

Executive Function and Bilingualism: What are the Effects of Language Proficiency?

by

Sarah Michelle Hutchison  
B.A., Athabasca University, 2008

A Thesis Submitted in Partial Fulfillment  
of the Requirements for the Degree of

MASTER OF SCIENCE

in the Department of Psychology

© Sarah Michelle Hutchison, 2010  
University of Victoria

All rights reserved. This thesis may not be reproduced in whole or in part, by photocopy or other means, without the permission of the author.

Executive Function and Bilingualism: What are the Effects of Language Proficiency?

by

Sarah Michelle Hutchison  
B.A., Athabasca University, 2008

Supervisory Committee

Dr. Ulrich Mueller, Supervisor  
(Department of Psychology)

Dr. Daniel Bub, Departmental Member  
(Department of Psychology)

Dr. Gina Harrison, Outside Member  
(Educational Psychology & Leadership Studies)

## Supervisory Committee

Dr. Ulrich Mueller, Supervisor  
(Department of Psychology)

Dr. Daniel Bub, Departmental Member  
(Department of Psychology)

Dr. Gina Harrison, Outside Member  
(Educational Psychology & Leadership Studies)

## Abstract

An emerging topic in cognitive development is whether being bilingual constitutes an advantage in children's performance on executive function (EF) tasks. The purpose of this study was to compare the performance of EF tasks in English monolingual children and German-English bilingual children aged 3 to 6 years old. Fifty-six children completed tasks of short-term memory, working memory, inhibition, cognitive flexibility, and verbal ability. No significant difference was found between the performance of bilingual and monolingual children in EF tasks, even when level of language proficiency was taken into account. Monolingual children performed better on measures of English verbal ability than bilingual children. Limitation to the study and avenues for future research are presented.

## Table of Contents

Supervisory Committee .....	ii
Abstract .....	iii
Table of Contents .....	iv
List of Tables .....	vi
Acknowledgements .....	vii
Dedication .....	viii
Introduction .....	1
Definitional Issues and Challenges .....	2
Effects of Bilingualism .....	3
Effects of Bilingualism and Executive Function .....	5
Working Memory .....	6
Inhibition .....	7
Cognitive Flexibility .....	11
Language Proficiency .....	16
Goals and Hypotheses of the Present Study .....	21
Method .....	22
Participants .....	22
Materials .....	23
Procedure .....	23
Child Measures .....	25
Working Memory Tasks .....	25
Short-Term Memory Tasks .....	26
Response Inhibition Tasks .....	27
Cognitive Flexibility Tasks .....	29
Language .....	31
Parent Report Measures .....	32
Language .....	32
Results .....	33
General Analytic Considerations .....	33

Missing Data .....	33
Normality .....	34
Impact of Procedural Factors .....	35
Preliminary Analysis.....	36
Demographic Characteristics .....	36
Data Reduction.....	36
Verbal Ability .....	38
Correlations between age, verbal ability and SES .....	39
Relations between EF and language group .....	39
Language Proficiency .....	40
Relations between EF and language proficiency groups .....	40
Discussion .....	41
Summary of Primary Findings.....	42
German Language Proficiency and EF .....	43
Limitations .....	47
Suggestions for Future Research .....	52
References.....	57
Tables.....	70

## List of Tables

Table 1: <i>Frequency of missing data by task and reason (child measure)</i> .....	70
Table 2: <i>Demographic characteristics and parent questionnaires</i> .....	71
Table 3: <i>Mean raw scores and standard deviation for tests of vocabulary and Executive function tasks by language group</i> .....	72
Table 4: <i>Correlations among measures</i> .....	73
Table 5: <i>Mean raw scores and standard deviation for age and language group</i> .....	74

## Acknowledgements

A special thanks to my supervisor, Dr. Ulrich Müller, for his support, wit, insightful criticisms, and kind words of encouragement. Thanks also to my committee members, Dr. Daniel Bub and Dr. Gina Harrison, for their expertise and feedback. Additionally, I would like to thank Michael Miller for his assistance and answering my many questions along the way. Finally, a big thank-you goes out to the Gingerbread Pre-School and Daycare, the Victoria German Language School, the North Shore German School, the Vancouver Westside German School, and the Surrey German School, in addition to all the children and parents who took the time to participate in the study.

## Dedication

To my parents, Joyce and Ken, for their unconditional love and encouragement; thanks for always cheering me on from the sidelines.

And to Jason, for his patience, support, and daily long distance phone conversations that encouraged the completion of my thesis.

## **Executive Function and Bilingualism: What are the Effects of Language Proficiency?**

Canada is often described as a bilingual nation, yet according to Statistics Canada only 13% of all Canadians report that they are able to speak more than one language (2005). This minority group of bilingual Canadians is poorly understood, especially because the media often presents conflicting information regarding the cognitive benefits and disadvantages of being bilingual. Historically, studies have focused on the negative aspects of bilingualism; this line of research was based on speculation rather than empirical studies (Carlson & Meltzoff, 2008). Recent research on the cognitive abilities of bilingual children has found that they significantly perform better than their monolingual peers in tasks demanding cognitive control (Bialystok, 2009; Carlson & Meltzoff, 2008).

An emerging topic in cognitive development is whether being bilingual constitutes an advantage in children's performance on executive function (EF) tasks (Bialystok, 2001). EF broadly refers to higher cognitive processes that are involved in the conscious control of action and thought (Zelazo & Müller, 2010). This includes working memory, response inhibition, and shifting, among other processes (Garon, Bryson & Smith, 2008). EF is important because researchers have found that performance on EF tasks is predictive of school readiness and school achievement (Müller, Liebermann, Frye, & Zelazo, 2008). Furthermore, EF has been implicated in various developmental disorders such as autism spectrum disorders and Attention-Deficit Hyperactivity Disorder (Zelazo & Müller, 2010).

I will begin by first reviewing definitional issues and challenges of research on bilingualism. Second, I will review the literature on bilingualism and EF and the importance of assessing language proficiency. Third, limitations of research on bilingualism and EF are discussed. Following the discussion of the limitations, the goals and three hypotheses for the

present study are presented. The purpose of this study was to compare the performance of EF tasks in English monolingual children and German-English bilingual children aged 3 to 6 years old. Finally, details of the present study will be discussed.

### **Definitional Issues and Challenges**

Two main issues complicate research on bilingualism: (a) how to define bilinguals, and (b) how to ensure equivalency between monolingual and bilingual groups. Currently, there is no accepted standard for defining who is 'bilingual'; thus, researchers have not yet developed an objective way of measuring bilingualism (Carlson & Meltzoff, 2008). There are different ways to define bilinguals. One way is to conceptualize bilingualism as a dichotomous variable (bilingual vs. monolingual). When bilingualism is defined as dichotomous, researchers create two groups – one group including monolinguals, the other bilinguals -- without regard for proficiency levels in each language (Morton & Harper, 2007; Bialystok, 1999). This is a problem because Ricciardelli (1992) found that only high proficiency bilinguals that perform better on cognitive tasks compared to their monolingual peers. Another way is to conceptualize bilinguals as a continuous variable (subgroups ranging from monolingual to bilingual; Bialystok, 2001). The advantage of using this categorization is that researchers can create subgroups of low and high proficiency for monolinguals and bilinguals (see Ricciardelli, 1992), to determine how levels of proficiency influence cognitive performance.

There is also a distinction between bilinguals and second language learners. Some researchers have suggested there are two main types of dual language learners: (a) second language children and (b) simultaneous bilingual children (Genesee, Paradice & Crago, 2004). Second language children start learning an additional language after the first language is established, usually around three years of age. Children who attend language immersion

programs starting in preschool or elementary school would fall under this category. In contrast, simultaneous bilinguals are children who learn at least two languages from birth or within the first year after birth.

The other issue complicating research on bilingualism is the difficulty of controlling for confounding variables. For example, compared to non-bilingual children, bilingual children may have a different home environment, they may travel more, and they may have additional schooling such as weekend language classes, which may influence the course of social-cognitive development (Bialystok, 2001). An ideal situation would be to have both bilingual and monolingual speakers with equivalent proficiency in their common language, in addition to having equivalent economic and social circumstances (Carlson & Meltzoff, 2008). However, even if this could be achieved by meticulous matching procedures, the results would not be representative of the range in language abilities and the range in SES of the bilingual population.

### **Effects of Bilingualism on Cognition and Verbal Ability**

Early studies on the differences between bilinguals and monolinguals tended to focus on the negative effects of learning two languages. Bilinguals were shown to have deficient articulation (Carrow, 1957), reduced vocabulary (Barke & Williams, 1938; Grabao, 1931; Saer, 1924), and a lower standard in written composition (Harris, 1948, Saer, 1924). These findings lead to statements condemning bilingualism as a “hardship devoid of apparent advantage” (Yoshioka, 1929 p. 476) and comparing bilingualism to a social plague (Epstein, 1905). Diebold (1968) claimed that bilingualism leads to psychodynamic conflict and emotional maladjustment and other researchers, such as Macnamara (1966), suggested that bilinguals have lower general and verbal intelligence due to limited cognitive and linguistic resources (see Genesee, Paradis & Crago, 2004). However, these early studies had methodological shortcomings because the

bilingual groups were mostly from a lower socioeconomic status (SES) and were tested in their weaker language, whereas monolingual groups were from higher SES. Another major flaw of these early studies was that bilinguals were defined by location of parent birth, family name or place of residence, rather than actual language use (for a review see Hakuta & Diaz, 1985).

More recent research suggests that bilingual children have a smaller vocabulary in each language compared to monolingual children (Mahon & Crutchley, 2006; Umbel et al., 1992). Other research suggests that bilingual children do not differ on measures of vocabulary compared to their monolingual peers. Davidson, Raschke and Pervez (2010) found that there was no difference on the English PPVT III between both groups of bilingual Urdu-English children aged three to six and a matched monolingual group. Bialystok (1999) found that receptive vocabulary (as measured by the Peabody Picture Vocabulary Test-Revised [PPVT-R]), of bilingual children did not differ from their monolingual peers.

Previous research with Spanish-English children has shown that when administered the English version of the PPVT, these children perform in the low-average range (Umbel, Pearson, Fernandez, & Oller, 1992). However, when the same bilingual children were tested in the Spanish version of the PPVT, their performance was comparable to Spanish monolinguals. Further, a recent study by Bialystok and Feng (as cited in Bialystok, 2009) found that bilingual children between the ages of 5 and 9 years had a significantly lower receptive vocabulary than their monolingual peers. However, these results must be interpreted with caution because most studies do not assess the language abilities of bilinguals in both languages. It is not clear whether in Bialystok and Feng's study the bilingual group was tested in their non-English language because they used an aggregate sample of bilinguals who had previously participated in various studies. By not testing the bilingual groups in their non-English language, Bialystok and

Feng may be underestimating the language abilities of their bilingual sample. This illustrates the importance of evaluating children in both languages.

Further, researchers have argued that lower vocabulary scores do not indicate that bilingual children are poor vocabulary learners (Oller, Pearson, Cobo-Lewis, 2007). Rather, these scores indicate that some of the vocabulary used by bilingual children is encoded in one language (e.g. Spanish) but not in the other language (English), and vice versa. Two studies have demonstrated that when bilingual toddlers' knowledge in both languages (German-English, English-Spanish) is taken into account, bilinguals' total vocabulary is very similar to that of monolingual peers from similar backgrounds as measured by parental questionnaires (Junker & Stockman, 2002; Pearson, Fernández, & Oller, 1995). In other words, bilinguals may have smaller vocabularies in each language but their total vocabulary is usually equivalent to that of their monolingual peers.

### **Effects of Bilingualism on Executive Function**

Peal and Lambert (1962) were the first to observe that bilinguals had superior cognitive flexibility when SES, age and sex were controlled. In their study, both bilingual and monolingual groups of 10-year-old children attended the same school system and were screened to ensure equivalency between groups using language proficiency measures. Both groups were administered a variety of intelligence tests. Bilinguals performed significantly better than their monolingual peers on most subtests measuring verbal and non-verbal abilities. However, there were several limitations to this study. For instance, bilinguals with low proficiency in their second language were excluded from the study and the bilingual sample had a higher grade average (Hakuta & Diaz, 1985).

Following the lead of Peal and Lambert's study, there is a growing body of research suggesting that growing up learning two languages has an advantageous effect on the performance on specific cognitive tasks. Bilinguals have demonstrated superior performance on EF tasks involving cognitive flexibility, but not working memory or inhibition. Each of these EF components will be discussed in turn.

**Working memory.** Working memory tasks involve both the storage capacity of working memory and also processing capacity (Zelazo, Müller, Frye, & Marcovitch, 2003). Prototypical working memory tasks (e.g., the backward digit or word span task) require participants to simultaneously store (i.e. keep two digits in mind) and manipulate information (i.e. reverse the order of the digits).

Working memory is distinct from short-term memory. Short-term memory refers only to the storage capacity of working memory and requires only that participants hold information in mind. The majority of studies using short term memory tasks have failed to find any differences in performance between monolinguals and bilinguals. For example, using the forward digit span (FDS) task, which requires children to only repeat the digits in the same order as spoken by an experimenter, Bialystok and Martin (2004) failed to find a difference in the performance of mono- and bilingual preschool children (see also Bialystok, 1999). Studies using another short-term memory task, Visually- Cued Recall, also found that there was no difference between bilingual preschool children (Bialystok, 1999) and bilingual kindergarten children (Carlson & Meltzoff, 2008) compared to their monolingual peers.

The performance of bilinguals and monolinguals also do not differ on working memory tasks. The Corsi block test (Milner, 1971) has shown that there was no difference in performance between young adult bilinguals and young adult monolinguals (Bialystok, Craik, & Luk, 2008).

The Corsi block test involved presenting a random array of wooden blocks. Each block had a number from 1 to 10 painted on the back that was not visible to the participant. There was a backward and a forward condition. In the forward condition, the experimenter tapped a sequence of blocks and participants were required to repeat the sequence in the same order. When the participants responded correctly for two given sequences, another block was added to the set of blocks. Testing continued until the participants responded incorrectly to both trials of a given sequence length. In the backward condition, the procedure was the same except that participants were asked to repeat the sequence in the reverse order. Results showed that young adults (20 years) recalled significantly more items than older adults (68 years), but there was no difference between language groups. In summary, these studies suggest that bilinguals and monolinguals do not differ on tasks intended to measure working memory or short-term memory.

