidell 2007). All values of skew and kurtosis within each group were acceptable (i.e. −2 to 2 are acceptable for normal univariate distribution, George and Mallery 2010).

Functional Communication

To examine whether there were significant differences between the groups on FC an ANOVA was conducted, $F(3,170) = 54.59$, $p < .001$, $\eta^2 = 0.53$ (see Table 1). Due to the difference in sample size and the exploratory nature of the analysis, a post-hoc Hochberg's GT2 test showed that there were significant differences between the ASD NSE group and: (a) the TD NSE group, $p < .001$, and (b) the TD SE group, $p < .001$. In addition, there were significant differences between the ASD SE group and: (a) the TD NSE group, $p < .001$, and (b) the TD SE group, $p < .001$. There was no significant difference between the ASD NSE group and the ASD SE group, $p = .99$, and no significant difference between the TD NSE group and the TD SE group, $p = .51$. In sum, the ASD NSE group had the lowest average FC score, indicating poorer FC skills than TD NSE group and the TD SE group, but the ASD NSE group did not have significantly poorer FC skills than the ASD SE group.

It is worth noting that both ASD groups had mean T scores in the “at risk” range (between 31 and 40). In the ASD NSE group, there were 24 participants in the “at risk” range and 18 participants in the clinically significant range (≥30). In the ASD SE group, there were 21 participants in the “at risk” range and 10 participants in the clinically significant range. To compare the frequencies of those in the clinically significant range, a Pearson’s χ^2 test was conducted. Results showed no significant association between second language exposure and parent ratings of FC in the clinically significant range for children with ASD, $\chi^2(1) = 0.42$, $p = .52$, Cramer’s $V = 0.07$. Conversely, the TD NSE group had eight participants in the “at risk” range and one participant in the clinically significant range. The TD SE group had 16 participants in the “at risk” range and no participants in the clinically significant range. To compare the frequencies of those in the clinically significant range, a Fisher’s exact test was used because there were two cells with an expected frequency less than 5. Results showed no significant association between second language exposure and parent ratings of FC in the clinically significant range for TD children, $p = .71$.

Executive Function

An analysis of variance (ANOVA) was conducted between groups on the executive function content scale T scores (see Table 1) and there was a significant difference between groups, $F(3,170) = 59.19$, $p < .001$, $\eta^2 = 0.49$. Due to a violation of homogeneity of variance and two extreme means between the four groups, Brown-Forsythe F is reported. As there were differences in sample size between groups and due to the exploratory nature of the analysis, a post-hoc Hochberg’s GT2 test indicated significant differences between the ASD NSE group and (a) the TD NSE group, $p < .001$, and (b) the TD SE group, $p < .001$. In addition, there were significant differences between the ASD SE group and (a) the TD NSE group, $p < .001$, and (b) the TD SE group, $p < .001$. There was no significant difference between the ASD NSE group and the ASD SE group, $p = .24$, and the TD NSE group and the TD SE group, $p = .57$. In sum, the ASD NSE group had the highest executive function content scale T score, indicating the poorest average EF skills, significantly higher than both TD groups, but not higher than the ASD SE group.

It is worth noting that both ASD groups had mean T scores in the “at risk” range (between 60 and 69). In the ASD NSE group, there were 14 participants in the “at risk” range and 21 participants in the clinically significant range (≥70). In the ASD SE group, there were 17 participants in the “at risk” range and five participants in the clinically significant range. To compare the frequencies of those in the clinically significant range, a Pearson’s χ^2 test was conducted. Results showed a significant association between second language exposure and EF ratings in the clinically significant range in children with ASD, $\chi^2(1) = 8.30$, $p < .01$, Cramer’s $V = 0.30$. Conversely, the TD NSE group had one participant in the “at risk” range and no participants in the clinically significant range. The TD SE group had two participants in the “at risk” range and none in the clinically significant range. It was not possible to compare the frequencies of those in the clinically significant range, as there were no participants in the clinically significant range for the TD NSE group and the TD SE group.

