Testing the Bilingual Cognitive Advantage in Toddlers using the
Early Executive Functions Questionnaire

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Abstract

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The present study aimed to assess differences in executive functioning between 39 monolingual and 42 multilingual 23-month-old toddlers, both when dichotomizing multilingualism and assessing it on a continuum. It was hypothesized that multilinguals, individuals with greater non-dominant language exposure, and individuals with more translation equivalents would perform better in the following domains: response inhibition, attentional flexibility, and regulation. No differences were expected for working memory. The Early Executive Functions Questionnaire, a newly developed parental report, was used to measure the four executive functions of interest. Multilinguals and individuals with greater non-dominant language exposure had significantly higher response inhibition; however, no differences were noted for any other executive function. Additionally, no associations between translation equivalents and executive functioning were found among French-English multilinguals ($n = 31$). Post-hoc analyses revealed that non-dominant language production had a positive correlation with working memory. The present findings support the notion of a domain-specific cognitive advantage for multilingual toddlers.

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Contribution of Authors

All authors reviewed the final manuscript and approved of the contents. Dr. Diane Poulin-Dubois contributed to the conceptualization, supervision, and editing of the manuscript. Kayla Beaudin contributed to the data curation, formal analysis, investigation, validation, visualization, and writing of the manuscript. Both authors jointly contributed to funding acquisition, methodology, project administration, and resources.

Table of Contents

Table of Contents (Continued)

List of Figures

List of Tables

Testing the Bilingual Cognitive Advantage in Toddlers using the Early Executive Functions Questionnaire

Bilingualism is not a rare experience; more than half of the world's population speaks more than one language (Grosjean, 2010). Over the past decades, a large body of work on bilingualism has suggested that being bilingual brings a number of advantages. One such benefit, as proposed by the bilingual cognitive advantage, is that bilingual individuals may have greater cognitive skills than monolinguals (e.g., Adesope et al., 2010; Bialystok, 2017; Gunnerud et al., 2020). More specifically, a large number of studies have documented that bilingual individuals have greater executive functioning skills than their monolingual peers. Executive functioning includes controlled and coordinated mental processes required for daily tasks, such as planning and attentional control (Arizmendi et al., 2018), and is multifaceted, including inhibitory control, attentional flexibility, working memory, and regulation. The basis for the bilingual cognitive advantage is believed to be due to bilinguals' experience of selectively attending to one of multiple jointly-activated languages, while inhibiting the others, in order to prevent interference from any non-target language (Bialystok, 2017; Bialystok et al., 2010). Importantly, it appears that there is no general cognitive advantage for bilinguals, as confirmed by two recent meta-analyses (Gunnerud et al., 2020; Lowe et al., 2021). Instead, if a bilingual cognitive advantage does exist, it is likely domain-specific.

Inhibitory Control

Two domains of inhibitory control exist: cold inhibition and hot inhibition. Cold inhibition, also referred to as attentional inhibition, refers to the ability to suppress attentional shifts to external stimuli (Arizmendi et al., 2018) and is typically measured with conflict tasks that require participants to inhibit distracting stimuli to successfully complete the task (e.g., Stroop tasks, Flanker task, Attention Network Task; see Lowe et al., 2021). Among children, the bulk of past research suggests that attentional inhibition may be stronger among bilingual children. For example, throughout early childhood bilinguals have been found to outperform monolinguals on various conflict tasks, such as the Flanker task (Carlson & Meltzoff, 2008; Sorge et al., 2016). Furthermore, the link between bilingualism and attentional inhibition may develop early in life. Poulin-Dubois and colleagues (2011) found that 24-month-old bilinguals displayed better performance than monolingual participants on a child-appropriate Stroop task. While the extant literature on attentional inhibition reports evidence for a bilingual advantage, note that there is low convergent validity between tasks, so that the manifestation of inhibitory control may differ across tasks (Bialystok & Craik, 2022; Poarch & Krott, 2019; Poarch & van Hell, 2019). This may lead to significant differences between monolinguals and bilinguals on one task, but not another.

Alternatively, hot inhibition refers to response suppression and is typically measured using delay tasks, such as delay of gratification tasks (e.g., Mischel et al., 1989). Few studies have assessed the differences in response inhibition between monolingual and bilingual children; indeed, a meta-analysis by Gunnerud and colleagues (2020) reported that language effects for response inhibition were inconclusive as too few studies were available for analysis. In contrast, a more recent meta-analysis by Lowe and colleagues (2021) indicated that bilinguals aged 3- to 17-years-old had greater response inhibition than monolinguals, although this effect may be partially explained by bilingual children typically having higher socioeconomic status (SES). Nevertheless, some research has failed to find a bilingual advantage in response inhibition. For example, while Carlson and Meltzoff (2008) reported an advantage in attentional inhibition, they failed to find o2\8ne for response inhibition as measured through delay tasks. Additionally, Crivello and colleagues (2016) found a monolingual advantage on a gift delay task at 31 months of age. Finally, a recent review noted that monolinguals and bilinguals tend to have similar performance on tasks measuring response inhibition (Bialystok & Craik, 2022). Thus, further research is needed to determine whether a bilingual advantage in hot inhibition does exist during early childhood, and whether this advantage is due to SES.

As the present study is interested in hot inhibition, it expanded upon Lowe and colleagues' (2021) meta-analysis in three important ways. First, SES was controlled for. Second, we aimed to assess whether response inhibition is affected by language status and language exposure around 2 years of age. Finally, unlike all studies testing response inhibition in bilinguals, the present study used a parental questionnaire to measure response inhibition.

Attentional Flexibility

The ability to shift focus from one stimulus to another, termed attentional flexibility (Calcott & Berkman, 2015), is thought to be central to the bilingual cognitive advantage (Bialystok 2017; Bialystok & Craik, 2022). The ability to manage multiple language systems and efficiently switch between the two is imperative to bilinguals' communication, and it is believed that attentional flexibility skills gained in linguistic contexts can be transferred to non-linguistic scenarios, thus aiding in everyday tasks. Indeed, a link between language status and attentional flexibility has been noted, even among pre-verbal infants. For example, Kovács and Mehler (2009) reported that, compared to monolinguals, 6- to 7-month-old bilinguals were better able to redirect their attention to a target cue during an implicit anticipatory looking task. Recently, Comishen and colleagues (2019) replicated Kovács and Mehler's findings, further supporting the notion that attentional flexibility may be stronger among bilingual infants. Overall, these findings suggest that bilingual advantages in attentional flexibility are not limited to linguistic tasks and that these advantages emerge early in development.

While the above findings have highlighted the evidence for a bilingual advantage in attentional flexibility, not all studies have succeeded in finding this effect. For example, Poulin-Dubois and colleagues (2021) found no difference between monolingual and bilingual 17-month-olds on a delayed response task. Additionally, many recent studies have failed to demonstrate that bilingual infants outperform monolingual peers on anticipatory looking tasks (D'Souza et al., 2020; Ibanez-Lillo et al., 2010; Kalashnikova et al., 2020; Tsui & Fennell, 2019). Finally, two recent meta-analyses have failed to report a language status effect on attentional flexibility throughout childhood (Gunnerud et al., 2020; Lowe et al., 2021). It remains possible that differences in attentional flexibility do not develop between monolinguals and bilinguals during childhood.

Working Memory

A third facet of executive functioning is working memory, a component of short-term memory that allows individuals to maintain and manipulate information during cognitive processing (Baddeley, 2000). Greater second language proficiency may be associated with stronger working memory (Grundy & Timmer, 2016; Linck et al., 2014). Specifically, a meta-analysis by Grundy and Timmer (2016) reported that a bilingual advantage in working memory existed across development and that this effect was larger among children, suggesting that differential working memory skills between monolinguals and bilinguals develop early in life. Additionally, by 5 to 7 years of age, Morales and colleagues (2012) reported that bilingual children have greater working memory skills on a visuospatial task compared to their monolingual peers; however, these results should be interpreted with caution, as the bilingual advantage was most evident on tasks that required the use of additional executive functions and did not purely measure working memory. Regardless, the bilingual advantage has been found for visuospatial working memory across adulthood. Luo and colleagues (2013) noted that among younger and older adults, and on simple and complex tasks, bilinguals performed better on visuospatial tasks than monolingual adults. However, the opposite was found for verbal working memory tasks, where a monolingual advantage was instead discovered. Overall, it appears that bilingual children may outperform monolinguals on working memory tasks, specifically those assessing visuospatial working memory. However, it is possible that this advantage may be influenced by the use of additional executive functions during working memory tasks.