**Inhibition.** Inhibition is a more challenging component of EF to describe because researchers are not in agreement on how inhibition should be defined. Some suggest that there are two aspects of inhibition: interference suppression and response inhibition (Bunge, Dudukovic, Thomason, Vaidya and Gabrieli, 2002). Interference suppression refers to the inhibition of an interfering cue. In other words, conflict is resolved by attending to the relevant stimulus cue while ignoring a competing cue. Interference suppression is also known as “inference control” (Friedman & Miyake, 2004) or “inhibitory control” (Bialystok, & Viswanathan, 2009). In contrast, response inhibition refers to the restraint of a motor response (see Garon, Bryson & Smith, 2008). Response inhibition is also known as “response suppression” (Bialystok, & Viswanathan, 2009). Studies with bilingual children have shown that bilinguals perform better than their monolingual peers on tasks intended to measure interference suppression (Bialystok & Senmen, 2004; Bialystok & Shapero, 2005) but not on tasks intending

to measure response inhibition (Bialystok, Craik, Ryan, 2006; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008).

One widely used measure of inhibition is the Simon task. In the Simon task, children learn a rule that connects two different stimuli to corresponding response keys. For example, children might be shown red or blue squares on a computer screen and instructed to press the right key when the red square is presented and to press the left key when the blue square is presented. Presentation of the square on the same side of the response key (e.g., the red square is presented on the right side of the screen) constitutes a congruent trial; presentation of the square on the opposite site (e.g., the red square is presented on the left side of the screen) constitutes an incongruent trial.

Compared to monolingual preschool children, bilingual preschool children have been shown to have shorter reaction times on the Simon Task for both congruent and incongruent trials (Martin-Rhee & Bialystok, 2008). This reaction time difference also has been found in young adults (Bialystok, 2006), middle-aged adults and older adults (Bialystok, Craik, Klein and Viswanathan, 2004). These results suggest that bilinguals may have enhanced interference suppression because they were able to manage attention by inhibiting distracting spatial cues in rapidly changing contexts. However, Bialystok and colleagues do not address the possibility that the improved performance in the Simon task may be due to better response inhibition or a combination of better interference control and response inhibition.

Morton and Harper (2007) argued that Bialystok's studies using the Simon Task did not appropriately control for SES. In their study, they found that the bilingual advantage disappeared on the Simon Task when ethnicity and SES were controlled. Bialystok (2009) argued that these results should be interpreted with caution because Morton and Harper's study

involved older preschool children, a smaller sample size, inappropriate use of statistical methods, and unclear measures of ethnicity. In addition, Bialystok (2009) claimed that all of her studies controlled for SES because the monolingual and bilingual children attended the same schools and lived in the same neighborhoods. In their response, Morton and Harper (2009) acknowledged that their sample was slightly older; however, they pointed out Bialystok had found robust group effects in adults using the same task so it is unlikely that an older sample of children would be the reason for the null effect. In regards to their measure of SES, Morton and Harper argue that even though Bialystok uses participants from the same neighborhoods, this would be an insufficient method to control for SES because parental education or family income is not taken into account. Also, Morton and Harper note that Bialystok's samples tend to include a large number of Canadian immigrants who earn less money on average but are more educated compared to the monolingual sample. Thus, it is possible that highly educated parents may have more frequent and positive interactions with their children which may lead to better EF task performance, even though the family has a lower income compared to the monolingual sample. In sum, the Simon Task does not always demonstrate a bilingual advantage among children and there is debate among researchers on why this might be.

Other studies using measures intended to measure inhibition have also found a bilingual advantage (Costa, Hernandez, & Sebastian-Galles, 2008). For example, Bialystok and colleagues (2008) examined the performance of younger and older mono- and bilingual adults on the Stroop test. Monolingual and bilingual participants were presented with three control conditions and one conflict condition in counterbalanced order. The control conditions measured color-naming speed (name of ink color in a sequence of Xs), word-reading speed (words in black ink), and congruent color-naming (words in corresponding ink color). The conflict (Stroop) condition

presented color names with conflicting font colors and the participant named the font color. Results of Bialystok and colleagues (2008) demonstrated that both older and younger bilingual participants had significantly faster reaction times on the conflict condition compared to their monolingual peers. Younger adult participants were also significantly faster compared to older adult participants. In other words, there was a larger Stroop effect for older and monolingual participants. According to the authors, these results suggest that bilinguals do better on tasks intended to measure interference suppression.

However, there are alternative explanations for what the Stroop task is intending to measure. Variants of the Stroop task with older adults have not found common inhibition ability most likely because of the different idiosyncratic nature of each task (Shilling, Chetwynd, & Rabbitt, 2002, Experiment 1). The Stroop task has also been classified as a resistance to interference task (e.g. Nigg, 2000); however, because it differs in that the avoidant response is dominant (MacLeod, 1991), the Stroop task can also be considered to be proponent response inhibition (e.g. Miyake & Friedman, 2004; Miyake, Friedman, et. al, 2000; Vendrell et al., 1995).

Cummins (1976) has suggested that the superior performance of bilinguals on tasks intended to measure interference suppression may be due to having two symbols (i.e. labels) for objects from a young age onwards which allows for more flexible and abstract thinking throughout development. Bialystok (2007) also believes that the bilingual experience of routinely referring to the same thing by different names promotes selective attention, which may assist bilingual children in ignoring irrelevant information. For example, if a child is bilingual in French and English, she or he will need to inhibit her or his French vocabulary when conversing in English. This repeated experience is said to lead to superior interference suppression skills, which may generalize to better performance on cognitive flexibility tasks. Morton and Harper

(2009) have also suggested that bilinguals not only manage two lexicons, but also two systems of grammar, two phonologies, and often two different cultures. Thus, more research is needed to rule out these additional explanations for why bilinguals demonstrate an advantage on some tasks measuring inhibition.

**Cognitive flexibility.** Cognitive flexibility (attention shifting, set shifting) refers to the ability to shift from one mindset to another mindset (Davidson, Amso, Anderson & Diamond, 2004). This often involves acting according to rules from one mindset that would be incompatible with rules from another mindset. Flexibility tasks require the ability to solve problems that include more than one set of rules, which taxes both inhibition and working memory. This is because the new rules must be held in mind to perform a specific task (working memory) and the previous stimulus-response relations must be suppressed (inhibition).

One example of a flexibility task is the Dimensional Change Card Sort task (DCCS), which is intended to measure attention shifting (Zelazo et al, 1995). In the DCCS, children sort cards first according to one dimension (pre-switch phase), and then according to a second dimension (post-switch phase). For example, children are shown two cards affixed to two different trays. One tray has a card with a picture of a blue rabbits and the other tray has a card with a red boat. Children are asked to put blue cards in the tray with the blue rabbit and to put red cards in the tray with the red boat. In the post-switch phase, children are asked to put rabbit cards in the tray with the rabbit as the target card, and the boat cards in the other tray, thus sorting the cards based on the shape dimension.

The typical error of 3 year olds is to continue sorting by the pre-switch criteria (e.g. color) during the post-switch phase, even when they are able to correctly state the post-switch sorting rule (e.g. shape). By the time children are 4 years of age, they typically sort correctly

during the post-switch phase. The post-switch phase of the DCCS requires cognitive flexibility because children must suppress the previous color rule, and cognitively switch to activate the new shape rule.

Bialystok and colleagues have used the DCCS in a series of studies with bilingual children. A group of sixty preschoolers ranging in age from 3 to 6 years were administered the DCCS (Bialystok, 1999). Half of the participants were monolingual and the other half were fluent in English and Mandarin or Cantonese. Seventy-seven percent of the bilingual children passed the DCCS, but only 50% of monolinguals passed the task. Further, Bialystok and Martin (2004) conducted a series of studies to clarify the source of the superior performance of bilingual children in the DCCS. It was suggested by the authors that bilinguals may demonstrate superior performance on the DCCS because of better representational abilities. The first study involved monolingual and Chinese- English bilingual preschool children who were assessed using a modified, computerized version of the DCCS. In this version there were four conditions: color, color- shape, color-object and function-location. The four conditions represented different levels of representational demands. In each condition, children were presented with target test stimuli on the computer screen and were asked to press a button on a keyboard that corresponded to the location of where they wanted the item to be placed. For example, in the color condition, the stimuli were five blue squares and five red squares presented in random order. In the pre-switch phase, children were asked to press a button on the right side of the keyboard when the square was blue and to press a button on the left side of the keyboard when the square was red. After 10 trials, children were told that the rule had changed. In the post-switch phase, children were asked to press the right button when the square was red and to press the left button when the square was blue. Again, the squares were presented in random order and there were 10 trials.

The other conditions were similar to the color conditions with the exception that different stimuli were used. In the color-shape condition, the stimuli were blue squares and red circles, and children were asked to switch from sorting these stimuli by color to sorting them by shape. In the color-object condition, objects (red flowers and blue rabbits) were presented instead of geometrical shapes (rectangles and circles). In the function-location condition, stimuli represented a function (e.g. something to wear) or a location (e.g. something that goes inside the house), and children were asked to switch from sorting stimuli by function to sorting stimuli by location. According to Bialystok and Martin (2004), the function-location condition was supposed to assess more demanding representational abilities because stimulus complexity increased with each successive condition as the stimuli were more detailed.

Results of the study showed that monolinguals and bilinguals did not differ in their performances on the color condition or the function-location conditions. However, bilinguals performed better than monolinguals in the color-shape condition and in the color-object condition. These findings suggest that bilinguals do not have better representational abilities as compared to monolinguals; however, bilingual children did do better on DCCS version that required less representational abilities. This is an unexpected finding; thus a second study was conducted that used a paradigm intended to separate demands in representational abilities and demands in attention and inhibition.

The second study was designed to examine which features of different DCCS conditions affected performance differences between mono- and bilinguals. This study involved 15 mono- and 15 bilingual preschool children who were administered two non-computerized conditions of the DCCS, the color-shape condition and the function-location condition. It was hypothesized that manual administration would increase the need for inhibition, but further justification was

not provided. Results for the function-location condition showed that more bilinguals correctly solved the task (bilinguals passing = 10, monolinguals passing = 6), but this difference was not significant. As in study 1, there was a significant bilingual advantage for the color-shape condition. These results suggest that bilinguals have superior classification skills based on perceptual features (color-shape) and not for semantic features (function- location).

The third study was designed to explore the distinction between perceptual and semantic classification. This study involved monolingual and Chinese-English bilingual 4-year-olds who were administered four conditions of the DCCS: color-shape, color-object, function-location, and kind-place. The difficulty level of the kind-place condition was supposed to be intermediate between the color-shape condition and the object-location condition. In the kind-place condition, the stimuli represented animals (e.g., fish) or things to ride (e.g., vehicles). As a reminder of the rule, an example of the target stimulus was always present (e.g., a squirrel or a sailboat). Similar to study 2, results showed that the bilingual advantage was only present for perceptual features (color-shape or color-object) and not for semantic features (function-location or kind-place).

In summary, Bialystok and Martin (2004) found that monolinguals and bilinguals do not differ on DCCS tasks requiring semantic feature sorting as involved in the function-location condition and place-kind condition. However, bilingual preschoolers performed better than their monolingual peers in the color-shape condition, which required sorting based on a perceptual dimension. The bilingual advantage was also found for the color-object condition, but was only significant in one of the two studies that included this condition. Therefore, these results suggest that the bilingual advantage is not due to the superior ability to categorize complex stimuli.

One explanation for these unexpected results would be that the integration of stimulus features, function-location or kind-place, created a task that was too difficult for either

monolingual or bilingual children. A study by Dimond, Carlson and Beck (2005) that involved three year olds and the DCCS found that when the cards were sorted based on background color, rather than the color of the stimuli (e.g. a truck), children successfully sorted the cards six months earlier. Thus, separating the dimensions (color of the truck vs. color of the background) rather than integrating dimensions into one object improved their abilities to switch attention to the new rules, so children performed better on the task. A similar study conducted by Kloo and colleagues (2010), found that when the spatial separation of the two dimensions was manipulated (separated, overlapping, spatially distinct), level of spatial separation had no additional significant influence. In other words, space-based intentional processes were not a significant source of children's difficulty on the DCCS. In sum, if the dimensions of the function-location or kind-place were modified so that each dimension was distinct, it would be interesting to see if bilinguals or monolinguals or both groups would perform better on these tasks.

Only one other study has been conducted using bilingual children and the DCCS. Carlson and Meltzoff (2008) included the DCCS in a battery of EF tasks with bilingual kindergarten children drawn from three language groups: Spanish-English bilinguals, monolinguals, and English speakers enrolled in a Japanese immersion kindergarten. Results showed only bilingual children performed significantly better than their monolingual peers on the DCCS, controlling for age, verbal ability, and parent education. This suggests older and younger bilingual children perform better their peers on the DCCS. Interestingly, the performance of immersion children on the DCCS was comparable to monolingual children, suggesting that intensive and early mastery of another language may be necessary in order to demonstrate a better performance of EF tasks. Thus, these results suggest second language

learners may not demonstrate an advantage on the DCCS; however, simultaneous bilinguals may demonstrate an advantage on the DCCS.

In summary, the effects of bilingual experience are selective. There is no difference in performance between bilinguals and monolinguals on short term memory tasks, working memory tasks, and on inhibition tasks intended to measure response inhibition. However, bilinguals consistently performed better than monolinguals on inhibition tasks intended to measure interference control, such as the Simon Task and the Stroop task, and on cognitive flexibility tasks such as the DCCS.

### **Language Proficiency**

In this section I first argue that it is important to assess language proficiency and then review the bilingual literature in relation to language proficiency. Proficiency is an important variable in bilingual research because it has been suggested that language proficiency, rather than age of acquisition, influences the neural organization of language (Perani, 1998). Research has shown that bilinguals and multilinguals with low proficiency display more diffuse neural activation patterns (Perani et al. 1996; Yetkin et al., 1996). Research has also shown that bilinguals with high proficiency display second language (L2) neural activation that converges on first language (L1) activation (Abutalebi, Tettamanti, & Perani, 2009). In other words, highly proficient bilinguals demonstrate more focused neural activation. Bilinguals with high proficiency have been shown to have increased density of grey matter in the left inferior parietal cortex (Mechelli et al., 2004). This brain region has been shown to be responsive to vocabulary acquisition in both bilinguals and monolinguals. An fMRI study comparing high and low proficiency Italian-English bilinguals using a language production task found that the high proficiency bilinguals had activation in their left temporal lobe, and left superior temporal sulcus.