Post-hoc analyses were used to identify any differences between participants who reported their primary language as English and other. No significant differences on the EF content scale raw scores between participants in the ASD SE group whose primary language was English ($n = 23$; $M = 14.83$; $SE = 0.80$) and was not English ($n = 16$; $M = 16.19$; $SE = 0.95$), $t(37) = -1.10$, $p = .28$, $r = .18$. As well no differences were found between the participants in the TD SE group whose primary language was English ($n = 29$; $M = 7.45$; $SE = 0.70$) and was not English ($n = 30$; $M = 7.77$; $SE = 0.71$), $t(57) = -0.32$, $p = .75$, $r = .04$.

Similar analyses for FC raw scores revealed no differences between participants in the ASD SE group whose primary language was English ($n = 23$; $M = 17.00$; $SE = 1.02$) and was not English ($n = 16$; $M = 17.81$; $SE = 1.14$), $t(37) = -0.52$, $p = .60$, $r = .09$. As well no significant differences were found between participants in the TD SE group whose primary language was English ($n = 29$; $M = 29.34$; $SE = 1.01$) and was not English ($n = 30$; $M = 27.50$; $SE = 1.69$), $t(57) = 1.30$, $p = .20$, $r = .17$.

Discussion

In the current study we focused on parent reports of functional communication and executive function that are part of the broader communication repertoire for children with ASD who use a variety of means to communicate. As expected, we found that parents of children with ASD, regardless of second language exposure, reported poorer FC and EF than parents of TD children. However, the children with ASD who were exposed to a second language were not significantly different on FC and EF parent ratings than those not exposed to a second language. These results provide further evidence that exposure to a second language is not associated with an adverse impact on the communication and cognitive skills of children with ASD.

In a previous study on FC, the focus was on toddlers and preschool children (Ohashi et al. 2012), with this study we extend the finding of no delays in FC to children and adolescents with ASD who ranged in age from 6 to 16 years.

Contrary to our expectations, however, we did not find that TD children or children with ASD who had been exposed to a second language fared better on FC ratings as compared to their peers who were not exposed to a second language. It may be that only at certain time points and/or certain aspects of functional communication improve with second language exposure as suggested by Valicenti-McDermott et al.'s (2013) findings of increased use of gestures and vocalizations in bilingual (English–Spanish) toddlers with ASD. Alternatively, hypothesized second language advantages in FC may be related to SES. These possibilities need to be examined in future research in both TD children and children with ASD.

Our findings suggest that second language exposure does not have an adverse impact on EF even over the long term when older school age and adolescent children are reported to show declines in EF performance using rating scales (Rosenthal et al. 2013; van den; Bergh et al. 2014) as well as lab-based EF tasks (Hill 2004a; Pennington and Ozonoff 1996; Russo et al. 2007). Given that EF rating scales are more reflective of caregivers' behavioural concerns across contexts (i.e., home and school) than lab-based measures (Burgess et al. 2006), the findings are noteworthy in that they show that fewer children exposed to a second language as compared to those exposed to one language fell within the clinically significant range of the BASC-2. This clinical advantage was not found for the TD SE group, however, there were few TD children who fell within the clinically significant range.

It is important to note that FC and EF are usually impaired in children with ASD and thus, merely exposing children to a second language would not remediate these difficulties, but possibly reduce the impairment compared to other children with ASD who were not exposed to a second language. Although there were no statistical differences in EF and FC ratings across language exposure groups, clinical T scores on the BASC-2 indicated that whereas 27% of the children with ASD in the NSE group were in the Clinically Significant range, only 10% of the children with ASD in the SE group were in the Clinically Significant range on EF ratings. This association was significant, meaning that children with ASD who had been exposed to a second language were less likely to have EF ratings in the clinically significant range. Similarly, whereas 35% of the children with ASD in the NSE group were in the Clinically Significant range, only 28% of the children with ASD in the SE group were in the Clinically Significant range on FC ratings. However, no significant association was found between second language exposure and parent ratings of FC in the clinically significant range for children with ASD. Although preliminary, these results suggest that second language exposure may be associated with a reduced risk of clinically significant EF impairment in children and adolescents with ASD.

For practicioners this is particularly relevant for diagnostic and intervention purposes. Children with ASD without intellectual disability exposed to a second language may present with less functional impairment, at least with regard to parent reported executive functioning and, thus, the clinical profiles of these children with ASD may be less 'typical'. With regard to intervention recommendations, second language exposure in the home may be associated with a beneficial impact on day-to-day executive functioning. Future research on clinical/functional rather than simply statistical differences between groups is needed to further elaborate on the potential benefits to EF in children with ASD exposed to a second language.