Indeed, ambiguous evidence for a bilingual advantage in working memory is prevalent in the literature, with many studies failing to report a significant language effect. Recent studies have found that working memory likely develops similarly between monolingual and bilingual infants (Brito et al., 2021; Brito et al., 2014; Bialystok, 2017; Poulin-Dubois et al., 2021). Specifically, no statistically significant differences in performance on multiple location tasks was reported between bilinguals and monolinguals aged 17 months (Poulin-Dubois et al., 2021), 18 months (Brito et al., 2021) nor 24 months (Brito et al., 2014). Even during childhood there is no clear evidence for a bilingual advantage; previous studies have reported that among children aged 6 to 12 years, there is no effect of language status on working memory task performance (Bonifacci et al., 2011; Engel de Abreu, 2011). Finally, among younger and older adults, past studies have found similar performance on working memory tasks between monolingual and bilingual adults (Bialystok et al., 2008; Ratiu & Azuma, 2015). It is possible that monolingual and bilingual individuals have similar working memory skills, and differences between the two groups may be due to assessments requiring the use of additional executive functions. Instead of solely relying on in-lab measures of cognitive skills, perhaps researchers should also aim to utilize parental reports. While the results from parental assessments may also be influenced by intrusions of other executive functions, when both forms of assessment are included in the literature, a better understanding of bilingual cognition may be achieved. While in-lab assessments bring the advantage of strong experimental control, parental reports offer greater ecological validity.

Regulation

Less is known about a possible bilingual advantage in a fourth cognitive skill, regulation. Regulation requires executive functioning in order to manage the intensity and duration of emotional expressions (Calkins & Marcovitch, 2010). Limited work has been conducted on the differences between monolingual and bilingual individuals in this domain; however, one study conducted by Barker and Bialystok (2019) suggested that emotional regulation is stronger among bilingual young adults. Specifically, bilinguals were better at suppressing outward emotional expressions, such as anger and happiness, than monolingual participants. To our knowledge, no studies have yet assessed the differences in emotional regulation between monolingual and bilingual toddlers, and the present study is the first to do so.

What Explains the Mixed Evidence on the Bilingual Cognitive Advantage?

A number of explanations have been offered for the mixed evidence concerning the bilingual cognitive advantage. Lowe and colleagues (2021) indicated that if this advantage does exist during childhood, it may be small and variable. The bilingual cognitive advantage may also be partially due to confounding variables, such as SES (Bialystok & Craik, 2022; Brito & Noble, 2018; Calvo & Bialystok, 2014; Lowe et al., 2021). However, even when controlling for SES, there is evidence for cognitive advantages among bilingual children (for a review, see Bialystok & Craik, 2022). It is also possible that variability within the bilingual group may contribute to the mixed evidence. For example, language exposure has been linked to performance on executive function tasks, where bilinguals who have greater non-dominant language exposure perform better on a Stroop task than bilinguals with less non-dominant language exposure (Poulin-Dubois et al., 2011). It is argued that bilinguals with greater non-dominant language exposure may have more practice switching between and inhibiting language systems, thus leading to greater cognitive skills.

Past evidence also suggests that bilingual children whose vocabulary contains a greater proportion of cross language synonyms, or translation equivalents (TEs), may have greater executive functioning (Crivello et al., 2016). TEs refer to concepts that have similar meanings in different languages (e.g., *dog* in English and *chien* in French). TEs can be used as a measure of how effectively individuals can switch between multiple languages, as bilinguals must manage each language system by selectively inhibiting one language to activate another (Bialystok et al., 2010; Meuter & Allport, 1999). Thus, individuals who switch between language systems more often tend to have a higher proportion of TEs in their vocabulary (Genesee & Nicoladis, 2006; Pearson et al., 1997). Bilinguals with a higher TE proportion may have more opportunities for inhibiting one language while another is activated. Additionally, as language systems may be independently activated (Singh, 2014), bilinguals may need to frequently switch between multiple language systems, and thus gain strong inhibition and attention skills (Patterson & Pearson, 2004). Supporting this idea, a longitudinal study used TEs as an index of children's ability to code-switch and found that bilingual toddlers who acquired more TEs between the ages of 24 and 31 months had greater inhibition skills by 31 months than those who acquired fewer TEs during the same period (Crivello et al., 2016). Further, Prior and Gollan (2011) found that bilingual young adults who frequently switched between their known languages exhibited greater ease in task switching compared with monolinguals; this difference did not hold for bilinguals who code-switched less frequently. Thus, gains in attentional flexibility and inhibition occur when bilinguals switch between two language systems more frequently. The present study used TEs as a proxy for code-switching experience. Additionally, because older children naturally have larger vocabularies and produce more TEs than younger children (Tsui et al., 2021), the present study used a proportional TE measure to control for overall vocabulary size.

A further explanation for the mixed results is that cognitive advantages may be task-specific (de Bruin et al., 2015; Paap, 2019; Poarch & Krott, 2019; van den Noort et al., 2019; Ware et al., 2020). Past research has typically measured various executive functions using in-lab assessments (e.g., gift delay tasks, Flanker Inhibitory Control and Attention Task, and the Dimensional Card Sort Task); however, this comes with limitations. Among infants and young children in particular, executive functioning can be difficult to assess in tasks administered in the laboratory where the aim is to measure specific skills in isolation. During the first few years of life executive functioning skills are mildly unstable and children may display poor performance on individual tasks measured at a single timepoint (Hendry et al., 2016). Additionally, administering a battery of executive function tasks may result in high attrition rates, as children may lose focus throughout the testing session (Poulin-Dubois et al., 2021). Willoughby and colleagues (2010) further outlined limitations of assessing childhood executive functioning using in-lab tasks. One issue is that many tasks use dichotomous scoring (e.g., pass/fail); this scoring technique provides limited information of individual differences in task performance. Further, in-lab assessments are often difficult to administer and may not be consistent between labs, as experimenters must be trained to administer tasks, assessments often lack formally written training documents, and task materials are inconsistent between labs. Another problem is that specific cognitive tasks may not purely measure executive functioning; instead, these tasks may also measure verbal comprehension. If toddlers have low comprehension skills, they may misunderstand verbal instructions and perform poorly on the task (Burgess, 1997; Hendry et al., 2016; Miyake & Friedman, 2012). In order to minimize these measurement issues, executive functioning can instead be assessed through parental reports, which provide both broad and detailed information of children's behavior over a longer time period (Rothbart & Muaro, 1990). Also, parental reports can be easily completed in online formats (e.g., Wordbank; Frank et al., 2016), allowing for remote testing. Given the methodological challenges of testing executive functions in very young children, the present study used a recently created parental report, the Early Executive Functions Questionnaire (EEFQ; Hendry & Holmboe, 2021). The EEFQ has four sub-scales that respectively measure response inhibition, attentional flexibility, working memory, and regulation. Three of the sub-scales (inhibitory control, attentional flexibility, and working memory) are additionally loaded into a global cognitive measure, Cognitive Executive Function (CEF).

The Present Study

The present study aimed to fill a number of gaps in the extant literature on the emergence of a bilingual cognitive advantage in early childhood. First, given the limited research conducted to assess the bilingual cognitive advantage during the second year of life, it was designed to provide further insight into the development of executive functioning in multilingual and monolingual toddlers. Second, this study assessed differences in executive functioning by analyzing the impact of language exposure on a continuum. Finally, past research has consistently assessed the cognitive advantage with in-lab assessments. To our knowledge, no study to date has measured executive functioning among multilinguals with a questionnaire-based assessment. Thus, the main goal of the present study was to assess differences in executive functioning between monolingual and multilingual toddlers using the EEFQ. Three hypotheses were tested. First, when comparing samples of monolingual and multilingual children, it was predicted that multilinguals would show higher executive functioning than monolinguals in the following domains: inhibitory control, attentional flexibility, and regulation. However, as there is limited evidence to suggest that children exposed to multiple languages have greater working memory than monolinguals, we expected this cognitive skill to be similar between both groups. Second, among all participants, we expected that those with greater non-dominant language exposure would exhibit stronger inhibitory control, attentional flexibility, and regulation than those with less non-dominant language exposure. However, no such effect was predicted for working memory. Third, given that TEs provide opportunities for language switching, multilinguals with a larger proportion of TEs should have greater inhibitory control, attentional flexibility, and regulation than participants with a lower proportion of TEs.