In contrast, bilinguals in the low proficiency group did not have activation in the temporal poles or in the posterior and left anterior part of the temporal gyrus (Perani et al., 1998). The authors of this study concluded that proficiency is a key variable responsible for the differences between groups, but they acknowledged that age of acquisition is a major determinant of proficiency.

Proficiency levels of bilinguals are also important because neural organization influences cognitive performance. A recent study suggests that a more focal distribution of neural activation, similar to neural activation patterns of high proficient bilinguals, is associated with better performance on cognitive tasks (Durstun, et. al., 2006). In a combined cross-sectional and longitudinal study, an fMRI was used to measure brain activity of children tested at age 9 and again at age 11 using a Go-NoGo Task. This task is designed to measure cognitive control. Improvements in task performance were associated with a shift from a diffuse to a more focal neural activation pattern. In other words, changes in neural activation may allow for more efficient processing. Durston and colleagues (2006) suggest this change in neural activation is likely related to experience-driven maturational processes. As mentioned previously, bilingual adults with low proficiency have more diffused neural activation patterns, which may have repercussions for cognitive performance. In a similar vein, bilinguals with high proficiency may have a more efficient neural organization, which suggests that they may be more efficient at solving cognitive tasks. This may be an alternative explanation for why bilinguals perform better on specific EF tasks; thus, it needs to be explored with further research.

Only one study has specifically examined the relation between language proficiency in both languages and cognitive performance. Ricciadelli (1992) categorized Italian-English bilingual children into four proficiency groups: a) high English and high Italian, b) high English and low Italian, c) low English and high Italian, d) low English and low Italian. Monolingual

children were also categorized into two groups: high English proficiency and low English proficiency. Categorization was based on performance on three verbal tests and the PPVT, Form M (Dunn & Dunn, 1981). All children were also administered cognitive tasks intended to measure nonverbal, visual-spatial reasoning. In addition, bilingual children were administered the PPVT in Italian. Results showed that only bilingual children with high proficiency in both languages demonstrated significantly better performance on two of the four cognitive tasks compared to monolinguals with high English proficiency and bilinguals with high English and low Italian. These differences in bilingual performance suggest the importance of testing bilingual proficiency in both languages.

In the same study, bilinguals with low English and high Italian were not included in the analysis because they performed significantly poorer compared to monolinguals with low English proficiency and bilinguals with low English and low Italian proficiency. These results suggest that bilingual children with low English and high Italian proficiency were at a disadvantage because the cognitive tasks were administered in their weaker language. Thus, testing language proficiency in both languages is important because if bilingual children with low proficiency in the language used for task administration, they may perform less well due to not being able to understand the task.

Ideally, proficiency testing should always be conducted in both languages. In the majority of bilingual studies, language proficiency in both languages is not assessed (Bialystok, 1999, 2006; Bialystok & Martin, 2004; Bialystok & Senman 2004; Bialystok & Shapero, 2005; Morton & Harper 2007; Carlson & Meltzoff, 2008). The main reason why proficiency is not assessed is because current research does not have an objective proficiency scale to classify bilingual children. Another reason why proficiency scales for children have not been developed

is the high number of possible language combinations. Researchers may argue that it would be too difficult to determine proficiency levels in both languages because some bilingual studies include participants from various ethnic groups containing up to twenty-four languages (Bialystok, 2006; Bialystok, 2008). However, limiting bilingual participants to one language group would make controlling for participants' language proficiency more efficient, and it would take into account Morton and Harper's (2007) suggestion to control for ethnicity.

Despite these challenges, current research uses an index of proficiency by calculating daily use of both languages to ensure that language production in both languages is equivalent (Bialystok et al., 2004; Morton & Harper, 2007). Further, some studies have asked adult bilinguals to rank their proficiency on a five point scale (Bialystok, Craik, & Luk 2008), whereas other studies have administered a proficiency questionnaire to assess frequency of second language use (Bialystok, 2008; Morton & Harper, 2007). The disadvantage of using questionnaires is that participants may over or underestimate their abilities in order to impress the experimenter with their humility or ability. A more precise measurement of proficiency would be to administer the PPVT in both languages, which allows researchers to categorize bilinguals as high and low proficient bilinguals (see Ricciadelli, 1992). One advantage of using well standardized measures of verbal ability is that norm-referenced scores can be used. However, norm-referenced scores can only be used if a) the tests exist in both target languages b) the tests are being used in the same country where the tests were standardized. It is a psychometric truism that tests are only valid and reliable for participants belonging to the populations for which the test was standardized; however, general practice does not always adhere to this rule (Aburdarham, 1997). Thus, it would not be appropriate to use a German PPVT test in another country such as Canada.

In addition to a measure of receptive vocabulary, a measure of expressive vocabulary should be included. Expressive vocabulary should be assessed because vocabulary has been a reliable and useful measure of language growth (Junker & Stockman, 2002). Further, research suggests that gains in receptive vocabulary occur before gains in expressive labeling (Barnett, Yarosz, Thomas, Jung & Blanco, 2007). Differences between expressive and receptive vocabulary have been reported for monolingual children (Bates, Bretheron, & Snyder, 1988) and for bilingual children (Rhode & Tiefertal, 2000). It should be noted that bilingual children acquire both languages unevenly during the early years of language production which may lead to the development of language preferences. A 'silent period' may emerge, which refers to a child who may comprehend one language but does not produce it (Yip & Matthews, 2007). For example, a child who is exposed to English and French may go through period of time where he will understand a question being asked in English, but he will only respond in French. These silent periods lasts longer in some children than in others and occur more frequently with second language children than with simultaneous bilingual children (Lakshmanan & Selinker, 2001). However, it is assumed that even though one of the languages is not being produced, children are still passively acquiring this language (Yip & Mathews, 2007).

Parental assessments are also useful to determine proficiency. Currently, there are two parent-report checklists that have been used to measure proficiency. The Language Development Survey (LDS; Rescorla 1989, Rescorla, & Alley, 2001) and the MacArthur-Bates Communicative Development Inventories (CDI; Jackson-Moldonado, Thal, Marchman, Bates, & Gutiérrez-Clellan, 1993) have been successfully used to compare vocabulary development in relatively large samples of bilingual versus monolingual toddlers. Both the CDI and the LDS have yielded highly reliable and valid results (Costarides & Shulman, 1998; Klee et. al., 1998;

Dale, 1991, 1996; Rescorla, 1993). This work needs to be expanded to include preschool bilingual children because the validity of parent report as a measure of expressive vocabulary in preschool children has been established by numerous studies (e.g., Dale, 1991, or Klee, et. al, 1998). For these reasons, it was decided that a combination of parental reports, expressive language tests, and receptive languages tests would be used to measure language proficiency.

### **Goals & Hypotheses of the Present Study**

This study will address three gaps in the existing research on the cognitive development of bilingual children by using an untested language group, administering a variety of EF tasks, and administering language proficiency tests. First, even though researchers have used a variety of language groups so far (see Bialystok, 1999; Bialystok & Martin, 2004; Bialystok & Viswanathan, 2009; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008; Morton & Harper, 2007) there have been no studies on the EF of German-English bilingual preschool children. For simplicity, I will refer to the bilingual sample as “German-English” and this refers to both “German-English” and “English- German”. German has been considered more similar to English than Spanish (Campbell, 2000, Junker & Stockman, 2002) and few studies currently exist on young bilingual German-English speakers (Junker & Stockman, 2002).

Second, the majority of studies have relied on only one or a few measures of EF. As described above, some studies only use one inhibition task such as the Simon Task (Bialystok, Craik, Klein & Viswanathan, 2004; Morton & Harper, 2007). Other studies use multiple tasks to measure inhibitory skills, but do not include measures of working memory or cognitive flexibility (Carlson & Meltzoff, 2008). As a result, it is not clear whether the bilingual advantage will manifest itself in other aspects of EF using the same sample. Thus, the proposed study will use a variety of EF tasks to measure all three components: cognitive flexibility,

inhibition (response inhibition), and working memory using a monolingual and bilingual sample. As mentioned previously, Bialystok and others have suggests that the bilingual experience of switching between languages leads to superior interference suppression skills, which may generalize to better performance on cognitive flexibility tasks. Thus, I hypothesize that: (1) there will be no difference between bilingual and monolingual children on tasks measuring short-term memory, working memory and response inhibition, and (2) bilingual children will perform better than their monolingual peers on tasks intended to measure cognitive flexibility.

Lastly, it is unclear whether children's proficiency in both languages affects the bilingual advantage because proficiency is rarely assessed in both languages (Morton & Harper, 2007, Bialystok, 2008). The proposed study will assess proficiency by a) administering the PPVT in both languages, b) administering the CELF in both languages, and c) including parental measures of proficiency using a questionnaire. I hypothesize that only bilinguals with high language proficiency in German will perform better on tasks measuring cognitive flexibility compared to monolinguals and bilinguals with low language proficiency in German.

## **Method**

### **Participants**

Participants included 56 children and their parent or legal guardian ( $M$  age = 65 months,  $SD$  = 12.04 months, range = 37-83 months; 31 boys, 25 girls)<sup>1</sup>. An additional 5 children participated but were not included in the analyses due to ADHD diagnosis ( $n$  = 1) or moderate second language exposure in the home in the monolingual group ( $n$  = 4).

---

<sup>1</sup> Because there were two sets of twins (one set of six year old girls in the bilingual group and one set of six year old boys in the monolingual group), all variables were screened for differences related to the removal of one participant from each and no significant differences were found. Thus, both sets of twins were included.

The Bilingual Group consisted of 27 children with regular exposure to German and English. They were recruited through a handout provided to four German language schools and through word of mouth. A questionnaire was administered to parents to examine language exposure. In this group, either both parents were native German speakers who spoke both German and English at home and in the community, or one parent spoke German and the other spoke English.

The Monolingual group included 29 English monolingual children with no exposure to a second language. The first language of both parents was English. Table 1 contains detailed demographic information.

### **Materials**

All tasks were administered on the computer except for the Forward Word and Digit tasks, the Backward Word and Digit tasks, the DCCS, the Animal Color game and the language tasks. For task administration, a laptop computer and a touch monitor was used. A video camera was used to record one of the tasks (CELF in German) for later coding.

### **Procedure**

Participants were either tested individually at their corresponding daycares, or in the parental home, or a university playroom. Parental informed written consent was provided and child oral assent was obtained. All tasks were administered in English with the exception of the German language measures. Tasks were administered in a quiet space in order to discourage distraction for both the participant and the other children. Children received several small gifts (e.g. stickers) during task administration. Parents received a \$5 gift card for a local coffee shop.

There were two sessions (A and B) that lasted approximately 20-40 minutes each and the order of sessions was counterbalanced. Due to parental or child preference, some children had

both their session on the same day ( $n = 40$ ) and the remaining children had the second session on another day ( $n = 16$ ). Average number of days between sessions was 10 days. The order of the tasks for session A was: Dimensional Change Card Sort, Backward Word Span, Backward Digit Span, Tower of Hanoi for monolingual children and either the German PPVT or the German CELF for bilingual children, Forward Word Span, Forward Digit Span, and either the English PPVT or the English CELF. Administration of the PPVT and CELF was counterbalanced. Because bilingual children needed to be tested in both English and German for the PPVT and the CELF, the monolingual children were administered the Tower of Hanoi task so that there was a task in between the Forward and Backward Tasks to match the number and order of tasks presented to the bilingual group. Performance on the Tower of Hanoi task was not used in the analysis.

The order for session B was: Jack in the Box, Boy-Girl Stroop, the Go/No-Go Task, the CPT for monolinguals and either the German PPVT or German CELF for bilinguals, the Animal Color Task, and either the English PPVT or English CELF. Again, the monolingual children were administered the CPT so that there was a task in between the Go/ No-Go Task and the PPVT or CELF to match the number and order of tasks presented to the bilingual group. Performance on the CPT was not used in the analysis. For the bilingual group, the administration of the CELF and PPVT in English and German was counterbalanced for both sessions. For example, a bilingual child could be presented with the German CELF then the English PPVT during the first session. The same child would then be administered the English CELF and German PPVT during the second session. Thus, for each session both German and English were used in the language tasks. In other words, bilingual children were not given both language tasks in the same language during one session (e.g. English CELF and English PPVT).

This order of tasks was chosen to separate tasks of similar cognitive demand and, thereby, reduce practice effects while conserving children's attention and interest.

## **Child Measures**

### **Working Memory Tasks.**

***Backward Word Span (BWS).*** This task is intended to measure working memory by asking children to recall a series of words in reverse order (Davis & Pratt, 1995). The experimenter used a puppet to demonstrate how to say words backwards. The experimenter said, *"Now we are going to play a different game with Molly. This time, whatever words she says, we will say it backwards. Let me show you how to play. If Molly says the words 'cat, pen' then I will say 'pen, cat'."* Children were then asked to do what the experimenter had done. A two-word practice trial was administered. The experimenter corrected errors if children were wrong, and the example was repeated. If children were unsuccessful after two repetitions of the practice trial, the task was ended, and they were given a score of zero. Children who passed the practice trial received two trials each that used 2-, 3-, and 4-word lengths. The task was discontinued if children made errors on both trials of a given length. The total number of trials passed was recorded for analysis and higher scores indicated better performance.

***Backward Digit Span (BDS).*** This task is intended to measure working memory by asking children to recall a series of digits in reverse order (Davis & Pratt, 1995). The experimenter used a puppet to demonstrate how to say digits backwards. The experimenter said, *"We are going to play a silly game with Molly, so whatever she says, I will say it backwards. Let me show you how to play. If Molly says the numbers '1, 2' then I will say '2, 1'."* Children were then asked to do what the experimenter had done. A two-digit practice trial was administered. The experimenter corrected errors if children were wrong, and the example was repeated. If

children were unsuccessful after two repetitions of the practice trial, the task was ended, and they were given a score of zero. Children who passed the practice trial received two trials each that used 2-, 3-, and 4-digit lengths. The task was discontinued if children made errors on both trials of a given length. The total number of trials passed was recorded for analysis and higher scores indicated better performance.