In this study we were able to evaluate the FC and EF outcomes in comparison to both ASD and TD peers who were not significantly different on age, IQ and SES. This permitted us to establish the performance of TD groups with and without exposure to that of the same exposure groups with ASD as well as comparisons within TD and ASD exposure groups once critical variables such as age, IQ, and SES were controlled. Due to previous research suggesting that SES variables may account for the second language advantage in EF performance (Morton and Carlson 2017), it was important to determine the effect of the exposure when there were no significant differences in SES. We found no difference in parent reported EF between the TD groups (as well as in ASD groups) with and without exposure to a second language when there were no significant differences in SES and, thus, no evidence of an advantage. However, in this study EF was assessed by parent ratings, whereas in previous studies a bilingual advantage was found using lab-based measures of EF. The lack of a bilingual advantage in the TD groups may indicate that there is no second language advantage for EF (Paap et al. 2015; Mezzacappa 2004; Morton and Harper 2007) or that the advantage is only present under certain circumstances related to the child's language learning environment such as age of acquisition, language proficiency, frequency of language use and degree of code-switching (Dong and Li 2015). These will be important factors to investigate in future research to determine whether there is a parent reported EF advantage for second language learners and to what extent these specific learning conditions may be implicated.

This study included a sample of children whose parents reported that they had been exposed to a variety of second languages reflective of the diverse ethnic groups found in the Canadian context (Statistics Canada 2011). Although we cannot make claims about exposure to any one language due to sample size, it suggests that children exposed to languages other than Canada's official languages of English and French examined in previous studies, also show similar results.

The study has a few limitations that need to be considered. One limitation is that the outcome measures of FC and EF are based on parent report. Independent measures of communication and EF would add relevant information and should be considered in future studies. However, in this study we were interested in parent perceptions on their child's communication and EF as a unique source of information. For example, in contrast to traditional performance-based EF tasks, in which children solve problems in highly structured settings where the demands are clear and distractions are limited, ratings of EF in real-life settings assess how children are able to interpret competing social information, discern between information that is relevant and distracting, and flexibly shift from one activity to the next. Behaviour rating scales, therefore, consider EF from an ecological perspective, as they assess how multiple components of EF are applied across different contexts within the child's everyday activities (Kenworthy et al. 2008; Toplak et al. 2013).

Another limitation was that although parents reported that their children were exposed to two, and in a few cases three or four languages, we could not quantify the amount of exposure that each child had to each language or how directed the exposure was to any specific child for the entire sample. We did not employ any formal measures of bi/multilingualism, though these are more often focused on language rather than communicative proficiency. We did, however, ask the parents to report on the primary language spoken in the home and we know that 41% of children with ASD and 54% of children withut ASD had a language other than English as the language spoken most often in the home. This suggests that at least half of the children in each group would have had regular exposure to a language other than the one that they are exposed to in public schools in Canada. In addition, we know from a subset of our sample that the children with ASD and their TD peers listened to an average of 7 h per day of conversations and TV or radio in their second language.

Given the specificity of our sample, we must acknowledge that the findings only apply to children with and without ASD who have IQ scores within the average range. Although there is some evidence that children with intellectual disabilities fare as well as their peers without intellectual disabilities on second language learning (Hambly and Fombonne 2014) this study cannot draw conclusions on the effects of second language exposure in children with intellectual disability.

Conclusion

Parents raising children with ASD in a multilingual context report a desire to expose their child with ASD to multiple languages to aid communication with family members, others at school, and within their community (Kay-Raining Bird et al. 2012; Yu 2013). However, despite encouraging evidence, misconceptions about the role of second language exposure in the development of children with ASD persist. The results of this study indicate no evidence that functional communication and executive functioning are further impaired in children with ASD who have been exposed to a second language, rather, there was evidence of a reduced clinical impact as indexed by a lower percentage of children whose FC and EF ratings fell within the clinical range. Further study is warranted to determine whether second language exposure in children with ASD may be associated with clinical/functional improvements in performance.

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Compliance with Ethical Standards

Conflict of interest G. Iarocci, S. M. Hutchison, G. O' Toole declares that they have no conflict of interest.

Ethical approval All procedures performed in this study that involved human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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