Method

Participants

Participants were recruited in Montréal, Canada through birth lists provided by a governmental health agency, posts made on the laboratory Facebook account, and flyers mailed to consenting daycares. To be eligible for the study, participants were required to be between 20 and 27 months old, be born full-term, have some exposure to French or English, and have no visual or auditory difficulties.

A total of 95 children participated in the study; however, 11 participants did not complete the testing and 3 participants were found to be statistical outliers (see Results section for further information on data cleaning). No participant was excluded for other reasons. To test our first and second hypotheses, we used a final sample of 81 participants (41 male, M_{age} = 23.36 months). On average, participants had 24.22% exposure to one or more non-dominant languages (see Table 1 for descriptive statistics), and the most common first, second, or third languages spoken were French and English (see Table 2 for language breakdown).

Table 1

Descriptive Statistics

	N	Minimum	Maximum	Mean	Standard Deviation
			Total Sample		
Age (months)	81	20.00	27.00	23.36	2.27
ND Exposure *	81	0.00%	54.45%	24.22%	18.84%
Parental Education (years) **	81	11	23	16.75	2.50
			Monolinguals		
Age (months)	39	20.00	27.00	23.46	2.27
ND Exposure	39	0.00%	18.81%	6.63%	5.61%
Parental Education (years)	39	11	23	16.78	2.64
			Multilinguals		
Age (months)	42	20.00	26.00	23.26	2.30

ND Exposure	42	21.00%	54.45%	40.56%	9.77%
Parental Education (years)	42	11	22	16.73	2.39
French-English Multilinguals					
Age (months)	31	20.00	26.00	23.58	2.157
ND Exposure	31	3.96%	64.64%	36.02%	17.14%
French Exposure	31	2.97%	96.04%	51.02%	24.28%
English Exposure	31	2.97%	91.09%	35.45%	23.46%
TE ***	31	5.8%	67.7%	33.99%	15.04%
Dominant Production	28	29	507	199.00	140.15
ND Production	31	10	492	113.39	100.50
Parental Education (years)	31	11	23	16.92	2.43

* ND refers to non-dominant; ** In Québec, 11 years of education corresponds to a high school diploma; *** TE refers to translation equivalent.

Table 2

Language Frequencies for Total Sample

Language *	Total
First Language	
French	33
English	28
Spanish	6
Mandarin	4
Serbian	2

Arabic	1
Bulgarian	1
Chinese	1
German	1
Greek	1
Korean	1
Russian	1
Yoruba	1
Second Language	
English	32
French	23
N/A	8
Arabic	4
Spanish	3
Italian	2
Bulgarian	1
Chinese	1
Creole	1
Filipino	1
Kabyle	1
Mandarin	1
Patois	1
Portuguese	1
Bisaya	1
Third Language	

N/A	47
English	14
French	14
Armenian	1
Mohawk	1
Polish	1
Tamil	1
Ukrainian	1
Yiddish	1
Fourth Language	
N/A	79
Chinese Dialect	1
Spanish	1

* Language is self-reported by participants' parents.

The mean parental education of all participants was 16.75 years, which is roughly equivalent to a bachelor's degree. Parental education did not significantly differ between monolingual and multilingual participants ($t(79) = .10$, $p = .92$, Cohen's $d = .02$) and there was a wide range of parental education represented in all groups (high school diploma to doctorate degree). However, the sample was slightly skewed toward higher education. While highly educated and high SES participants are over-represented in the literature on bilingualism and limit the generalizability of results to participants from lower socioeconomic backgrounds, our sample roughly matches the education demographics in Montréal (Statistics Canada, 2017).

To test our first hypothesis, we split our final sample into two language groups: monolinguals (39 participants) and multilinguals (42 participants). Monolingual participants are those with over 80% exposure to their dominant language (i.e., the language with the greatest exposure), as reported by the Language Exposure Assessment Tool. Dominant language exposure ranged from 81.19% to 100% for monolinguals (*M* = 93.37%). Monolinguals' average non-dominant language exposure was only 6.63%. As the sample includes 34 participants with exposure to more than two languages, multilingual participants are defined as those with 20% or greater combined exposure to their non-dominant language(s) (i.e., sum of second, third, and fourth language exposure). Previous literature typically cites a range of 10% to 40% minimum non-dominant language exposure for multilinguals (Byers-Heinlein, 2015); the present study required a minimum of 20%, as this is a common selection criterion used in previous literature (see Crivello et al., 2016; Legacy et al., 2016; Poulin-Dubois et al., 2011; Poulin-Dubois et al., 2021). Combined non-dominant language exposure ranged from 21.00% to 54.45% for multilingual participants (*M* = 40.56%). Bilingualism research typically assesses only two languages: a first language and a second language. When limited to two languages, the maximum second language exposure score is 50%. However, because some of our participants were exposed to four languages, the maximum composite non-dominant language value could have been up to 80%.

To test our third hypothesis, we created a sub-sample of 31 French-English multilingual participants from our overall sample (16 female, M_{age} = 23.58 months). French-English multilinguals were individuals who had any amount of exposure to both French and English. Participants not exposed to both French and English, or who did not complete both the French and English versions of the MacArthur-Bates Communicative Development Inventories were excluded from this sub-sample. Average French exposure was 51.02% (range = 2.97% – 96.04%) and average English exposure was 35.45% (range = 2.97% – 91.09%; see Table 1 for descriptive statistics and Table 3 for language breakdown).

Table 3

Language Frequencies for French-English Multilinguals

Language *	Total
First Language	
French	20
English	8
Italian	1
Mandarin	1
Spanish	1
Second Language	
English	17
French	8
Arabic	2
Bulgarian	1
Mandarin	1
Portuguese	1
Spanish	1
Third Language	
N/A	17
English	6
French	3
Armenian	1
Italian	1

Polish	1
Ukrainian	1
Yiddish	1
Fourth Language	
N/A	29
Chinese Dialect	1
Greek	1

* Language is self-reported by participants' parents.

Measures

Language Exposure Assessment Tool (LEAT)

The LEAT (DeAnda et al., 2016) is a semi-structured interview conducted with the participants' parents to assess children's exposure to various languages from birth. Parents report any adult who has had regular communication with their child (i.e., daily or weekly), which languages each adult speaks, and how much time they spend with the child. This information allows researchers to estimate the percentage of time that the child has heard each language since birth. We used the information provided by the LEAT to calculate dominant and non-dominant language exposure and determine participants' language group (monolingual or multilingual).

MacArthur-Bates Communicative Development Inventories: Words and Sentences (MCDI:WS)

The American-English MCDI:WS (Fenson et al., 1993) and its Québec-French adaptation (Trudeau et al., 1999) are parent checklists that estimate the size of children's productive vocabulary in their respective languages. Both versions of the MCDI:WS were administered online via Wordbank (Frank et al., 2016). The MCDI:WS is suitable for use in children 16- to 30-months-old. We used both the American-English and Québec-French forms to measure TEs among French-English multilingual participants. However, all participants were asked to complete one or both versions of the MCDI:WS, as the questionnaire also included a one-page demographics form that was used to assess participants' family and health history and SES.

The frequency of TEs in the children's vocabulary was calculated by identifying word pairs that refer to similar concepts in both French and English (e.g., *dog* in English and *chien* in French). To match French-English TEs we used a template created by Legacy and colleagues (2016). We also identified and removed any cognates and semi-cognates from the count of TEs. Finally, as past research has found that children with larger vocabularies in both their dominant and non-dominant languages also report more TEs (David & Wei, 2008; Legacy et al., 2016; Montanari, 2010; Pearson et al., 1995; Pearson et al., 1997; Tsui et al., 2021), we controlled for combined French-English vocabulary size by calculating proportional TEs using the following formula:

Translation Equivalents = ((Total Word Pairs – Cognates – Semi-Cognates) x 2) ÷ (Total French-English Vocabulary Size – Cognates – Semi-Cognates – Total Non-Equivalents)

Early Executive Functions Questionnaire (EEFQ)

The EEFQ (Hendry & Holmboe, 2021) is a parental report that has been validated for use in children 9- to 30-months-old and measures four domains of executive functioning: inhibitory control (Cronbach's alpha = .629 - .717), attentional flexibility (Cronbach's alpha = .540 - .763), working memory (Cronbach's alpha = .659 - .711), and regulation (Cronbach's alpha = .818 - .862; Hendry & Holmboe, 2021). Additionally, the combined averages of the inhibition, flexibility, and working memory scales load into an overall Cognitive Executive Function (CEF) scale. Among the total sample of the present study similar Cronbach's alpha scores were found for inhibitory control (.615), attentional flexibility (.652), and regulation (.870). A relatively high Cronbach's alpha value was also noted for the CEF scale (.771). However, we noted low internal consistency for the working memory scale (.333).