### **Short Term Memory Tasks.**

***Forward Word Span (FWS).*** This task is intended to measure short term memory by requiring children to repeat a series of words in the same order as the experimenter. The experimenter used a puppet to demonstrate how to say the words. The experimenter said, “*Now we are going to play a game with Simon. We are going to say exactly the same words that Simon says. Let me show you how to play. If Simon says the words ‘ball, top’ then I will say ‘ball, top’.*” Children were then asked to do what the experimenter had done. A two-word practice trial was administered. The experimenter corrected errors if children were wrong, and the example was repeated. If children were unsuccessful after two repetitions of the practice trial, the task was ended, and they were given a score of zero. Children who passed the practice trial received two trials each that used 2-, 3-, and 4-word lengths. The task was discontinued if children made errors on both trials of a given length. The total number of trials passed was recorded for analysis and higher scores indicated better performance.

***Forward Digit Span (FDS).*** This task is intended to measure short term memory by requiring children to repeat a series of digits in the same order as the experimenter. The experimenter used a puppet to demonstrate how to say the digits. The experimenter said, “*This is Simon. We are going to play a new game with Simon. This time we are going to say exactly the same numbers that Simon says. Let me show you how to play. If Simon says the numbers ‘1, 4,’*”

*then I will say '1, 4'.*" Children were then asked to do what the experimenter had done. A two-digit practice trial was administered. The experimenter corrected errors if children were wrong, and the example was repeated. If children were unsuccessful after two repetitions of the practice trial, the task was ended, and they were given a score of zero. Children who passed the practice trial received two trials each that used 2-, 3-, and 4-word lengths. The task was discontinued if children made errors on both trials of a given length. The total number of trials passed was recorded for analysis and higher scores indicated better performance.

### **Inhibition Tasks.**

***Boy- Girl Stroop.*** The Boy-Girls Stroop is a computerized task in which children are required to verbally label stimuli presented on the computer screen. The experimenter introduced the children to the task by saying, *"This is the Boy and Girl game. In this game, sometimes you'll see a picture of a boy and sometimes you'll see a picture of a girl. This is a...*[pointed to the boy and allowed the child to label the picture] *and this is a...*[pointed to the girl and allowed the child to label the picture]. *Good job. Now, this game is a little silly because when you see the boy, I want you to say 'girl'. That's silly, right? And when you see the girl, I want you to say 'boy'. Let's try practicing that.* [Show screen with picture of boy]. So what do we say when we see a picture of a girl? [Provide feedback, repeat rules if necessary]. And what do we say when we see a picture of a boy? [Provide feedback, repeat rules if necessary]. Okay, let's try to play the game. Try to go as fast as you can without making mistakes. Ready? Let's play!" The experimenter then proceeded to practice section and as the child verbally responded, the experimenter recorded answers by pressing "g" key for girl and "b" key for boy. Children who passed the practice trial went on to the next trial. The task was discontinued if children went through the practice twice and got all items incorrect. Before starting the task once again

the experimenter asked the child to repeat the rules, “So remember, if we see a boy, what we say? And if we see a girl what do we say? All right, try to go as quickly as you can without making mistakes. Are you ready? Let’s play!”. Immediately following completion of the task, the experimenter asked the child: “*Can you tell me what you were supposed to do in this game?*” If the child is slow to respond, ask, “*When you saw the boy, what did you say? And when you saw the girl, what did you say?*”. Children’s responses were recorded to ensure that all participants understood the rules. The total number of correct responses was recorded for analysis and higher scores indicated better performance. Self-corrections were recorded as incorrect (e.g., for a picture of a boy, the child says, “*Bo...Girl*”).

***Go/No-Go.*** This task is a child friendly version of the traditional Go/No-Go Task (Lapierre, Braun & Hodgins, 1995). It is adapted for a study of EF in school-aged children (Archibald & Kerns, 1999). This task consisted of two blocks. During the first block, children were shown a dog every second for 60 seconds. The children were then asked to touch the screen every time a dog appears to develop a prepotent response to dogs. This trial was not scored. The second block consisted of 150 trials divided into three sections with 50 trials per section. In the first section, both dogs and koala bears were presented to the child. The child was asked to only touch the koala bears and not the dogs. This required the child to withhold her/his prepotent response to the dogs. In the second section, both dogs and koala bears were presented and the child was asked to touch only the dogs, and not the koala bears. This section required the child to withhold her/his prepotent response to the koala bears. In the final section, both dogs and koala bears were presented and the child was asked to touch only the koala bears, not the dogs. This section required the child to withhold her/his prepotent response to the dogs.

Performance was scored on commission errors (e.g. touching the dog when child should be touching for the koala bear only) and lower scores will indicate better performance

### **Cognitive Flexibility Tasks.**

***Dimensional Change Card Sort (DCCS).*** Procedures for administering the DCCS followed Hongwanishkul et al. (2005). In this task, children were required to sort cards that differed along two dimensions: colour and shape. Materials consisted of two different types of sorting card (blue rabbits and red boats) and two sorting trays with a red rabbit affixed to one and a blue boat affixed to the other. Note that children never sorted cards that were identical to the cards affixed to the sorting tray, sorting cards always matched on one dimension (e.g. shape) and mismatched on another dimension (e.g. color). The task began with the experimenter identifying the two dimensions of the cards (i.e., shape and colour) by pointing to the cards that had been affixed above the two sorting trays and saying, “Look. Here is a red rabbit and here is a blue boat.” Next, the experimenter randomly chose either colour or shape as the first sorting rule and explained the rules for playing this *preswitch phase*. For example, children who sorted by colour during the preswitch were told, “We are going to play a colour game. In the colour game, if its red put it here” (pointing to the tray below the red rabbit) “but if it’s blue put it there” (pointing to the tray beneath the blue boat). The experimenter then demonstrated the sorting procedure by sorting one card facedown into the appropriate tray. A second card was sorted in this manner, but this time children were asked to place the card on the appropriate tray. The experimenter provided corrective feedback as needed. This was followed by six preswitch trials in which the experimenter randomly selected a test card (with the constraint that the same type of card could not be presented on more than two consecutive trials), labeled the card by the relevant dimension only (e.g., during the colour game the experimenter would say “here is a blue one”), and then

asked participants, “Where does this go?”. Children were required to place the card facedown in one of the trays. No feedback was provided.

After completing six trials, children were told, “Now we are going to play a new game. We are not playing the colour game (for example) anymore. Now we are going to play the shape game.” The rules for the *postswitch phase* were the same as preswitch in every respect except that the dimension used for sorting changed. Thus, children were told, “In the shape game, if it’s a boat put it here” (experimenter pointing to the boat affixed to the sorting tray), “but if it’s a rabbit put it here” (experimenter pointing to the rabbit affixed to the sorting tray). Six postswitch trials were administered.

Children who passed the postswitch phase (correctly sorted at least 5 of the 6 cards) were given a third, more difficult phase immediately following completion of the postswitch phase. In this *border phase*, children were shown two test cards similar to those used in the pre- and postswitch and two new test cards that had a  $\frac{1}{4}$  inch black border framing the image of the blue rabbit or red boat. Children were told that the presence or absence of a black border indicated which sorting rule was relevant for that particular card (e.g., “If there’s a black border, you have to play the shape game; if there is no black border, you have to play the colour game”). On each of 6 test trials that followed the experimenter stated the rule, randomly selected a test card (with the constraint that the same type of card could not be presented on more than two consecutive trials), labeled the card by the relevant dimension (i.e., “This one has a border” or “This one has no border”), and then asked children, “Where does this go?” As with the previous phases, no feedback was provided. The total number of correctly sorted cards was calculated for the three phases combined.

***Animal-Color Task.*** This task is intended to measure cognitive flexibility. Children were told they were going to play a game that required them to name either animals or colors. Children were first shown a row of 5 black and white animals inside 5 boxes and the experimenter ask them to name each animal. Feedback was provided. Then the children were shown 5 animals in boxes that had a colored background and the experimenter asked them to name the color in each of the boxes. Feedback was provided. Then the experimenter said, “*Good, you know all the animals and colors you are going to see in this game. Now, let me tell you the rules of this game. If you see a box that has color in it like this one [pointed to first box in practice row] color in it then you are to say the color name. This box is red so I would say “red” for this one. But if you see a box that does not have a color in it like this one [point to second box] then you are going to say the animal name. See, this box does not have a color so I would say “cat” for this box. So “red” [pointed to 1<sup>st</sup> box], “cat” [pointed to 2<sup>nd</sup> box], what would you say for this box [pointed to 3<sup>rd</sup> box]?”*. The examiner pointed to the rest of the boxes one at a time and corrected any errors by reminding the child of the rules (“*Remember, if the box has a color you say the color name, but if the box does not have a color then you say the animal name*). “*Now, can you try doing that whole row by yourself?*”. If the child did not understand the practice after two repetitions of the rules, then the task was discontinued. Once children understood the task, the experimenter presented the test page and repeated the instructions. The experimenter instructed the children to go as fast as they could without making mistakes. Total time of completion and number correct was recorded. Self-corrections were counted as errors.

### **Language.**

***The Peabody Picture Vocabulary Test (PPVT-4).*** The PPVT-4 (Dunn & Dunn, 2007) was administered to assess children’s level of receptive vocabulary. The materials consist of a

booklet containing 4 pictures on each page. For each page, children heard a word read aloud (e.g., banana) and were asked to point to the picture on the page that corresponded to the word. Two practice trials were administered and corrective feedback was given as needed to ensure that children understood the task. The task discontinued when children make an error on 8 out of a set of 12 words. Raw scores (ceiling item – number of errors) were used in data analyses. Higher scores indicated better verbal ability. Bilingual children were tested in English and a German translation of the PPVT and the order was counterbalanced so that half the children were tested in English first and German second, and the remaining children were tested in German first and English second. This provided a rough measure of the verbal ability in German as no standardized norms are available for administering the PPVT in German in a non-German context. Despite these limitations, this method was preferred to using a German version of the PPVT because scores were not standardized for use in Canada. For example, specific German words may be used in Germany, but not used by German bilinguals in Canada. Translation was done by native German speakers who were fluent in both German and English.

*Clinical Evaluation of Language Fundamentals (CELF)*. The expressive language subtest "Formulating Labels" was administered (Wiig, Secord, Semel, 2004). The experimenter pointed to a picture from a standardized series of pictures, and asked questions such as "*what is this?*" or "*what is the baby/boy/ woman doing?*". Children said what was happening in a picture, using single words, phrases, or complete sentences. The task was discontinued when children made eight errors in a row. Raw scores out of 20 were used in data analysis. Bilingual children were tested in English and a German translation of the CELF.

## **Parent Report Measures**

### **Language**

*Caregiver Language Proficiency & Language Exposure Questionnaire.* A short questionnaire was distributed along with the consent form for the parents or caregivers of each child. The questions were designed to collect demographic information, identify any developmental or learning disabilities that children might have, and also assess participants' knowledge and practice of language use.

## Results

In the following sections, I first describe the analytic strategies and screening procedures applied to all variables. Then I describe the strategies used to reduce data for the different constructs assessed in this study. Next, I report results from tests of the relation among EF tasks, verbal ability and SES. Finally, I describe the relations between language proficiency and EF. All statistical analyses reported were two-tailed and alpha was set to .05.

### General Analytic Considerations

#### Missing Data

*Child Measures:* Data for child measures were missing for three reasons (see Table 1). One reason was equipment failure ( $n = 1$ ), which would be characterized as MCAR (missing completely at random). Another reason for missing data was cases when children attempted a task, but was unable to complete it ( $n = 7$ ). For example, if the child tried the practice section of the Animal Color task, but did not understand the task after two repetitions of the rules, the task was discontinued by the experimenter. It was decided that in these cases, rather than imputing the lowest possible score, it was appropriate to assign a score of 0 to these children because it reflected the child's ability on that task. Finally, data were missing because children refused to complete the task ( $n = 4$ ). There was a significant mean difference between participants who refused to attempt the German PPVT or the German CELF; thus, these missing values are

characterized as missing not at random (Tabachnick & Fidell, 2007). Overall, these three categories of missing data represented 1.5% of responses from children.

To address the missing data problem due to refusals and to computer error ( $n = 5$ ), and to avoid biased results and sample size reduction in case of listwise deletion, the missing values were imputed using the Maximum Likelihood (ML) estimation using SYSTAT. ML is appropriate because ML estimates uses EM (expectation maximization) algorithm, and uses key population parameter values which allow the user to estimate a range of linear models (see Ender, 2006). For this study, population parameters included: age, maternal education, paternal education, English vocabulary score, German vocabulary score, Backward Digit and Word scores, Forward Digit and Word scores, in addition to the Boy-Girl Stroop score. These parameters were chosen because they were correlated with the variables containing the missing data. Enders (2006) suggests that using a large number of parameters is appropriate because simulated results have found parameter estimates are not effected by a large number of added variables.

***Parent Measures:*** Missing data was generally isolated to one or two items missing from a multi-item parental questionnaire. For example, some parents ( $n = 3$ ) left the approximate family income level blank. Return rate for questionnaires was 100%.

### **Normality**

All variables were screened for outliers, skewness, and kurtosis. Three variables had univariate outliers: DCCS, Forward Task Aggregated, and the Go/ No-Go Task. Before a decision was made about how to handle these outliers, they were screened for the presence of multivariate outliers using Mahalanobis Distance with (conservative)  $p < .001$  for the  $\chi^2$  value

(Tabachnick & Fidell, 2001, p. 99). No cases were multivariate outliers; the problem was therefore limited to individual variables.

The DCCS task was negatively skewed and platykurtic (skewness = -1.8, kurtosis = 3.6). The Forward Tasks was also negatively skewed and platykurtic (skewness = -1.0, kurtosis = 2.4); however, the Go/ No-Go Task was positively skewed and leptokurtic (skewness = 4.5, kurtosis = 26.7). Examination of the files revealed that these children seemed to understand and were engaged in the task. Thus, it was decided not to conduct any score transformations. All other variables were reasonably distributed (i.e. values of skewness and kurtosis were below 2).