The EEFQ was administered in either Québec-French or English via SurveyMonkey. This questionnaire consists of two parts: games and survey questions. In the first portion of the EEFQ, parents play three games with their children and are prompted to report how their child performed. Parents were provided with verbal instructions for each game prior to administration; additionally, written and video instructions were directly embedded in the online survey.

During the Waiting Game (an inhibitory control task), parents gave their child any food that the child likes and asked that the child wait 30 seconds before eating it. Parents then indicated how long their child waited before eating the food. During the Finding Game (a working memory task), parents placed a small toy under one of two distinct, opaque containers and asked their child to reach to where the toy was hidden. Parents repeated this task four times in total, switching between the two containers each time. Parents then indicated how often their child reached for the correct container. Finally, during the Finding Game (an attentional flexibility task), parents asked that their child sort five small spoons into a small bowl and five large spoons into a large bowl. If the child performed well on this task, they were then asked to sort the five large spoons into the small bowl and the five small spoons into the large bowl. Parents indicated how their child performed on both of these tasks. While most parents opted to use materials found in their home, we provided the game materials to parents who requested it (16 of 96 participants tested requested materials). The second portion of the EEFQ consists of 27 questions that assess the child's cognitive functioning over the past two weeks, ranked on a 7-point scale from *Never* to *Always* (e.g., *how often in the last two weeks did your child work for a long time trying to do something difficult*).

The EEFQ is composed of four sub-scales, one for each facet of executive function the questionnaire measures. Each sub-scale has seven or eight items with each game counting as a single item. We calculated sub-scale averages, which can range from 1 (low functioning) to 7 (high functioning). Participants with less than 70% of items answered for a specific sub-scale were removed from that sub-scale's analyses (Hendry & Holmboe, 2021).

Procedure

The testing unfolded in two parts: a video call and the online questionnaires. First, parents met with a research assistant via Zoom Video Communications; meetings and all corresponding study materials were offered in either French or English. During the video call a research assistant fluent in French or English obtained parental consent through an online form hosted on Google Forms. The research assistant then presented a PowerPoint to parents which outlined the study procedure, answered any initial questions, and asked if parents would require game materials. Finally, the research assistant administered the LEAT.

Parents were then emailed links to the EEFQ and MCDI. If a child had exposure to both French and English, parents were sent both versions of the MCDI to complete; however, if the child was only exposed to one of the two languages, parents were only sent the corresponding version. Participants were given approximately two weeks to complete the questionnaires; upon completion of the study, participants were compensated with a Certificate of Merit and a $20 gift card to a local bookstore.

Results

Data Cleaning

Data analyses were performed in SPSS 27 (IBM, 2020). Prior to conducting the main analyses, assumptions were checked for both the total sample and sub-sample of French-English multilinguals (see Table 4 for descriptive statistics of EEFQ sub-scales).

Table 4

Descriptive Statistics of EEFQ Sub-Scales

	N	Min.	Max.	Mean (SD *)	Skewness (SE **)	Kurtosis (SE **)
				Total Sample		
Inhibitory Control	80	2.75	6.13	4.66 (0.75)	−0.26 (0.27)	−0.23 (0.53)
Attentional Flexibility	78	2.88	6.75	4.96 (0.83)	0.03 (0.27)	−0.01 (0.54)
Working Memory	80	4.57	7.00	5.76 (0.52)	0.17 (0.27)	−0.18 (0.53)
Regulation	79	1.63	6.60	4.56 (1.13)	−0.62 (0.27)	−0.17 (0.54)
CEF ***	81	3.83	6.39	5.12 (0.55)	0.17(0.27)	−0.48 (0.53)
				Monolinguals		
Inhibitory Control	39	2.75	6.00	4.41 (0.85)	0.06 (0.38)	−0.75 (0.74)
Attentional Flexibility	38	2.88	6.75	4.98 (0.91)	−0.22 (0.38)	0.14 (0.75)
Working Memory	39	4.83	7.00	5.73 (0.51)	0.29 (0.38)	−0.07 (0.74)
Regulation	38	2.38	6.60	4.59 (1.10)	−0.38 (0.38)	−0.30 (0.75)
CEF	39	4.13	6.13	5.04 (0.52)	.30 (0.38)	−0.79 (0.74)
				Multilinguals		
Inhibitory Control	41	3.88	6.13	4.90 (0.56)	0.27 (0.37)	−0.22 (0.72)

Attentional Flexibility	40	3.67	6.63	4.94 (0.75)	0.42 (0.37)	−0.31 (0.73)
Working Memory	41	4.57	7.00	5.78 (0.54)	0.05 (0.37)	−0.11 (0.72)
Regulation	41	1.63	6.25	4.54 (1.16)	−0.83 (0.37)	−0.02 (0.72)
CEF	42	3.83	6.39	5.19 (0.57)	0.02 (0.37)	−0.14 (0.72)
French-English Multilinguals						
Inhibitory Control	30	3.13	6.13	4.96 (0.69)	−0.49 (0.43)	0.37 (0.83)
Attentional Flexibility	29	3.75	6.63	5.12 (0.85)	0.37 (0.43)	−0.77 (0.85)
Working Memory	30	5.00	7.00	5.87 (0.47)	0.67 (0.43)	0.42 (0.83)
Regulation	31	2.29	6.25	4.65 (1.04)	−0.72 (0.42)	0.14 (0.82)
CEF	30	4.33	6.41	5.32 (0.55)	0.07 (0.43)	−0.84 (0.84)

* SD refers to standard deviation; ** SE refers to standard error; *** CEF refers to Cognitive Executive Function.

Total Sample

No participant had a *z*-score that was ± 3 standard deviations from the mean for any of the main variables (i.e., non-dominant language exposure, inhibitory control, attentional flexibility, working memory, regulation, and CEF); thus, no univariate outliers were identified. Bivariate outliers were identified by creating scatterplots between each combination of main variables. Two participants were identified to have extreme bivariate outlier scores and were removed from the dataset. This process was repeated once more, with no bivariate outliers identified during the second round. Finally, we checked the final scatterplots to assess normality, linearity, and homoscedasticity; these assumptions were met. Finally, the skewness and kurtosis of each variable were examined. All skewness statistics were <±1 and the only kurtosis score beyond ±1 was non-dominant language exposure (kurtosis = -1.583, standard error = .529). Overall, the study variables met the assumption of normality.

French-English Sub-Sample

No participant had a z-score that deviated ± 3 standard deviations from the mean for any main variable (i.e., TEs, inhibitory control, attentional flexibility, working memory, regulation, and CEF) and no univariate outliers were identified. Bivariate outliers were assessed in the same manner as described above; no extreme bivariate outliers were identified. We checked skewness and kurtosis of each main variable; all skewness and kurtosis statistics were < ±1, suggesting normality. Finally, note that one participant removed from our total sample was kept in the sub-sample analyses, as this participant did not have any bivariate outlier scores for the variables relevant to the sub-sample analyses.

Language Group Differences

Although current directions in bilingualism research suggest that multilinguals be assessed on a continuum (Bialystok & Craik, 2022; Kremin & Byers-Heinlein, 2021; Lowe et al., 2021; see sections 3.3 and 3.4), we first categorized monolinguals and multilinguals in order to assess between-group differences. As the EEFQ has not been previously used to investigate the bilingual cognitive advantage, using a categorical method, in addition to a continuous approach, allows the present findings to be more easily compared to the previous literature, which has largely used a categorical variable (see Adesope et al., 2010; Lowe et al., 2021).

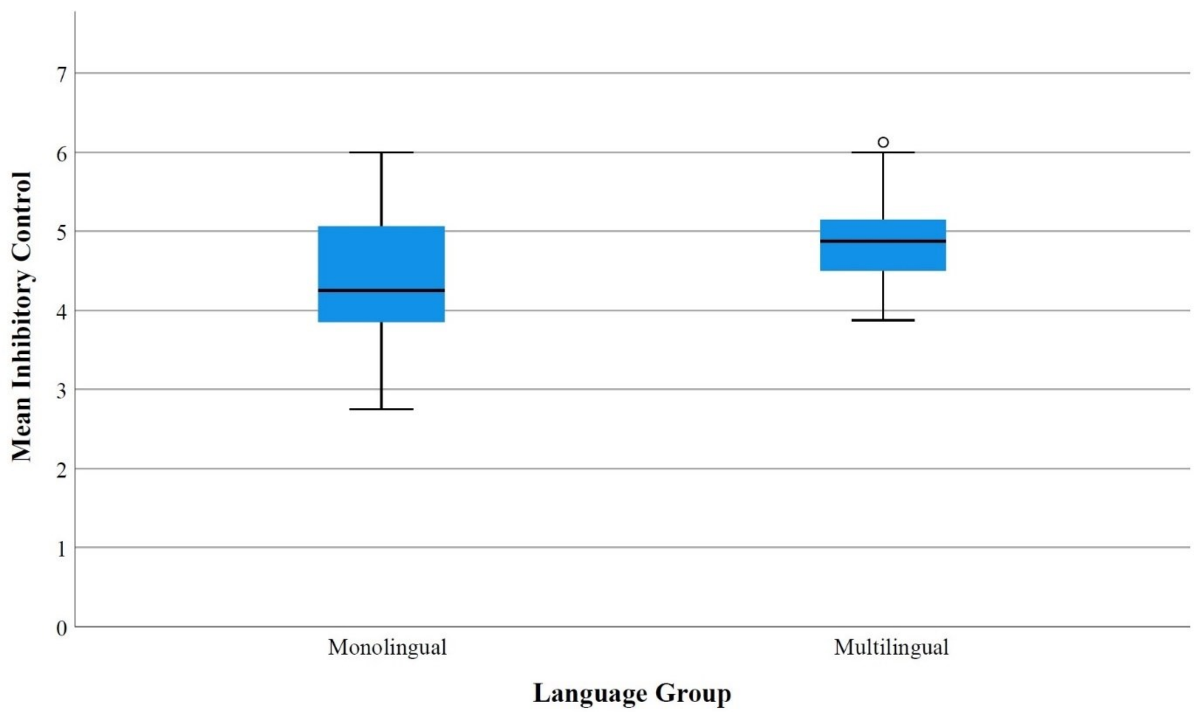
Before assessing language group differences on the key variables, we first ran an independent samples t-test to ensure that non-dominant language exposure significantly differed between monolingual and multilingual participants. As expected, multilinguals had significantly greater non-dominant language exposure (*M* = 40.56%) than monolinguals (*M* = 6.63%; $t(66.27) = 19.33$, $p = <.001$, Cohen's $d = 4.22$). To test the first hypothesis that multilingual participants would have greater inhibition, attentional flexibility, and regulation skills than monolingual participants, we conducted a series of one-way between-subjects ANCOVAs. For each ANCOVA, language group (monolingual or multilingual) acted as the independent variable with age and parental education as control variables. Each of the four executive function sub-scales and the average CEF score acted as dependent variables.

Inhibitory Control

After controlling for age and parental education, multilingual participants' average inhibitory control score was 0.50 points higher than that of the monolingual participants; this difference was statistically significant (Monolinguals: *M* = 4.40, *SE* = .11, 95% CI [4.18, 4.63]; Multilinguals: *M* = 4.90, *SE* = .11, 95% CI [4.68,5.12]; $F(1, 76) = 9.84$, $p = .002$; see Figure 1). Additionally, the main effect of language group explained about 11.5% of the total variance in inhibitory control scores ($\eta^2 = .115$). Thus, around the age of 23 months multilingual toddlers display greater inhibitory control skills than their monolingual peers, supporting our first hypothesis.

Figure 1

Boxplot of Inhibitory Control Score by Language Group



Attentional Flexibility

Contrary to our hypothesis, there was not a significant difference between monolinguals' and multilinguals' mean attentional flexibility scores after controlling for age and parental education (Monolinguals: $M = 4.98$, $SE = .14$, 95% CI [4.71, 5.26]; Multilinguals: $M = 4.93$, $SE = .13$, 95% CI [4.67, 5.20]; $F(1, 74) = .07$, $p = .787$). The main effect of language group only explained 0.1% of the total variance in attentional flexibility scores ($\eta^2 = .001$).

Working Memory

We did not predict that language group would influence working memory scores. As expected, there was not a significant difference between the two groups' average working memory score, with monolinguals scoring only .06 points lower than multilinguals (Monolinguals: $M = 5.72$, $SE = .08$, 95% CI [5.56, 5.90]; Multilinguals: $M = 5.79$, $SE = .08$, 95% CI [5.62, 5.95]; $F(1, 76) = .29$, $p = .589$). The main effect of language group only explained 0.4% of the total variance in working memory skills ($\eta^2 = .004$).

Regulation

We compared the regulation scores between monolingual and multilingual toddlers. Unexpectedly, multilinguals scored .09 points lower than monolinguals; this mean difference was not statistically significant (Monolinguals: $M = 4.61$, $SE = .18$, 95% CI [4.24, 4.97]; Multilinguals: $M = 4.52$, $SE = .18$, 95% CI [4.17, 4.88]; $F(1, 75) = .11$, $p = .741$). The main effect of language group only explained 0.1% of the total variance in regulation scores ($\eta^2 = .001$).

CEF

Finally, we assessed whether monolingual and multilingual participants significantly differed in their average CEF scores. While multilinguals did score .16 points higher than monolinguals, this was not a statistically significant difference (Monolinguals: $M = 5.04$, $SE = .09$, 95% CI [4.86, 5.21]; Multilinguals: $M = 5.19$, $SE = .08$, 95% CI [5.03, 5.36]; $F(1, 77) = 1.69$, $p = .198$). The main effect of language group explained 2.1% of the total variance in CEF scores ($\eta^2 = .021$).

Language Exposure on a Continuum

Our second hypothesis was that individuals with greater non-dominant language exposure would have greater inhibition, attentional flexibility, and regulation. To assess this hypothesis, we assessed multilingualism on a continuum. We first computed correlations between non-dominant language exposure and the four executive functions (see Table 5). We found a significant positive correlation between non-dominant language exposure and inhibitory control, supporting our hypothesis (r = .28, p = .011); however, non-dominant language exposure was not significantly correlated with any other executive function skills. In addition to bivariate correlations, we conducted a series of linear regressions to assess our second hypothesis. For each regression, non-dominant language exposure was entered as the independent variable. Model 1 included age and parental education, and Model 2 included the target executive function.

Table 5

Bivariate Correlations between Non-Dominant Language Exposure and EEFQ Sub-Scales

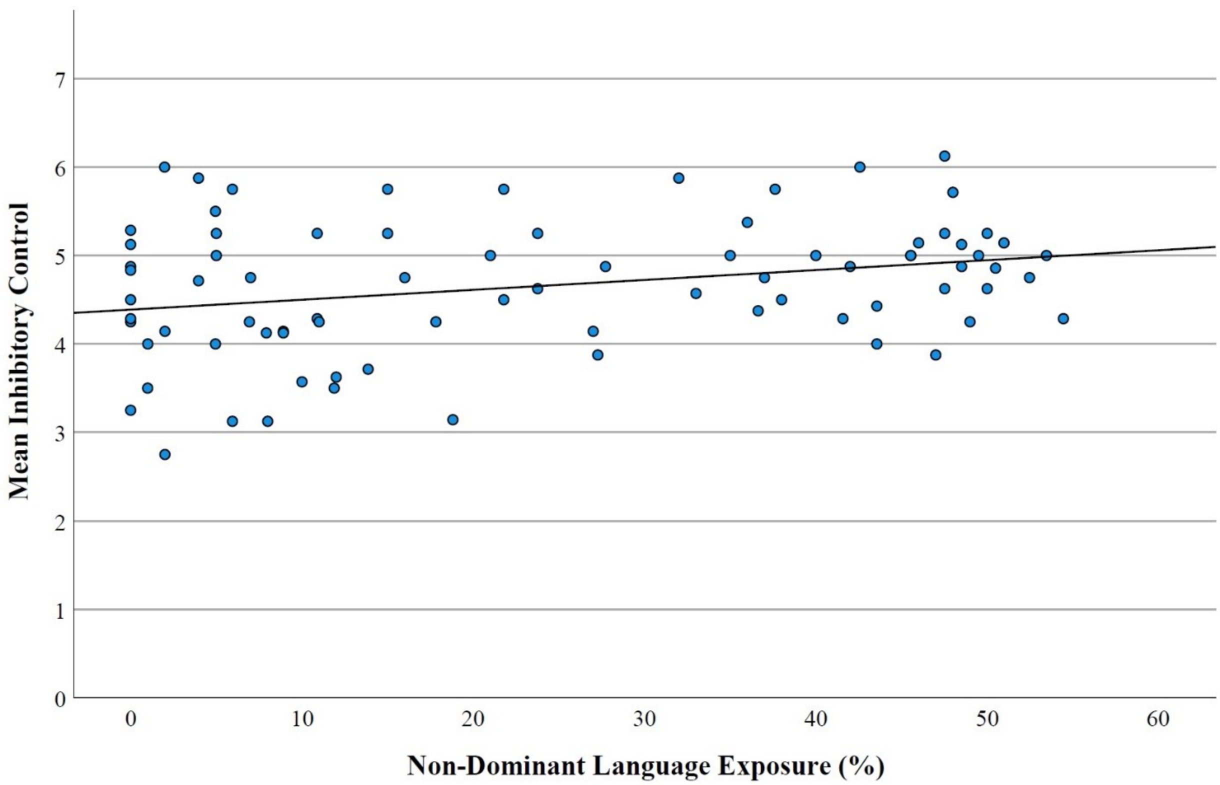
	Inhibitory Control	Attentional Flexibility	Working Memory	Regulation	CEF
ND Exposure					
Correlation	0.28	−0.07	0.02	0.02	0.18
p-value (2-tailed)	0.011	0.524	0.834	0.844	0.104
N	80	78	80	79	81