### **Impact of Procedural Factors**

There were three procedural factors that could have influenced the results. These differences were: setting, order of tasks, and number of sessions. First, children were recruited through three different strategies (community advertisements, a daycare, and German School handouts), and therefore tested in three different settings (university lab, daycare, and child's home). Second, children were administered tasks that were organized by random assignment into 4 groups (Session A with PPVT first, Session A with CELF first, Session B with PPVT first and Session B with CELF first). Finally, some children had both sessions administered in one day ( $n = 40$ ) and some children had sessions on different days ( $n = 16$ ; mean number days between sessions was 10.13,  $SD = 9.67$ , range = 1 to 31 days). In order to examine whether these factors influenced the results, a series of multivariate analysis of covariance was performed on 10 dependent variables (English PPVT, English CELF, Forward Word Span, Forward Digit Span, Backward Word Span, Backward Digit Span, Animal Color, Boy-Girl and Go/ No-Go) and two covariates (age and socioeconomic status). Independent variables were modified according to

the specific factor being examined. All MANCOVA's did not show any significant effect for any of the factors; thus, procedural factors did not influence the results.

## **Preliminary analyses**

### **Demographic characteristics**

Demographics and parent questionnaires are summarized in Table 2. Groups did not differ in age,  $SE = 3.24$ ,  $t(54) = .53$ ,  $p > .10$ . Groups did not significantly differ in the representation of males and females. The bilingual group was significantly socially advantaged compared to the monolingual group on several indicators: maternal education,  $SE = .82$ ,  $t(54) = 3.47$ ,  $p > .001$ , paternal education,  $SE = .83$ ,  $t(54) = 2.74$ ,  $p > .01$ , and family income,  $SE = .41$ ,  $t(51) = 2.63$ ,  $p < .05$ .

Half the parents reported the family had immigrated from German speaking country (Germany or Austria) less than 12 years ago; the other half reported immigrating from a German speaking country between 12 and 45 years ago. All children spoke a mixture of German and English at home. The majority spoke English with friends.

### **Data Reduction**

Raw scores for the vocabulary tests and EF tasks are presented in Table 3. A number of score calculations for language, SES, EF, and German language proficiency were conducted based on correlation values. As expected, high correlations were found between the English PPVT and the English CELF, see Table 4. Thus, the PPVT and CELF scores were converted to z scores and were aggregated to create an English Vocabulary Score. For the bilingual group, high correlations were also found between the German translation of the PPVT and the German translation of the CELF,  $r(27) = .50$ ,  $p < .05$ . Thus, the same procedure for the English Vocabulary score was followed to create a German Vocabulary Score.

With respect to SES, it was found that mother and father education scores were moderately correlated,  $r(56) = .32, p < .05$ . Thus, each parent received a score depending on his or her level of education (e.g. high school or less = 1, high school plus 6 years of university = 5) and then parent scores were averaged. Families also received a score depending on family annual income (e.g. <\$20,000 = 1, \$20-40,000 = 2... >\$170,000 = 7). Following Morton and Harper (2007), family income scores were then combined with the mean parent education score to create a composite SES score that could range from 4.5 to 14. Carlson and Meltzoff (2008) chose to only use parental education levels as a proxy for SES; however, it was decided that calculating the SES score using Morton and Harper's criteria would be beneficial because it also included a measure of family income. SES is most commonly measured by including income and education (Ensminger & Fothergill, 2003)

A series of EF component scores were computed. First, as expected, high correlations were found between the Forward Word Span and the Forward Digit Span,  $r(56) = .60, p < .01$ . Thus, the Forward Word and Digit Span task were converted to z scores and were aggregated to create a Short Term Memory Score. High correlations were also found between the Backward Word Span and the Backward Digit Span,  $r(56) = .78, p < .01$ . Thus, the Backward Word and Digit Span task were converted to z scores and were aggregated to create a Working Memory Score. Similar procedures were followed to create a Cognitive Flexibility Score using the Animal Color task and the Dimensional Change Card Sort task,  $r(56) = .38, p < .01$ , and the Inhibition Score using the Boy-Girl Stroop and the Go/ No-Go task,  $r(56) = .38, p < .05$ .

For the German Language Proficiency score, parental reports on speaking, listening, writing and reading skills were aggregated to create a Caregiver Proficiency Score with higher scores indicating better German skills compared to English skills. Moderate scores indicated that

German and English skills were similar, while low scores indicated better English than German skills. The Caregiver Proficiency score was highly correlated with the German Vocabulary Score,  $r(27) = .74, p < .01$ . Thus, both scores were converted to z scores and combined to create the German Language Proficiency score.

### **Verbal Ability**

Previous research has suggested a relation between age and verbal ability, in addition to a relation between language group and verbal ability (i.e. monolinguals performing better than bilinguals on the PPVT and vice versa); thus, it was important to explore these associations. Because there was an unequal number of younger children (17 three and four year olds; 8 bilingual, 9 monolingual) compared to older children (39 five and six year olds; 19 bilingual, 20 monolingual) a median split was used to dichotomize the age groups, as shown in Table 5. A two-way ANOVA for Age (younger; older) and Language Group (monolingual; bilingual) on the English Vocabulary score showed a main effect of Age,  $F(1, 52) = 23.06, p < .0001, \eta^2 = .30$ , due to better performance of older children. Language group was close to reaching significance,  $F(1, 52) = 3.81, p < .06, \eta^2 = .05, f = .26$ , due to the better performance of monolingual children. The interaction between Age and Language Group was non-significant,  $F(1, 52) = .001, p > .10, \eta^2 = .00$ . In sum, as expected, older children performed better on the English vocabulary tests.

Additionally, bilingual children's German and English receptive vocabulary was compared using a mixed ANOVA, with Age (younger, older) as the between-subjects variable and Language (English, German) as the within-subjects variable. A main effect of Language,  $F(1, 22) = 11.459, p < .01, \text{partial } \eta^2 = .34$ , was found with bilingual children performing better on the English PPVT. However, there was no effect of Age ( $F(1, 22) = 2.60, p > .10$ ), partial  $\eta^2 = .11$  or in the interaction between Language and Age,  $F(1, 22) = .01, p > .10, \text{partial } \eta^2 < .001$ .

The same analysis was conducted using the CELF as the dependent variable in a mixed ANOVA. A main effect of Language,  $F(1, 25) = 53.17, p < .001$ , partial  $\eta^2 = .68$ , was found with bilingual children performing better on the English CELF. However, Age was not significant,  $F(1, 25) = 1.94, p > .10$ , partial  $\eta^2 = .07$ , and the interaction between Language and Age was not significant,  $F(1, 25) = 3.21, p < .10$ , partial  $\eta^2 = .11$ . In sum, bilinguals performed better on the English PPVT and the English CELF compared to the German PPVT and the German CELF.

### **Correlation between age, verbal ability and SES**

As expected, several of the executive function measures were significantly related to age and verbal ability (see Carlson & Meltzoff, 2008). Individual EF tasks and their relation to age, verbal ability and SES were compared, see Table 4. EF composite scores (Working Memory Score, Short-Term Memory Score, and Cognitive Flexibility Score) were significantly correlated with age,  $r_s = .41-.62, p_s < .01$ . However, the Inhibition Score was not significantly correlated with age,  $r(27) = .02, p > .05$ .

### **Relations between EF and language groups**

To examine the relation between EF and language groups, a MANCOVA was conducted with age, English Vocabulary Score, and SES score entered as covariates and the Short Term Memory Composite, the Working Memory Composite, the Cognitive Flexibility Composite, and the Inhibition Composite as dependent variables, using language group (bilingual and monolingual) as the independent variable. The English language score had a significant multivariate effect on EF, Wilk's  $F(1, 53) = 4.62, p > .01$ , partial  $\eta^2 = .28$ . Univariate analyses showed that the English language score was only significantly associated with the Working Memory Score,  $F(2, 53) = 7.08, p < .05$ , partial  $\eta^2 = .12$  and the Cognitive Flexibility Score,  $F(2,$

53) = 13.14,  $p < .001$ , partial  $\eta^2 = .21$ . Interestingly, language group had no multivariate effect on EF, Wilk's  $F(1, 53) = 1.40$ ,  $p > .10$ , partial  $\eta^2 = .10$ .

### **Language Proficiency**

In order to test the third hypothesis and to further explore why language group had no effect on EF, the bilingual group was subdivided into high and low proficiency groups to explore whether level of proficiency affected performance on EF tasks. An index of the participants' proficiency in both languages was created based on the differences of the two PPVT scores (English – German) for each bilingual (see also Cromdal, 1999). The index was then used to separate the children into a highly proficient bilingual group and a lower proficiency group. The median difference of 23.00 points ( $M = 33.30$ ,  $SD = 35.35$ ) split the bilinguals into two groups with lower proficiency bilinguals given a score of 2 and highly proficient bilinguals given a score of 3. The same procedure was followed for the two CELF scores. The median difference of 17.00 points ( $M = 18.11$ ,  $SD = 11.24$ ) split the bilinguals into two groups. PPVT and CELF difference scores were highly correlated  $r(27) = .67$ ,  $p < .0001$ . In other words, the differences in language proficiency on the PPVT and CELF were similar. Thus, the mean difference scores for the PPVT and CELF were calculated. It was decided that only bilinguals who received an average score of 3 would be in the highly proficient group ( $n = 7$ ) because they demonstrated similar performance in both German and English for both receptive and expressive verbal abilities.

### **Relations between EF and language proficiency groups**

Another MANCOVA similar to the one described above was conducted with the only difference that the independent variable had 3 groups (high proficiency, low proficiency and monolingual) instead of two values. Results showed there was a multivariate effect of English

Vocabulary Score on EF, Wilk's  $F(1, 53) = 3.99, p > .01$ , partial  $\eta^2 = .25$ . Univariate analyses showed that the English Vocabulary Score was only significantly associated with Working Memory Score,  $F(2, 53) = 5.55, p < .05$ , partial  $\eta^2 = .10$ , and the Cognitive Flexibility Score,  $F(2, 53) = 11.90, p < .001$ , partial  $\eta^2 = .19$ . Interestingly, language group had no multivariate effect on EF, Wilk's  $F(1, 53) = .33, p > .10$ , partial  $\eta^2 = .08$ .

### **Discussion**

The aim of the present investigation was to examine the effect of the bilingual experience on young children's executive functioning. Toward this end, preschool monolingual and bilingual children completed batteries of EF and language tests, and bilingual parents reported on measures of language exposure and language use. This study extends previous research by using a battery of EF measures, using a previously unstudied group of bilingual children (German-English), and using both receptive and expressive measures of vocabulary to assess whether language proficiency would affect the performance of bilinguals.

The present study was guided by three hypotheses. First, it was hypothesized that the performance of bilingual and monolingual children would not differ on tasks measuring short-term memory, working memory, and response inhibition. Second, it was hypothesized that bilingual children would perform better than their monolingual peers on tasks intended to measure cognitive flexibility. Lastly, it was hypothesized that only bilinguals with high language proficiency in German would perform better on tasks measuring cognitive flexibility compared to monolinguals and bilinguals with low language proficiency in German. First, findings related to each hypothesis will be reviewed and discussed. Second, limitations of the study will be reviewed and suggestions for future research will be provided.

## Summary of Primary Findings

Based on a review of the literature on EF and bilinguals, I hypothesized that there would be no difference between bilingual and monolingual children on tasks measuring working memory, short-term memory, and inhibition. Consistent with previous studies, there was no significant difference between the performance of monolingual and bilingual children on short term memory tasks (Bialystok, 1999; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008). In a similar vein, there was no significant difference between the performance of monolinguals and bilinguals on working memory tasks. These results are consistent with Bialystok, Craik, and Luk (2008) who found that there was no difference in performance between young adult bilinguals and monolingual on the Corsi task, a working memory task. As expected, there was no significant difference between the performance of monolingual and bilingual children on tasks intended to measure inhibition. This is consistent with other studies that have used tasks intended to measure inhibition (Bialystok, Craik, & Ryan, 2006; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008).

I also had hypothesized that bilingual children would perform better than their peers on tasks intended to measure cognitive flexibility. However, the present study did not find a significant difference between bilingual and monolingual children's performance on cognitive flexibility tasks. As such, the present results are at odds with prior evidence of a bilingual advantage on tasks measuring cognitive flexibility (Bialystok, 1999; Bialystok & Martin, 2004; Carlson & Meltzoff, 2008). In reviewing the German proficiency scores, I found that there was a lot of variability in scores, some bilingual children had extremely low scores and other bilingual children had much higher scores regardless of age. It is possible that this variability in German proficiency is contributing to the null effect. In order to test the third hypothesis and to further

explore why language group had no effect on EF, the bilingual group was subdivided into high and low proficiency groups to explore whether level of proficiency affected performance on EF tasks.

### **German Language Proficiency and EF**

It was also hypothesized that only bilinguals with high language proficiency in German would perform better on measures of cognitive flexibility than monolinguals. It was also predicted that the performance of bilinguals with low language proficiency in German would not differ from that of monolinguals on tasks intended to measure cognitive flexibility. However, when the bilingual group was divided into high and low proficiency groups following criteria used by Cromdal (1999), there were no significant differences between groups. Even when an additional analysis was conducted following criteria for separating bilingual into high and low proficiency groups laid out by Ricciadelli (1992), no significant differences were found among all six language groups. In sum, the present study suggests that the language proficiency of bilinguals in either language does not affect performance on EF tasks, but it would be premature to exclude testing language proficiency in future research based only on the present study.

There are a number of reasons why the language proficiency of bilinguals in German language did not affect performance on EF tasks in the present study. I will limit my discussion to three possible explanations related to: (a) specific language combinations, (b) verbal ability, and (c) SES. First, it is possible that only specific language combinations result in a bilingual advantage on specific EF tasks. Studies that have found a bilingual advantage on tasks measuring cognitive flexibility included bilingual preschool children who spoke either: English and Spanish (Carlson & Meltzoff, 2008), English and French (Study 2, Bialystok and Martin, 2004) or English and Chinese (Cantonese or Mandarin; Bialystok, 1999; Study 1 & 3 Bialystok

and Martin, 2004). It could be that specific differences in phonologies or the system of grammar among language combination may contribute to whether bilinguals demonstrate an advantage. For example, German and English could be characterized as having more similar phonology and grammar compared to Cantonese and English. Thus, further research needs to be conducted with bilinguals with other language combinations to examine this possibility.