Inhibitory Control

Model 1 did not yield significant results and only accounted for 2.5% of the variance in inhibitory control scores ($F(2, 77) = .99$, $p = .376$, $R^2 = .03$, $R^2_{adjusted} = .00$). Additionally, the main effects of age ($\beta = .04$, $p = .301$, 95% CI [-.04, .11]) and parental education ($\beta = -.03$, $p = .377$, 95% CI [-.10, .04]) were not significant predictors of inhibitory control. Alternatively, Model 2 yielded significant results and controlled for 10.7% of the variance in the outcome (F(3, 76) = 3.03, p = .035, R^2 = .11, $R^2_{adjusted}$ = .07). After controlling for age and parental education, non-dominant language exposure explained 8.2% of the variance in inhibitory control scores; this was a statistically significant contribution (ΔR^2 = .08, ΔF(1, 76) = 6.95, p = .010). Finally, non-dominant language exposure was a significant unique contributor to inhibitory control scores, suggesting that the main effect of non-dominant language exposure significantly predicted inhibition (β = .01, p = .010, 95% CI [.00, .02]). Overall, the results from the linear regression support our first hypothesis when testing second language exposure on a continuum. Individuals with greater non-dominant language exposure had higher inhibitory control scores even when the effects of age and parental education were statistically removed (see Figure 2).

Figure 2

Regression Plot of Inhibitory Control Score by Non-Dominant Language Exposure



Other Executive Function Skills

The results of the linear regressions assessing the effects of non-dominant language exposure on attentional flexibility, working memory, regulation, and CEF were all statistically non-significant (see supplementary materials for regression table). Overall, our second hypothesis was partially supported. As expected, greater exposure to non-dominant language(s) predicted stronger inhibitory control skills whereas non-dominant language exposure did not significantly predict working memory. Unexpectedly, non-dominant language exposure also did not predict attentional flexibility nor regulation. The regression results do not support evidence for an overall multilingual cognitive advantage, even when assessing multilingualism on a continuum. Instead, as with the ANCOVA results, the regression analyses support the notion that individuals with more non-dominant language exposure have stronger inhibitory control (i.e., domain-specific cognitive skills).

Executive Function, Translation Equivalents, and Vocabulary Production

Our final hypothesis concerned the impact of TEs on executive functioning that could only be assessed with French-English multilingual individuals ($N = 31$, $M_{TE} = 33.99\%$). A higher proportion of TEs in productive vocabulary was expected to be associated with greater inhibition, attentional flexibility, and regulation. Due to the limited sample size, this hypothesis was assessed by calculating partial correlations, controlling for age and parental education. No significant correlations were found for any of the executive function sub-scales nor for the average CEF score (see Table 6). Thus, our third hypothesis was not supported. Executive functioning does not appear to be associated with the proportion of TEs known by 23-month-old French-English multilinguals.

Table 6

Partial Correlations between Translation Equivalents and EEFQ Sub-Scales Controlling for Age and Parental Education

	Inhibitory Control	Attentional Flexibility	Working Memory	Regulation	CEF
TE					
Correlation	0.14	−0.06	0.22	−0.11	0.11
p-value (2-tailed)	0.46	0.75	0.27	0.57	0.58
N	30	29	30	31	30

Upon discovering that the EEFQ-TE correlations were non-significant, we decided to conduct a series of post-hoc analyses to determine whether non-dominant vocabulary size would be associated with executive functioning within the French-English sub-sample. First, we ran a paired-samples t-test confirming that dominant vocabulary production size (M = 199.00 words, SD = 140.15 words) was significantly greater than non-dominant vocabulary production size (M = 121.21 words, SD = 102.57 words; $t(27) = 2.79$, $p = .009$, Cohen's $d = .53$). Second, we conducted a series of partial correlations between non-dominant vocabulary production and each executive function sub-scale, controlling for age and parental education. If any significant associations between non-dominant vocabulary production and executive functioning were found, we expected them to have a negative relationship. Past studies with adults have shown that when individuals know fewer words in their non-dominant language, they require more active suppression of their dominant language while the non-dominant language is engaged. More practice actively suppressing the dominant language may then lead to greater gains in executive functioning skills (Gollan and Ferreira 2009; Meuter and Allport 1999; Misra et al. 2012). The partial correlation results for each sub-scale, including CEF, were non-significant (*p*-value range: .411 - .909), with the exception of working memory. Unexpectedly, working memory had a positive and significant association with non-dominant language production ($r(26) = .45$, $p = .017$).

Discussion

The main goal of the present study was to test the bilingual cognitive advantage hypothesis in very young children. A unique contribution of the current study was to shed light on an early cognitive advantage in multilingual toddlers by collecting measures of executive functioning with a questionnaire completed by the participants' parents. Given that past studies have found evidence for a bilingual cognitive advantage in the domains of response inhibition (Lowe et al., 2021), attentional flexibility (Carlson & Meltzoff, 2008; Crivello et al., 2016), and regulation (Barker & Bialystok, 2019), it was hypothesized that multilingual toddlers would obtain higher scores in these domains. Additionally, by adopting an approach that treats bilingualism on a continuum, it was expected that participants with greater non-dominant language exposure would show higher response inhibition, attentional flexibility, and regulation. Finally, it was predicted that a higher proportion of TEs in productive vocabulary would boost cognitive skills, as TEs are assumed to provide more opportunities to practice switching languages, thus gaining stronger inhibition and attentional skills (Crivello et al., 2016; Patterson & Pearson, 2004; Singh, 2014). Across all three hypotheses, we expected no significant effects for working memory.

Our first two hypotheses were partially supported. First, multilinguals had greater response inhibition compared to monolinguals. Similarly, greater second language exposure predicted stronger response inhibition. There were no significant results observed for attentional flexibility, working memory, regulation, nor CEF. Additionally, TE proportion did not significantly predict any cognitive skill nor overall CEF. In line with recent meta-analyses on the bilingual advantage in children (Gunnerud et al., 2020; Lowe et al., 2021), our findings do not support the conclusion of a global cognitive advantage, regardless of whether language status, exposure, or TE proportion were assessed. Instead, a domain-specific advantage was found for response inhibition, which was present both when monolingual and multilingual groups were directly compared and when multilingualism was assessed on a continuum.

Response Inhibition

In line with a recent meta-analysis based on children aged 3 to 17 years (Lowe et al., 2021), we found that a multilingual advantage for hot inhibition, or response suppression, is present by 23 months of age. It is worth noting that the present study found a multilingual advantage using a non-dominant language exposure threshold of 20% for the multilingual group. This provides a conservative test of the bilingual cognitive advantage hypothesis. While Lowe and colleagues (2021) suggested that a multilingual advantage may be mitigated by SES, the present study found significant effects even after controlling for parental education. We further expand upon Lowe and colleagues' findings by looking beyond language status effects, finding that language exposure specifically predicts response inhibition skills.