Differences in verbal ability may also have contributed to why bilingual children and monolingual children did not differ in their performance of cognitive flexibility tasks. I will discuss the English verbal ability of monolingual and bilinguals and the bilingual children's proficiency in their second language. The present study found that the monolingual children performed better on the English vocabulary tests compared to the bilingual children. These results are consistent with other studies which have found that bilingual children perform more poorly compared to their monolingual peers on measures of receptive vocabulary (Bialystok, 2009; Mahon & Crutchley, 2006; Cromdal, 1999; Umbel, Person, Fernandez & Oller, 1992) and expressive vocabulary (Carlson & Meltzoff, 2008). In contrast, some studies have found that bilingual children do not differ on measure of receptive vocabulary from their monolingual peers (Bialystok, 1999; Davidson, Raschke, & Pervez, 2010; Morton & Harper 2007). Further research is necessary to resolve these inconsistencies.

In contrast to previous studies, the bilingual group performed significantly better on the English vocabulary tests compared to the German vocabulary tests. There are few studies with bilinguals that have also tested proficiency in both languages. Morton and Harper (2007) administered French and English versions of the PPVT to the bilingual children; however, the authors found that the differences between mean scores were not significant. Another study that assessed syntactic awareness found that bilingual children's scores on the English PPVT and the

translated Urdu version of the PPVT were also not significantly different (Davidson, Raschke, & Pervez, 2010). Thus, it is not known why, in the present study, bilingual children performed significantly better on the English vocabulary tests compared to the German vocabulary tests. It could be that the bilingual participants have had more English exposure than German exposure or that the German language is not valued as much compared to other languages in Canada. For example, Morton and Harper's study also took place in Canada; however, it would be easier for the bilingual participants to be more balanced in the languages examined in that study because a) there is more French media (music, television, etc) compared to German media in Canada, and b) French may be considered more valuable because it is one of Canada's official languages. It would be interesting to explore these explanations in future research.

Differences in SES may also explain why bilingual and monolingual children did not differ in their performance on cognitive flexibility tasks. The present study is unique because the bilingual children had a significant economic advantage compared to their monolingual peers. Thus, it was unexpected that, despite their significantly higher SES, the bilingual group did not perform better on cognitive outcome measures. Parents' access to financial resources and parents' levels of education affects their parental provision of cognitive stimulation (e.g. explaining events, direct teaching), and emotional support (e.g. sensitivity, warmth) (see Conger et al., 1994, 1995), which, in turn, contributes to the development of attention (Landry & Chapieski, 1989; Linver et al., 2002, Kochanska et al., Noble et al., 2005) and self-regulation (Giesbrecht, Müller, & Miller, 2010). Further, it has been suggested that in certain low-SES families, factors such as parenting stress or family chaos may limit opportunities for collaborative cognitive activities (e.g. reading, solving puzzles), while the presumably lower stress experienced by middle class families may provide more resources for competent

caregiving to encourage the development of the child's self-regulatory capacities (Bernier, Carlson, & Whipple, 2010).

However, even though the bilingual children in the present study had significantly higher SES compared to the monolingual children, this does not necessarily ensure that they will do better on cognitive tasks. Studies have demonstrated that language ability mediates the relation between EF and SES (e.g. Noble et al., 2005). Accordingly, it is possible that English ability and not the proficiency in the second language (i.e. German) may be predictive of EF performance. In a similar vein, results showed that English vocabulary scores were significantly correlated with EF, which is consistent with previous research (e.g. Carlson, Mandell, & William, 2004; Hughes, 1998). Further, the English Vocabulary Score was only significantly associated with working memory and cognitive flexibility, but not with inhibition. This finding is consistent with cross-sectional studies that have found significant correlations between, on the one hand verbal ability and, and on the other hand cognitive flexibility and working memory, however, the relation between verbal ability and inhibition is not consistently found (for review see Müller, Jacques, Brocki, & Zelazo, 2009). It should be acknowledged that family factors, such as the quality and complexity of mother-child interactions (Hoff, 2003), contribute to individual differences in verbal ability and may also underlie individual differences in EF (Hughes & Ensor, 2009).

The present study is also unique because other studies with bilingual children have found their SES background to be similar or at a disadvantage compared to monolingual children. Morton and Harper's (2007) sample consisted of bilingual and monolingual children who had comparable SES background and results showed that bilinguals did not perform significantly better on EF tasks. In contrast, Carlson and Meltzoff's (2008) sample consisted of bilinguals

who were significantly economically disadvantaged compared to their monolingual peers, and results showed that bilinguals performed significantly better on EF tasks after controlling for SES, verbal ability, and age. Carlson and Meltzoff (2008) suggest that the bilingual children were ‘doing more with less’ because their performance was similar to their monolingual peers on specific executive function tasks despite having lower SES and lower verbal ability. These results suggest that bilingual status may moderate the effects of lower SES. The present study found that the bilingual group had higher SES compared to the monolingual group and even when SES was statistically controlled for, there was no significant difference between the performance of monolingual and bilingual children on EF tasks. In sum, while Carlson and Harper’s sample was ‘doing more with less’, the present sample was ‘doing the same with more’. Together these findings raise the possibility that only when SES is low, might the bilingual experience have significant effect on EF by buffering against the adverse effects of low SES.

It is also possible that there is a limit to the extent to EF can be positively affected. Specifically, if an enriched environment is already present and there are no deficits in English verbal ability, then bilingual status will not further improve performance on EF tasks. This may explain why the present study failed to find a significant difference between bilingual and monolingual children on cognitive flexibility tasks.

In sum, specific language combinations in addition to differences in verbal ability and differences in SES, may have independently contributed to why the present study failed to find a significant difference between monolinguals and bilinguals on cognitive flexibility tasks. Future research is necessary to untangle the complex interplay between these factors.

## **Limitations**

One limitation of the present study is that bilingual children were presented with the German vocabulary tasks using an experimenter who was not a native German speaker. It is possible that this may have underestimated bilingual children's German ability because the experimenter could not prompt the children in German. In addition, bilingual children may have perceived the experimenter as non-German and may not have performed to their potential because they may have wanted to identify with the host (e.g. English) society. Another related limitation is that because the rest of the tasks were presented in English, this may have had a negative effect on children's German language scores. Marian and Fausey (2006) found that when Spanish-English bilingual adults were presented academic information in their two languages, they were more accurate at verbally responding to questions when the language of retrieval matched the language of encoding. In other words, when the experimenter presented information in Spanish and then asked questions in Spanish, participants performed well because the participants were primed to answer in Spanish. However, when the experimenter presented the information in Spanish and then switched to English to ask the questions, participants performed less well. Further, Sauders (1982) found that his son, who was raised as a German-English bilingual, made more errors in German when he had been using English all day. Thus, conducting all the tasks in English and then asking the children to switch to German for the German vocabulary tasks may have underestimated their abilities.

An ideal solution to this problem would be to have a native German experimenter administer vocabulary tasks (similar to Davidson, Raschke & Pervez 2010, experiment 2) and provide bilingual children the option of being tested in their preferred language (Carlson & Meltzoff, 2008; Cromdal, 1999). Efforts were made to address these limitations. First, the German PPVT and CELF were administered using video clips with a male native German

speaker to ensure instructions and tests items were pronounced correctly. The English PPVT and CELF were also administered using video clips with another male who is a native English speaker to ensure both tests were presented in a similar manner. Second, when administering the German vocabulary tests, the experimenter avoided any prompting in English whenever possible to ensure the bilingual child did not have the additional task of having to switch between two languages. Third, the CELF vocabulary task was videotaped so that each child could be scored by a native German speaker using the same restrictive coding scheme for the English CELF. Even though children were not given the option of being tested in either language, Davidson Raschke and Pervez (2010) found that testing the child in either language did not affect his or her performance on a syntactic awareness measure. Thus, it is likely that testing children in either language would not have made a significant difference in the performance of German vocabulary tests.

Another limitation specific to the vocabulary tests was that the same form of the PPVT was used for both the English and the German translation. It would have been better to use the A and B forms of the PPVT and to counterbalance the presentation of these forms. An alternative to using the A and B form of the PPVT would have been to mix up the 144 stimulus items within their blocks so they were not in the same order as they had been in the first presentation (following Abudarham, 1997). In the future, researchers should use either forms when possible or mix up the order to the stimuli to ensure children do not improve their performance as a result of recalling previously presented stimuli. It should be noted that this was not a problem with the CELF. Even though the same stimuli was presented twice, children could not use this information to improve their performance because they still needed to produce, rather than recall, the appropriate label for the picture in each language. It is possible that using the same form of

the PPVT might have influenced performance; however, results showed that CELF and PPVT scores in both languages were highly correlated. Thus, it is unlikely that using the same form of the PPVT differentially affected performance because bilingual children did not differ in their performance on the PPVT and the CELF.

Using a German translation of the PPVT is also problematic. As cited by Aburdarham (1997), there have been reports which warn about the potential problems of translating tests from one language to another (Chevez, 1982; Dunn, 1988). Thus, care and attention was taken to ensure that translational equivalents were appropriate for a German Canadian context. For example, for the CELF, the translation of the phrase “Was macht sie?” (What is she doing?) was initially suggested, but another native German speaker suggested “Was macht das baby” (What is the baby doing?) instead because it was considered to be more age appropriate. Because a German translation of the PPVT and CELF was used, which has not been standardized, it is not known whether this is a valid way of measuring German proficiency.

Using non-standardized tests of German vocabulary may also have contributed to why significant differences in EF performance were not found. This is because language proficiency included the German translated versions of the PPVT and the CELF. If the non-standardized German vocabulary tests are not a valid measure of German verbal abilities, then the creation of groups based on language proficiency may not accurately represent the actual abilities of the bilingual children. Additional research is necessary to explore this possibility.

Another limitation of the study is that the age range used (three to six years of age) is associated with significant changes in language development. Specifically, improvements in phonology (rules governing the sequence of speech sounds), semantics (the way underlying concepts are expressed through words), grammar (rules for word arrangement), and pragmatics

(rules for effective communication) occur during the preschool period and into early childhood. Language is much more in flux in younger children; thus, interindividual differences are not stable. In contrast, interindividual differences in language are more stable in older children. Thus, if older participants (e.g., 6- to 8 years of age) had been included in the study instead of preschool children, a relation between EF and the bilingual experience may have been found.

In a similar vein, additional language measures could have been used to evaluate abilities in syntax (i.e., rules for the formation of grammatical sentences). The present study only tested semantic ability and it is possible that other aspects of language, specifically the knowledge of syntax, affect EF. Morton and Harper (2009) have suggested that because bilinguals manage two systems of grammar and two phonologies, this may also contribute to why bilinguals demonstrate an advantage compared to monolinguals on specific EF tasks. During the initial planning stages of the present study, administering a narrative task to evaluate syntax skills was considered. However, this task was dropped in favor of standardized measures such as the PPVT and the CELF. Further, because children were already being tested on several EF tasks, there was concern that this additional task would make the testing session too long for the children, especially for bilingual children who would have had to complete the narrative task in German and in English.

One final limitation is the small number of bilinguals who were proficient in German as indicated the German translated PPVT and CELF scores. The majority of bilingual children had scores on the English PPVT and the English CELF that were significantly higher than the German PPVT and German CELF scores. Further, older bilingual children did not perform better on the German CELF compared to younger bilingual children; however, older bilingual children performed significantly better on the English CELF compared to the younger bilingual

children. It is not known why performance on the German CELF did not improve with age. These results could be due to differences in language exposure, which will be discussed in more detail in the following section.

### **Suggestions for Future Research**

Some directions for future research have already been noted. In addition, future studies may need to explore children's development of EF in relation to how and when children learn their first and second language. In the present study, the majority of bilingual children were regularly exposed to German and English from birth ( $n = 23$ ); however, some children did not have regular exposure to German until they were three to five years of age ( $n = 4$ ). In other words, 23 of the bilingual children could be categorized as bilinguals; whereas the remaining children could be categorized as second language learners. There was also great variability in the types of language exposure (live vs. recorded) and the amount of language exposure in German and English within the bilingual sample. Because the majority of research studies do not describe the time of exposure, the type of exposure, nor the amount of exposure to both languages in the bilingual samples (Bialystok 1999; Bialystok & Martin, 2004; Bialystok et al., 2004; Carlson & Meltzoff, 2008; Morton & Harper, 2007); it is not known if the timing, type or amount of second language exposure may also influence performance of bilinguals on cognitive tasks.

These differences in second language exposure may reveal which environmental factors lead to being a highly proficient bilingual. Interestingly, parents anecdotally revealed that even if they tried to minimize English exposure to increase German proficiency, they were not always successful. This is because English is the majority language in almost all social contexts; thus, bilingual children would have more opportunities to hear and use English, regardless of parental

efforts. If it was known which factors (e.g. duration, type and amount) related to second language exposure were associated with being a highly proficient bilingual, this information would be very beneficial to second language educators, parents, and the scientific community.

Future research should consider the value of the second language that is being learned. In a broader social context, German would not be considered the quintessential “additive” form of bilingualism (Genesee et. al, 2004, as cited in Paradis, 2010). In contrast, French is one of the official languages of government, it the second most widely spoken language in Canada, and there is widespread availability to French media. Thus, German-English bilingualism would not have the same status as French-English bilingualism in Canada. To illustrate, one parent who regularly tried to speak German to her children was recently rebuffed by her five year old daughter who said, “German is for people in Germany, we live in Canada land so we should speak English!”. It is likely that growing up in English-dominated environment reduces language exposure to and discourages expressive vocabulary development of German. If that were the case, what recourse would parents have to effectively counter act this English-dominated environment? Future research is needed to determine effective intervention for parents in order to support second languages which are also a minority language. It would be interesting to see if participants who were randomly assigned to language interventions (e.g. daily language classes) could improve performance on EF tasks. If so, the amount and type of language exposure could be explored as possible factors that would lead to better performance on EF tasks.

Research on the bilingual development in early childhood and later adulthood has made significant contributions to how the bilingual experience may positively influence cognitive development. However, one study did not replicate the bilingual advantage when ethnicity and

SES were controlled for (Morton & Harper, 2007). Thus, results across studies are not always consistent, nor is it fully understood how being bilingual may affect cognition throughout the lifespan. For example, some research suggests preschool bilingual children demonstrate a cognitive advantage on specific EF task (Bialystok 1999; Bialystok & Martin, 2004; Bialysok et al., 2004; Carlson & Meltzoff, 2008), whereas Morton and Harper (2007) did not find a significant advantage. Further, the majority of research has been limited to preschool or young children (Bialystok 1999; Bialystok & Martin, 2004; Bialysok et al., 2004; Carlson & Meltzoff, 2008; Morton & Harper, 2007), but not older children or adolescents. Thus, it is not known whether the bilingual advantage is consistently found into young adulthood or whether the bilingual advantage varies with age.

One study with older bilingual adults has found a bilingual advantage in older adults using the Simon task (Bialystok et al., 2004); however, these results have yet to be replicated by other researchers. Also, it is not known whether other cognitive tasks such as a modified version of the DCCS would result in a bilingual advantage for both younger children and middle-aged or older adults. In sum, future research should attempt to fill this gap in the literature and create a more integrative and comprehensive understanding of the cognitive development of bilinguals. Linguists, developmentalists, psychologists, educators, and government policy will benefit from the understanding of the cognitive development of bilingual children into older adulthood. Thus, future research should consider longitudinal studies in order to better understand how learning two languages at an early age may influence cognitive development during adolescence and early adulthood. Longitudinal studies are beneficial because they would provide more information about intraindividual changes (i.e. how within-person changes in language

proficiency affect performance on EF tasks) and interindividual change (i.e. how between-person differences in language proficiency are linked to differences in EF).

Consistent with previous research, the present study did not find a significant difference between the performance of bilingual and monolingual children on EF tasks intended to measure working memory, short-term memory, or inhibition. However, bilinguals did not perform better than monolinguals on tasks intended to measure cognitive flexibility, which is inconsistent with previous research. It was also found that when level of language proficiency was taken into account, there was no significant difference in performance on EF tasks when monolinguals, low proficiency bilinguals, and high proficiency bilinguals were compared. There are several reasons why there was a discrepancy between previous research and the present study. Specific language combinations in addition to differences in verbal ability and SES may have contributed to why bilinguals did not perform better than monolinguals on cognitive flexibility tasks. It is possible that being bilingual only has a benefit when SES is low (Carlson & Meltzoff, 2008); in the present study bilingual children had higher SES compared to the monolingual group. Accordingly, it is also possible that if an enriched environment is already present (i.e. high SES) and there are no deficits in English verbal ability, then bilingual status will not further improve performance on EF tasks.

Future research on the study of bilingual children into adulthood is necessary to understand how growing up with two languages influences cognitive development over the lifespan. The study of bilingual children is extremely relevant to a multicultural and multilingual nation such as Canada, because the knowledge gathered by this line of research can inform government policy, the scientific community, educators, parents, and their children. First, information about the cognitive development of bilingual children will aid government funded

education programs to better support bilingual students, their parents, and educators. Second, the present study will provide information for the scientific community about the relation between thought and language. Finally, parents will be able to use this knowledge to make an informed decision on whether to raise their child to become bilingual.

## References

- Abudarham, S. (1997). The tenability of comparing the receptive lexical proficiency of dual language children with standardized monoglot norms. *Educational Studies*, 23, 127-143.
- Abutalebi, J., Tettamanti, M. & Perani, D. (2009). The bilingual brain: linguistic and non-linguistic skills. *Brain and Language*, 109, 51-54.
- Archibald, S. J. & Kerns, K.A. (1999). Identification and description of new tests executive functioning in children. *Child Neuropsychology*, 5, 115-129.
- Ardila, A., Roselli, M., Matute, E., & Guajardo, S. (2005). The influence of parents' educational level on the development of executive function. *Developmental Neuropsychology*, 28, 539-560.
- Barke, E. M. & Williams, D. E. P. (1938). A further study of the comparative intelligence of children in certain bilingual and monolingual schools in South Wales. *British Journal of Educational Psychology*, 8, 63-77.
- Barnett, W. S., Yarosz, D. J., Thomas, J., Jung, K., & Blanco, D. (2007). Two-way monolingual English immersion in preschool education: An experimental comparison. *Early Childhood Research Quarterly*, 22, 277-293.
- Bates, E., Bretherton, I., & Snyder, I. (1988). *From first words to grammar*. New York, NY: Academic Press.
- Bernier, A., Carlson, S. M., & Whipple, N. (2010). From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. *Child Development*, 81, 326-339.
- Bialystok, E. (1999). Cognitive complexity and intentional control in the bilingual mind.

- Child Development*, 70(3), 636-644.
- Bialystok, E. (2001). *Bilingualism in Development: Language, Literacy, & Cognition*. Cambridge, UK; New York: Cambridge University Press.
- Bialystok, E. (2006). Effect of bilingualism and computer video game experience on the Simon task. *Canadian Journal of Experimental Psychology*, 60, 68-79.
- Bialystok, E. (2007). Cognitive effects of bilingualism: How linguistic experience leads to cognitive change. *International Journal of Bilingual Education and Bilingualism*, 10, 210-233.
- Bialystok, E. (2008). Bilingualism: the good, the bad, and the indifferent. *Bilingualism: Language and Cognition*, 12, 3-11.
- Bialystok, E. (2009). Claiming evidence from non-evidence: a reply to Morton and Harper. *Developmental Science*, 12, 499-501.
- Bialystok, E., Craik, F.I.M., Klein, R & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology and Aging*, 19, 290-303.
- Bialystok, Craik, F. & Luk, E. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34, 859-873.
- Bialystok, E., Craik, F.I.M., & Ryan, J. (2006). Executive control in a modified anti-saccade task: effects of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 32, 1341-1354.
- Bialystok, E., & Feng, X. (2009). Language proficiency and executive control in proactive

- interference: Evidence from monolingual and bilingual children and adults. *Brain & Language, 109*, 93-100.
- Bialystok, E., & Martin, M. (2004). Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science, 7*, 325-339.
- Bialystok, E., & Senman, L. (2004). Executive processes in appearance-reality tasks: The role of inhibition of attention and symbolic representation. *Child Development, 75*, 562-579.
- Bialystok, E., & Shapero, D. (2005). Ambiguous benefits: the effect of bilingualism on reversing ambiguous figures. *Developmental Science, 8*, 595-604.
- Bialystok, E. & Viswanathan, M. (2009). Components of executive control with advantages for bilingual children in two cultures. *Cognition, 112*, 494-500.
- Bunge, S. A., Dudukovic, N. M., Thomason, M E., Vaidya, C. J., & Gabrieli, J. D. E. (2002). Immature frontal lobe contributions to cognitive control in children: Evidence from fMRI. *Neuron, 33*, 301-311.
- Campbell, G. L. (2000). *Compendium of the Worlds Languages* (2nd ed.). London: Routledge.
- Carlson, S. M. (2009). Social origins of executive function development. In C. Lewis & J. I. M. Carpendale (Eds.), *Social interaction and the development of executive function* (pp. 87-98). San Francisco: Wiley Periodicals, Inc.
- Carlson, S. M. (2009). Social Origins of Executive Function Development. *New Directions for Child and Adolescent Development, 123*, 87-99.
- Carlson, S., Mandell, D. J., & Williams, L. (2004). Executive function and theory of mind: Stability and prediction from ages 2 to 3. *Developmental Psychology, 40*, 1105-1122.

- Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11*, 282-298.
- Carlson, S. M., Moses, L. J., & Breton, C. (2002). How specific is the relation between executive function and theory of mind? Contributions of inhibitory control and working memory. *Infant and Child Development, 11*, 73-92.
- Carrow, S. M. A. (1957). Linguistic functioning of bilingual and monolingual children. *Journal of Speech and Hearing Disorders, 22*, 371-380.
- Chavez, E. (1982). Analysis of a Spanish translation of the Peabody Picture Vocabulary Test. *Perceptual and Motor Skills, 54*, 1335-1338.
- Conger, R.D., Ge, X., Elder, G.H., Lorenz, F.O., & Simons, R.L. (1994). Economic stress, coercive family processes, and developmental problems of adolescents. *Child Development, 65*, 541-561.
- Conger, R.D., Patterson, G.R., & Ge, X. (1995). It takes two to replicate: A mediated model for the impact of parents' stress on adolescent adjustment. *Child Development, 65*, 541-561.
- Costa, A., Hernandez, M., & Sebastian-Galles, N. (2008). Bilingualism aids conflict resolution: Evidence from the ANT task. *Cognition, 106*, 59-86.
- Costarides, A. H., & Shulman, B. B. (1998). Norm-referenced language measures: Implications for assessment of infants and toddlers. *Topics in Language Disorders, 18*, 26-33.
- Cromdal, J. (1999). Childhood bilingualism and metalinguistic skills: Analysis and control in young Swedish-English bilinguals. *Applied Psycholinguistics, 20*, 1-20.
- Cummins, J. (1976). The influence of bilingualism on cognitive growth: a synthesis of research findings and explanatory hypotheses. *Working Papers on Bilingualism, 9*, 1-43.

- Dale, P. S. (1991). The validity of a parent report measure of vocabulary and syntax at 24 months. *Journal of Speech and Hearing Research, 34*, 565–571.
- Dale, P. S. (1996). Parent report assessment of language and communication. In K. N. Cole, P. S. Dale, & D. J. Thal (Eds.) *Assessment of communication and language* (pp. 161–182). Baltimore: Paul H. Brooks.
- Davidson, M. C. Amso, D. Cruess-Anderson, L, & Diamond, A. (2006). Development of cognitive control and executive functions from 4-13 years: Evidence from manipulations of memory, inhibition and task switching. *Neuropsychologia, 44*, 2037-2078.
- Davidson, D., Raschke, V. R., & Pervez, J. (2010). Syntactic awareness in young monolingual and bilingual (Urdu-English) children. *Cognitive Development, 25*(2), 166-182.
- Davis, H. L., & Pratt, C. (1995). The development of children's theory of mind: The working memory explanation. *Australian Journal of Psychology, 47*, 25-31.
- De Sousa, D. S., Greenop, K., & Fry, J. (2010). Simultaneous and sequential cognitive processing in monolingual and bilingual children in South Africa. *South Africa Journal of Psychology, 40* (2), 165-173.
- Dimond, A., Carlson, S. M., & Beck, D.M. (2005). Preschool children's performance in task switching on the Dimensional Change Card Sort Task: Separating the dimensions aid ability to switch. *Developmental Neuropsychology, 28* (2), 689-729.
- Dunn, L. M. & Dunn, L. M. (1981). Peabody Picture Vocabulary Test- Revised Form M. Toronto, Canada: Psycan.
- Dunn, L.M., & Dunn, D.M. (2007). *The Peabody Picture Vocabulary Test, Fourth Edition*. Bloomington, MN: NCS Pearson, Inc.
- Durston, S., Davidson, M. C., Tottenham, N., Galva, A., Spicer, J., Fossella, J. A., & Casey, B.J.

- (2006). A shift from a diffuse to focal cortical activity with development. *Developmental Science*, 9, 1-20.
- Enders, C. K. (2006). A Primer on the use of modern missing data methods in psychosomatic medicine research. *Psychosomatic Medicine*, 68, 427-436.
- Epstein, I. (1905). *La pensee et la poligloise*. Lausanne: Libraire Payot.
- Ensminger, M.E., & Fothergill, K.E. (2003). A decade of measuring SES: What it tells us and where to go from here. In M.H. Bornstein & R.H. Bradley (Eds.), *Socioeconomic status, parenting and child development* (pp. 13-27). Mahwah: Lawrence Erlbaum.
- Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent variable approach. *Journal of Experimental Psychology: General*, 133, 101-135.
- Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: a review using an integrative framework. *Psychological Bulletin*, 134, 31-60.
- Genesee, F., Paradis, J., & Crago, M. B. (2004). Dual language development and disorders: A handbook on bilingualism and second language learning. Baltimore [MD]; London: Paul H. Brookes Pub Co.
- Giesbrecht G, Müller U, Miller M. (2010). Psychological distancing in the development of executive function and emotion regulation. In B. Sokol, U. Müller, A. Young, G. Iarocci & J. Carpendale (Eds.), *Self- and social-regulation: exploring the relations between social interaction, social cognition, and the development of executive function* (pp. 337-357). Toronto: Oxford University Press.
- Grabao, P.P. (1931). *A study of comparative vocabularies of junior high school pupils from*

- English sand Italian speaking homes* (Bulletin No. 13). Washington, D.C.: U.S. Office of Education.
- Green, D. W., Crinion, J., & Prince, C. J. (2007). Exploring cross-linguistic vocabulary effects on brain structures using voxel-based morphometry. *Bilingualism: Language and Cognition, 10*, 189-199.
- Hakuta, K & Diaz, R. M. (1985). The relationship between degree of bilingualism and cognitive ability: A critical discussion and some new longitudinal data. *Children's Language, 5*, 319-344.
- Harris, C. W. (1948). An exploration of language skill patterns. *Journal of Educational Psychology, 39*, 351-364.
- Hoff, E. (2003). The specificity of environmental influence: Socioeconomic status affects early vocabulary development in maternal speech. *Child Development, 74*, 1368-1378.
- Hongwanishkul, D., Happaney, K. R., Lee, W. S. C., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology, 28*, 617-644.
- Hughes, C. (1998). Executive Function in preschoolers: Links with theory of mind and verbal ability. *British Journal of Developmental Psychology, 16*, 233-253.
- Hughes, C., & Ensor, R. A. (2009). How do families help or hinder the emergence of early executive function? In C. Lewis & J. I. M. Carpendale (Eds.), *Social interaction and the development of executive function. New Directions in Child and Adolescent Development, 123*, 35-50.
- Jackson-Moldonado, D., Thal, D., Marchman, V., Bates, E., & Gutiérrez-Clellan, V. (1993). Early lexical development in Spanish-speaking infants and toddlers.