While the present study has succeeded in finding an effect of language status and language exposure for hot inhibition, past studies have reported a benefit for attentional inhibition to a distractor, as measured by the Dimensional Change Card Sort, Attentional Network, or Stroop tasks (e.g., Bialystok & Martin, 2004; Carlson & Meltzoff, 2008; Poarch & van Hell, 2012; Poulin-Dubois et al., 2011); however, bilingual advantages in response inhibition appear less prevalent in the literature (e.g., Carlson & Meltzoff, 2008; Crivello et al., 2016; for a review see Bialystok & Craik, 2022). Perhaps measuring response inhibition through a parental report provided insight into a greater range of behaviors that may be overlooked in lab assessments with a single task. For example, response inhibition may be more salient in everyday contexts, as measured in the EEFQ, than is the case for a single laboratory-based task. Another possibility is that the tasks typically used to assess conflict in toddlers may have also measured response inhibition (Esposito et al., 2013). Future research could investigate differences between parental report and in-lab measures of hot inhibition with a similar sample of children.

Attentional Flexibility

Although attentional flexibility is believed to be a core function of the bilingual cognitive advantage (Bialystok, 2017; Bialystok & Craik, 2022), the present study failed to find any significant effects for this skill in a young sample. None of the measures of multilingualism (i.e., language status, language exposure, TE proportion, or non-dominant language production) were significantly associated with this executive function. While these findings were unexpected, they replicate many recent studies failing to find a bilingual advantage in attentional flexibility among infants and children (Gunnerud et al., 2020; Lowe et al., 2021; Poulin-Dubois et al., 2011; Poulin-Dubois et al., 2021). In bilinguals, this executive function is typically tested with tasks that require inhibitory control and working memory, such as the Dimensional Change Card Sort task. Among infants and toddlers, Reverse Categorization has resulted in null findings, likely due to a floor effect (Poulin-Dubois et al., 2011). Similarly, the attentional flexibility sub-scale of the

EEFQ may not be a pure measure of this executive function; in the game included in this sub-scale, rules are switched half-way through the game (small spoons that had previously been placed in the small container should instead be placed in the large container). This task likely requires both response inhibition and working memory skills, as well as attentional flexibility. Thus, the explicit measures mentioned above may not capture attentional control as measured in the anticipatory looking tasks used with preverbal infants by Kovács & Mehler (2009) and Comishen and colleagues (2019), explaining the difference in results.

Working Memory

As expected, we found no evidence that language status, language exposure, nor TE proportion are significantly associated with working memory skills. These results replicate and extend recent meta-analyses failing to find a significant effect of language status on working memory skills during childhood (Gunnerud et al., 2020; Lowe et al., 2021) and individual studies failing to find a language status effect during infancy (Brito et al., 2021; Poulin-Dubois et al., 2011; Poulin-Dubois et al., 2021); the present study also failed to find a significant effect when also considering non-dominant language exposure. Finally, we extended the findings of Crivello and colleagues (2016) who found that TE growth over a 7-month period was not significantly associated with performance on a similar multi-location task. There is also no evidence for an association between working memory and TE proportion measured at a single time-point. Somewhat unexpectedly, there was a significant positive association between working memory and non-dominant vocabulary production among the French-English multilingual sub-sample. Although we had not originally anticipated this finding, it does replicate previous research noting significant associations between second language proficiency and working memory, particularly among children (Grundy & Timmer, 2016). Overall, working memory does not appear to be associated with language exposure nor TEs; instead, non-dominant language production may influence working memory skills in children. Future research may be needed to assess the directionality of the association between non-dominant language production and working memory, specifically using the EEFQ to measure this cognitive skill.

Regulation

Limited research has been conducted on the differences between emotional regulation and multilingualism, particularly during childhood. However, it has been found that by early adulthood bilinguals exhibit greater emotional regulation than their monolingual peers (Barker & Bialystok, 2019). Unexpectedly, the present study failed to replicate these findings in a sample of 23-month-olds; no significant effects of language status, language exposure, TE proportion, nor non-dominant language production were noted. One possibility for these non-significant findings is that emotional regulation skills may be relatively undeveloped before 2 years of age, leading to limited, if any, differences between monolinguals and multilinguals at this age. The ability to efficiently monitor emotions and control emotional responses relies on the use of multiple executive functions (Montroy et al., 2016); however, before the third year of life, children may have difficulty coordinating the simultaneous use of multiple executive functions to regulate complex behavioral responses (Carlson et al., 2002; Diamond, 2002; Zelazo et al., 2003). Thus, it is possible that a multilingual advantage in emotional regulation develops later in life once executive functioning is better developed. A recent report on the validation of the EEFQ with a large sample of British children has revealed that, although inhibitory control, attentional flexibility, and working memory items load into a Cognitive Executive Function (CEF) sub-scale, regulation does not (Hendry & Holmboe, 2021). Thus, second language knowledge may not influence regulation in the same manner as theorized with cognitive executive functions.

Association between Translation Equivalents and Executive Functioning

The bilingual advantage in executive functioning is thought to stem from the fact that managing multiple languages requires executive resources in the form of selection of the relevant language and inhibition of the language inactive at that moment (Abutalebi & Green, 2007; Bialystok et al., 2009; Green, 1998; Meuter & Allport, 1999; Rodriguez-Fornells et al., 2006; Ye & Zhou, 2009). Studies on language switching provide evidence as to why inhibitory control is more efficient in bilinguals. Bilinguals who are less proficient in their non-dominant language must inhibit their dominant language more strongly in order to avoid interference while using their non-dominant language (e.g., Gollan & Ferreira, 2009; Meuter & Allport, 1999; Misra et al., 2012). In line with the hypothesis that the proposed bilingual cognitive advantage stems from practice in language control (i.e., selecting the target language and/or inhibiting the non-target language), the frequency of code-switching behaviors calling for such cognitive processes has been found to correlate with executive measures in both adults and children (Bosma & Blom, 2019; Gross & Kaushanskaya, 2015; Lai & O'Brien, 2020; Soveri et al., 2011). In the present study, we used the proportion of TEs as proxy for opportunities for code-switching. As the frequency of TEs in productive vocabulary may indicate switching between language systems (Patterson & Pearson, 2004), we assumed that evidence for switching between French and English would provide an estimate of the participants' ability to switch between several language systems; however, this may not have been the case. We failed to find any evidence that the proportion of TEs in participants' vocabulary was associated with better executive functioning among our sample of French-English multilinguals.

At first glance, these findings appear to conflict with previous reports that TE growth between 24 and 31 months is associated with stronger cognitive skills (Crivello et al., 2016).

However, the TE proportion used in the present study may be a conservative measure of participants' actual TE proportion. To maximize our sample size, the French-English sub-sample was not limited to strict French-English bilinguals; instead, many of the participants were exposed to a third or fourth language. Unfortunately, we were limited to analyzing only French-English TEs due to our lack of proficiency in other languages. Nevertheless, it is worth noting that our sample meets the benchmark of at least 30% TEs by 36 months of age (Byers-Heinlein & Werker, 2013; David & Wei, 2008; Lanvers, 1999), even with the conservative measure used. We also examined whether proficiency in the non-dominant language predicted executive functioning, as is the case in adults, but no such link was observed, with the exception of working memory. For the French-English multilinguals, the average non-dominant vocabulary size was 113 words, and 14 of these multilinguals were also exposed to a third language that was not assessed. Thus, it is likely that these factors did not allow us to document code-switching reliably. An aim for future studies will be to directly assess code-switching in very young children and its potential impact on executive functioning.

Strengths, Limitations, and Future Directions

A main strength of the EEFQ is its ecological validity. The use of a parental report contrasts with the standard approach that compare monolingual and multilingual cognition using in-lab assessments. Researchers have questioned whether multilingual advantages on laboratory tasks signify advantages in real-world behaviors (Poarch & Krott, 2019). As the EEFQ asks parents to reflect on children's everyday actions (e.g., *how often has your child approached or reached for something they had repeatedly been told not to touch*), this measure captures behaviors that might be missed in a single direct assessment conducted in the laboratory.