- Journal of Child Language*, 20, 523–549.
- Junker, D. A. & Stockman, I. J., (2002). Expressive vocabulary of German-English bilingual toddlers. *American Journal of Speech-Language Pathology*, 11, 381–394.
- Kerns, K., & McInerney, R. (2007). *Preschool Tasks* [Computer software]. Victoria, BC, CA: University of Victoria.
- Kirkham, N.Z., Cruess, L. & Diamond, A. (2003). Helping children apply their knowledge to their behavior on a dimension-switching task. *Developmental Science*, 6, 449-467.
- Klee, T., Carson, D. K., Gavin, W. J., Hall, L., Kent, A., & Reece, S. (1998). Concurrent and predictive validity of an early language screening program. *Journal of Speech, Language and Hearing Research*, 41, 627–641.
- Kloo, D., Perner, J., Aichorn, M., & Schmidhuber, N. (2010). Perspective taking and cognitive flexibility in the Dimensional Change Card Sorting (DCCS) task. *Cognitive Development*, 25, 208-217.
- Kochanska, G., Murray, K. T., & Harlan, E.T. (2000). Effortful control in early childhood: Continuity and change, antecedents, and implications for social development. *Developmental Psychology*, 36, 220-232.
- Lakshmanan, U., & Selinker, L. (2001). Analysing interlanguage: How do we know what learners know? *Second Language Research*, 17, 393-420.
- Landry, S. H., Chapieski, L.M. (1989). Joint attention and infant toy exploration: Effects of Down syndrome and prematurity. *Child Development*, 60, 103-118.
- Lapierre, D., Braun, C.J., & Hodgins, S. (1995). Ventral frontal deficits in psychopathy: Neuropsychological test findings. *Neuropsychologia*, 33, 139-151.
- Liebermann, D., Giesbrecht, G. F. & Müller, U. (2007). Cognitive and emotional aspects

- of self-regulation in preschoolers. *Cognitive Development*, 22, 511-529.
- Linver, M.R., Brooks-Gunn, J. & Kohen, D. E. (2002). Family processes as pathways from income to young children's development. *Developmental Psychology*, 38, 719-734.
- MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, 109, 163-203.
- Magiste, E. (1979). Recall of concrete and abstract sentences in bilinguals. *Scandinavian Journal of Psychology*, 20 (1), 179-185).
- Magiste, E. (1979). The competing language systems of the multilingual: Developmental study of decoding and encoding processes. *Journal of Verbal Learning and Verbal Behavior*, 18, 79-89.
- Mahon, M & Crutchley, A. (2006). Performance of typically-developing school age children with English as an additional language (EAL) on the British Picture Vocabulary Scales II (BPVS II). *Child Language Teaching and Therapy*, 22, 333-353.
- Marian, V., & Fausey, C.M. (2006). Language-dependent memory in bilingual learning. *Applied Cognitive Psychology*, 20, 1025-1047.
- Martin-Rhee, M. M., & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition*, 11, 1-13.
- Mechelli, A., Crinion, J. T., Noppeney, U., O'Doherty J., Ashburner, J., Frockowiak, . . . Prince, C. J. (2004). Structural plasticity in the bilingual brain. *Nature*, 431, 757.
- Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, 41, 49-100.
- Morton, J. B., & Harper, S. N. (2007). What did Simon say? Revisiting the bilingual

- advantage. *Developmental Science*, *10*, 719-726.
- Morton, J. B., & Harper, S. N. (2009). Bilinguals show an advantage in cognitive control- the question is why. *Developmental Science*, *12* (4), 502-503.
- Müller, U., Jacques, S. Brocki, K., & Zelazo, P. D. (2009). The executive function of language in preschool children. In A. Winsler, C. Fernyhough, & I. Montero (Eds.), *Private speech, executive functioning, and the development of verbal self-regulation* (pp. 53-69). New York: Cambridge University Press.
- Müller, U., Liebermann, D., Frye, D., & Zelazo, P. D. (2008). Executive function, school readiness and school achievement. In S. K. Thurman & K. A. Fiorello (Eds.), *Cognitive development in K-3 classroom learning: Research applications* (pp. 41-83). Mahwah, NJ: Lawrence Erlbaum Associates.
- Nigg, J. T. (2000). On inhibition/ disinhibition in developmental psychopathology. Views from cognitive and personality psychology and a working memory taxonomy. *Psychological Bulletin*, *126*, 220-246.
- Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science*, *8*, 74-87.
- Oller, D. K., Pearson, B.Z., & Cobo-Lewis, A. B. (2007). Profile effects in early bilingual language and literacy. *Applied Psycholinguistics*, *28*, 191-230.
- Paradis, J. (2010). Bilingual children's acquisition of English Verb Morphology: Effects of language exposure, structure complexity, and task type. *Language Learning*, *60* (3), 651-680.
- Peal, E., & Lambert, W. (1962). The relationship of bilingualism to intelligence. *Psychological Monographs*, *76*, 1-23.

- Pearson, B. Z., Fernández, S., & Oller, D. K. (1995). Cross-language synonyms in the lexicons of bilingual infants: one language or two? *Journal of Child and Language*, 22, 345-368.
- Perani, D., Dehaene, S., Grassi, F., Cohen, L., Cappa, S. F., Dupoux, E., . . . Mehler, J. (1996). Brain processing of native and foreign languages. *NeuroReport*, 7, 2439-2444.
- Perani, D., Paulesu, E., Galles, N. S., Dupoux, E., Dehaene, S., Bettinardi, V., . . . Mehler, J. (1998). The bilingual brain. Proficiency and age of acquisition of the second language. *A Journal of Neurology*, 121, 1841-1852.
- Rescorla, L. (1989). The Language Development Survey: A screening tool for delayed language in toddlers. *Journal of Speech and Hearing Disorders*, 54, 587-599.
- Rescorla, L., & Alley, A. (2001). Validation of the Language Development Survey (LDS): A parent report tool for identifying language delay in toddlers. *Journal of Speech, Language, and Hearing Research*, 44, 434-445.
- Ricciardelli, L.A. (1992). Bilingualism and cognitive development in relation to threshold theory. *Journal of Psycholinguistic Research*, 21, 301-317.
- Rohde, A. & Tiefenthal, C. (2000). Fast mapping in early L2 lexical acquisition. *Studia Linguistica*, 54 (2), 167-174.
- Saer, D. J. (1924). The effects of bilingualism on intelligence. *British Journal of Psychology*, 14, 25-38.
- Shilling, V.M., Chetwynd, A., & Rabbitt, P. M. A. (2002). Individual inconsistency across measure of inhibition: An investigation of the construct validity of inhibition in older adults. *Neuropsychologia*, 40, 605-619.
- Statistics Canada. (2005). *The People: Multilingual Canada, 2001 census*. Retrieved from [http://www43.statcan.ca/02/02a/02a\\_007\\_e.htm#t04](http://www43.statcan.ca/02/02a/02a_007_e.htm#t04)

- Statistics Canada. (2005). *Highlight Tables, 2001 Counts, for Canada, Provinces and Territories*. Retrieved from <http://www12.statcan.ca/english/census01/products/highlight/SAC/Page.cfm?Lang=E&Geo=PR&Code=01&Table=1a&StartRec=1&Sort=2&B1=Age&B2=Counts>
- Saunders, G. (1982). *Bilingual children: A guide for the family*. (Clevedon, Avon, England: Multilingual Matters).
- Tabachnick, B.G., & Fidell, L.S. (2007). *Using multivariate statistics* (5<sup>th</sup> ed.). Boston, MA: Pearson Education, Inc.
- Umbel, V. M., Pearson, B.Z., Fernández, M. C. & Oller, D. K. (1992). Measuring bilingual children's receptive vocabulary. *Child Development, 92*, 1012-1020.
- Vendrell, P., Junque, C., Pujol, M.A, Molet, J., & Grafman, J. (1995). The role of prefrontal regions in the Stroop task. *Neuropsychologia, 33*, 341-352.
- Wiebe, S. A., Espy, K. A., & Charak, D. (2008). Using confirmatory factor analysis to understand executive control in preschool children: I. Latent structure. *Developmental Psychology, 44*, 575-587.
- Yetkin, O., Yetkin, F. Z., Haughton, V.M & Cox, R. W. (1996). Use of functional MRI to map language in multilingual volunteers. *American Journal of Neuroradiology, 17*, 473-477.
- Yoshioka, J. G. (1929). A study of bilingualism. *Journal of Genetic Psychology, 36*, 473-479.
- Zelazo, P. D., & Müller, U. (2002). The balance beam in the balance: Reflections on rules, relational complexity, and developmental processes. *Journal of Experimental Child Psychology, 81*, 458-465.
- Zelazo, P. D., & Müller, U. (2010). Executive functioning in typical and atypical children.

Goswami, A. (Ed.), *Blackwell handbook of cognitive development* (2<sup>nd</sup> ed., pp. 574-603).  
Oxford: Blackwell.

Zelazo, P. D., Müller, U., Frye, D., & Marcovitch, S. (2003). The development of executive function in early childhood. *Monographs of the Society for Research in Child Development, 68*, 1-151.

Zelazo, P. D., Reznick, J. S. & Pinon, D. (1995). Response control and the execution of verbal rules. *Developmental Psychology, 31*, 508-517.

Table 1

*Frequency of missing data by task and reason (child measure)*

Study Variable	Equipment Error	Child unable to complete	Child refused to complete
German PPVT			3
German CELF			1
Forward Tasks		1	
Backward Tasks		1	
Animal Color		3	
Boy Girl		2	
Go/ No-Go	1		

Table 2

*Demographic characteristics and parent questionnaires*

Variable	Language Group	
	Bilingual	Control
Age (months)		
Mean ( <i>SD</i> )	66 (13.12)	64 (11.11)
Range	37-83	40-80
Sex	16m, 11f	15m, 14f
Mother Education		
Mean ( <i>SD</i> )	18 (3.54)	15 (2.58)
Range	12-25	12-22
Father Education		
Mean ( <i>SD</i> )	18 (3.67)	15 (2.47)
Range	13-25	12-22
Annual Family Income (Average)	\$80-110,000	\$50-80,000

*Notes:* Bilingual  $n = 27$ ; Control  $n = 29$ .

Table 3

*Mean raw scores and standard deviation for tests of vocabulary and executive function tasks by language group*

Task	Language Group	
	Bilingual	Monolingual
English PPVT		
Mean ( <i>SD</i> )	105.85 (23.27)	109.51 (25.59)
Range	51-138	35-140
English CELF		
Mean ( <i>SD</i> )	27.89 (7.53)	30.21 (6.57)
Range	8-40	14-40
German translation of PPVT		
Mean ( <i>SD</i> )	80.00 (40.14)	
Range	14-135	
German translation of CELF		
Mean ( <i>SD</i> )	10.37 (9.83)	
Range	0-32	
Forward Word Task (total correct)		
Mean ( <i>SD</i> )	5.67 (1.69)	6.17 (2.00)
Range	0-8	1-10
Forward Digit Task (total correct)		
Mean ( <i>SD</i> )	6.79 (2.47)	6.86 (1.68)
Range	0-10	4-11
Backward Word Task (total correct)		
Mean ( <i>SD</i> )	2.70 (1.81)	3.62 (1.42)
Range	0-5	0-6
Backward Digit Task (total correct)		
Mean ( <i>SD</i> )	2.78 (1.87)	2.93 (1.64)
Range	0-5	0-6
Animal Color Task (total correct)		
Mean ( <i>SD</i> )	16.22 (5.29)	17.23 (4.10)
Range	0-20	0-20
Dimensional Change Card Sort Border Version (total correct)		
Mean ( <i>SD</i> )	14.07 (3.34)	14.14 (3.00)
Range	3-18	6-18
Boy Girl Stroop (total correct)		
Mean ( <i>SD</i> )	16.19 (4.83)	17.00 (1.75)
Range	0-20	12-20
Go/ No-Go (total commission errors)		
Mean ( <i>SD</i> )	3.44 (2.52)	2.89 (3.18)
Range	0-10	0-16

*Note:* Bilingual  $n = 27$ ; Control  $n = 29$ .

Table 4

*Correlations among measures*

Variable	Age	Sex	PPVT	CELF	M.edu	F. edu	FW	BW	AC	DCCS	BG	GNG
Age	-											
Sex	-.18	-										
PPVT	.71**	-.18	-									
CELF	.64**	.04	.79**	-								
M. edu	-.15	.04	.10	-.06	-							
F. edu	-.21	-.05	-.09	-.18	.32*	-						
FW	.53**	.02	.45**	.48**	-.14	-.07	-					
BW	.62**	-.02	.66**	.59**	-.08	-.24	.59**	-				
AC	.39*	.15	.44**	.43**	.06	.04	.48**	.41**	-			
DCCS	.33*	.09	.53**	.47**	.12	-.12	.34*	.35**	.38**	-		
BG	.44**	-.02	.51**	.37**	-.08	-.20	.41**	.53**	.35*	.32*	-	
GNG	.34*	.04	.50**	.29*	.13	.03	.13	.46**	.32*	.36**	.34*	-

*Note:*  $n = 56$ , PPVT- Peabody Picture Vocabulary Test IV, CELF = Clinical Evaluation of Language Fundamental, FW = Forward Digit and Word (total correct), BK = Backward Digit and Word (total correct), AC = Animal Color Task, DCCS = Dimensional Change Card Sort (Boarder version), BG = Boy/ Girl Stroop, GNG = Go/ No-Go Task. \*\* $p < .01$ , \*  $p < .05$

Table 5

*Mean raw scores and standard deviation for age and language group*

Age and language group	PPVT version		CELF version	
	English	German	English	German
Younger children				
Monolingual	98.71		27.18	
(SD)	(28.09)		(7.06)	
Bilingual	91.00	69.38	23.45	10.82
(SD)	(23.92)	(27.94)	(7.38)	(11.11)
Older children				
Monolingual	124.83		34.50	
(SD)	(9.09)		(1.78)	
Bilingual	116.06	85.31	30.94	10.06
(SD)	(16.85)	(44.90)	(6.15)	(9.21)

*Note:* Younger monolingual  $n = 17$ , younger bilingual  $n = 11$ , total  $n = 28$ ; Older monolingual  $n = 12$ , Older bilingual  $n = 16$ , total  $n = 28$ .