While there are many advantages to the EEFQ, there are also disadvantages. In the present study, researchers had limited experimental control over the EEFQ games that parents administered independently. It is possible that some parents helped their children to complete the games, or that some parents were more familiar with the assessment used, giving them an advantage over parents less familiar with the tasks. Additionally, as parents were given the option to use materials they already had at their home, they may have used unsuitable materials. As we did not ask parents to record the games nor did we verify the materials used, we were unable to check for these potential sources of measurement error. However, to minimize this problem, we gave parents verbal, written, and video instructions prior to testing. Additionally, we offered to deliver materials to participants free-of-charge (for more information see Method section). Further, parents were not asked to record their children's performance on the EEFQ games for two reasons. First, the authors who developed and validated the EEFQ (Hendry & Holmboe, 2021) did not require that that tasks to be recorded. Second, we wished to minimize the participants' burden and privacy concerns in order to maximize our sample size. Finally, although the games could have been administered during a videocall, this would defeat a major benefit of the EEFQ, which is that the games can be administered whenever parents judge their children to be most cooperative.

Another limitation of the present study was the low variability in SES, measured through parental education. Whereas we found a multilingual advantage for response inhibition when controlling for SES, we noted no effects of SES in our regression models. This finding contrasts with the well-known links between SES and executive functioning (Bialystok & Craik, 2022; Brito & Noble, 2018; Calvo & Bialystok, 2014; Lowe et al., 2021) and may have been due to the low variability of SES in the present sample. It is well known that both SES and multilingualism impact executive functioning (Bialystok & Craik, 2022; Calvo & Bialystok, 2014).

Future research should aim to utilize parental reports when assessing the bilingual cognitive advantage among children. Specifically, the EEFQ can be used in younger children (as young as 9 months) in order to assess when a multilingual advantage in response inhibition develops. While an advantage in attentional inhibition has been noted among 24-month-old bilinguals (Poulin-Dubois et al., 2011), this advantage has not been observed at 17 months (Poulin-Dubois et al., 2021). Perhaps advantages in response inhibition develop earlier than attentional inhibition.

Conclusions

The present findings support the notion of a domain-specific cognitive advantage for response inhibition among multilinguals. Specifically, language exposure appears to be significantly associated with response inhibition, unlike both TE proportion and non-dominant vocabulary size. The present study adds to the previous literature by reporting an advantage in inhibition both when dichotomizing language status and assessing multilingualism on a continuum. Alternatively, language exposure alone is not a sufficient predictor of working memory at 23 months; instead, non-dominant language vocabulary size emerged as the only significant correlate of working memory. Additionally, to our knowledge, this is the first study to report differences between monolingual and multilingual executive functioning through use of a parental report. Finally, our results suggest that among 23-month-olds non-dominant language exposure may be a stronger indicator of executive functioning than second-language vocabulary production or proportional TE count.

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Appendix A: Early Executive Functions Questionnaire

Early Executive Functions Questionnaire Scoring

999 = Item not completed

888 = Item marked as Not Applicable

IC_game_i **The Waiting Game**

No time to play right now - come back to this later (999)

- ○ 0-1 seconds (touched immediately) (1)
- ○ 2-5 seconds (hesitated briefly) (2)
- ○ 6-10 seconds (3)
- ○ 11-20 seconds (4)
- ○ 21-30 seconds (5)
- ○ More than 30 seconds, and then touched as soon as I said s/he could (6)
- ○ More than 30 seconds, and then had to be really encouraged before touching the food (7)

IC1 **stop** reaching completely for something when you said "no / don't touch" or similar

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

IC2 **hesitate** for at least a second when you said “no / don’t touch” or similar

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

IC3 approach or reach for something that he/she has been repeatedly told not to touch (such as electrical sockets or the oven)

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

IC4 re-try an action slowly and carefully (for example to get a shape in a shape sorter, or to catch a dangling toy)

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

IC5 repeat a new skill or action until he or she could do it (e.g. grabbing a toy that's almost out of reach)

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

IC6 work for a long time trying to do something tricky

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

IC7 quieten down when you ‘shushed’ him/her so as not to disturb others (such as in a library or church, or on a bus)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

FX_game_i **The Sorting Game**

◯ No time to play right now - come back to this later (999)

◯ S/he didn’t put all of the spoons in the pots in the first part of the game (1)

◯ S/he put all the spoons in the pots in the first part of the game, but mostly in the wrong pots, or all in the same pot (2)

◯ S/he put just one or two spoons in the wrong pot in the first part of the game and got the rest correct (3)

◯ S/he put all the spoons in the correct pots in the first part of the game, but in the ‘silly game’ put them in the same place (e.g. small spoons in small pot) (4)

◯ S/he put all the spoons in the correct pots in the first part of the game, but in the 'silly game' got them muddled up or didn’t finish (5)

◯ S/he put all the spoons in the correct pots in the first part of the game and in the 'silly game' put just one or two spoons in the wrong pot (6)

◯ S/he put all the spoons in the correct pots in the first part of the game and in the 'silly game' also got them all in the correct place (7)

FX1 explore all or most of the options when playing with a toy with lots of different things to touch or move

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

FX2 play repeatedly in the same way with a toy without varying his/her play (e.g. always pressing the same button on a toy with lots of different options, or if playing with cars only spun the wheels and didn't race them)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

FX3 try a different way to complete a tricky task without being shown (e.g. when putting shapes in a shape sorter tried different holes)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

FX4 keep attempting the same action when trying to complete a tricky task, even after having been shown a different action to try (e.g. when trying to open a flap, kept pushing at it after being shown that it should be pulled)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

FX5 use everyday objects to solve problems without being shown (e.g. if something was out of reach dragged over a box to climb on, or got a stick to poke it)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

FX6 grab or point to the odd one out in a group (e.g. a bright piece of clothing in a pile of washing, or a ball in amongst toy animals)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

FX7 point to, touch or look at for a long time something s/he had not seen before such as a new toy or piece of clothing

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

WM_game_i **The Finding Game**

- ○ No time to play right now - come back to this later (999)
- ○ S/he didn't reach to either of the containers at all (888)
- ○ S/he reached to a container once, or more, but didn't complete the game (888)
- ○ S/he reached to the wrong hiding location each time (1)
- ○ S/he reached to the correct hiding location once (2)
- ○ S/he reached to the correct hiding location twice (4)
- ○ S/he reached to the correct hiding location three times (6)
- ○ S/he reached to the correct hiding location each time (7)

WM_1 follow a simple instruction for a task that s/he was interested in (e.g. getting a nearby toy), without getting distracted

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

WM_2 seem to forget what s/he was doing, mid-way through

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

WM_3 continue with what s/he had been doing after having been interrupted by a minor distraction (such as having clothing/socks adjusted)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

WM_4 repeat or copy something s/he had just been shown how to do (e.g. work a tricky toy)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

WM_5 notice (e.g. by expressing surprise or by searching) that something s/he was given a few minutes ago was missing or had changed

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

WM_6 go after something s/he wanted (e.g your phone or the remote control for the TV) even after you had just hidden it from view

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

RG1 return to being calm/happy within 3 minutes of a small frustration (e.g. not being able to do something)

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

RG2 get upset (e.g. crying or withdrawn) after s/he couldn't have something s/he wanted, and stay upset for more than a minute

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

RG3 get upset (e.g. crying or withdrawn) after being taken away from somewhere fun, and stay upset for more than a minute

- ○ never (1)
- ○ very rarely (2)
- ○ less than half the time (3)
- ○ about half the time (4)
- ○ more than half the time (5)
- ○ almost always (6)
- ○ always (7)
- ○ does not apply (888)

RG4 get upset (e.g. crying/wimpering or withdrawn) when s/he couldn't manage to do something

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

RG5 show anger (e.g. screaming, banging) when s/he couldn't manage to do something

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

RG6 show anger (e.g. screaming, shouting or lashing out) after s/he couldn't have something s/he wanted, and stay angry for more than a minute

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

RG7 show anger (e.g. screaming, shouting or refusing to move) after being taken away from somewhere fun, and stay angry for more than a minute

- never (1)
- very rarely (2)
- less than half the time (3)
- about half the time (4)
- more than half the time (5)
- almost always (6)
- always (7)
- does not apply (888)

RG8 get upset during a fun activity and need to be soothed

- ◯ never (1)
- ◯ very rarely (2)
- ◯ less than half the time (3)
- ◯ about half the time (4)
- ◯ more than half the time (5)
- ◯ almost always (6)
- ◯ always (7)
- ◯ does not apply (888)

1) Jamais

2) Très rarement

3) Moins de la moitié du temps

4) Environ la moitié du temps

5) Plus de la moitié du temps

6) Presque toujours

7) Toujours

The following items are then reverse scored so that 7=1, 6=2, 5=3, 4=4, 3=5, 2=6, 1=7:

IC3, FX2, FX4, WM_2, RG2, RG3, RG4, RG5, RG6, RG7, RG8