

ABSTRACT

ESPOSITO, ALENA GAYLE. *Emerging Bilingualism: Linkages with Cognitive Function*. (Under the direction of Lynne Baker-Ward, Ph.D.).

The following investigations and integrative review addressed several unresolved issues regarding performance differences between monolingual and bilingual speakers in areas of cognitive functioning, specifically interference suppression, autobiographical recall, and language-dependent recall. The specific aims of the work were to understand the effect of quantity of bilingual exposure and second language competence; to generalize previous findings of a performance advantage in executive function to a sample of low-income, minority students; to ascertain the conditions under which performance differences between bilingual and monolingual speakers are found; and to investigate the influence of the language of encoding and subsequent retrieval on access to memories. The three manuscripts comprising this dissertation each contributed to at least one of these aims. The knowledge accrued through this research has implications for understanding the broad impact second language acquisition has on cognitive functioning.

The first manuscript, Esposito and Baker-Ward (2013), examined the effect of second-language exposure as obtained through a dual-language program on executive function. This was followed by Esposito, Baker-Ward, and Mueller (2013), which investigated task conditions under which a bilingual performance advantage over monolingual speakers can be found. Finally, Esposito and Baker-Ward (under review) examined the influence of aspects of the language experience history on the distribution of memories across the lifespan and language dependent recall.

The results address current discrepancies in the literature regarding bilingual cognitive functioning. Task conditions, language of administration, and participant language history all contributed to differences in performance between monolingual and bilingual speakers. The findings also indicate that quantity of exposure predicts executive control while competency is linked with performance on linguistic measures. The results also provide evidence that children from low socio-economic backgrounds, like those from economically advantaged backgrounds, benefit from second-language experience. The discrepant findings in previous studies regarding language dependent recall appear to be resolved by the inclusion of language competence as a moderator.

The broad implications of this work are that language experience affects cognitive performance and thus needs to be considered in studies even when it is not of specific investigation, much as age and gender are routinely included in models. Researchers in this field of inquiry need to come to a quick consensus regarding how language experience is to be measured and quantified for ease of comparison across studies as well as to inform how other cognitive scientists can include language experience in their own models.

© Copyright 2014 Alena Gayle Esposito

All Rights Reserved

Emerging Bilingualism: Linkages with Cognitive Function

by
Alena Gayle Esposito

A dissertation submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

Psychology

Raleigh, North Carolina

2014

APPROVED BY:

Lynne Baker-Ward, Ph.D.
Committee Chair

Thomas Hess, Ph.D.

Agnes Bolonyai, Ph.D.

Jason C. Allaire, Ph.D.

DEDICATION

For Luke- you took on more than your share of the household responsibilities with enthusiasm and taught our girls what egalitarian looks like. You reminded me to laugh and tolerated my stress with the patience of a saint. It might be my dream, but you took it on as your own and helped me shoulder the weight to make it happen. You are the Master.

BIOGRAPHY

My passion for the study of cognitive development began when, at the age of ten, I read about Jean Piaget and spent the remainder of the summer walking my Greenville, NC, neighborhood with a clipboard as I tracked the developmental milestones of the neighborhood children. I remain fascinated by the developmental mechanisms that support school achievement in particular, because success in the classroom contributes to a developmental cascade that influences competent functioning across the lifespan in multiple contexts, including both physical and mental health. Although I have long been committed to improving education, it took a decade for me to understand that I would best serve this goal as a developmental researcher. I initially believed that the greatest contribution I could make to early childhood education was through classroom material design. I entered the NCSU College of Design and studied Industrial Design with an emphasis on child environments (BID, May 2002). Although my design education provided me with the creative problem solving skills that now augment my abilities as a researcher, I came to the conclusion that objects were of limited importance compared to the role of the teacher. I next obtained a professional degree in education (MAT, East Carolina University, June 2003) and subsequently taught kindergarten in a low-performing school district characterized by profound poverty, where I believed I could be of the most service.

While teaching in a dual-language education class, my interests in cognitive mechanisms supporting education were sparked again by the better-than-expected performance of my at-risk students who were immersed in second-language education. My students, who often came to my kindergarten class unable to distinguish between a letter and

a number, were reading and writing in two-languages by second grade. In contrast, many of their age-mates in traditional monolingual education were still struggling with English literacy. It seemed counter-intuitive that minority native English speakers growing up in poverty were outperforming their peers by receiving half of their instruction in a foreign language. I began to investigate how dual-language instruction contributes to cognitive development. So began my pursuit into the possible cognitive benefits of second-language acquisition as a graduate student at North Carolina State University under the guidance of Dr. Lynne Baker-Ward.

My first investigation with Dr. Baker-Ward involved language acquisition and earliest memory, driven by the question of how formal language acquisition supports and shapes our earliest memories. We were able to collaborate with Gallaudet University, at which all communication is in American Sign Language (ASL), to compare the early memories of children who acquired language at the typical time point (either hearing individuals who grew up in hearing households acquiring English or deaf individuals who grew up in deaf households acquiring ASL) to those who had no formal language until beginning school (deaf individuals who grew up in hearing households without ASL). The results indicate the importance of early language and were presented at the biennial meeting of the Society of Research in Child Development (Baker-Ward, Brown, Clark, & **Esposito, 2013**). This study inspired my investigation of the effects of cross-language immigration on memory distribution across the lifespan. Given the importance of language to encoding and retrieving early memories, how does removal from that language environment affect our ability to recall? The results indicated the importance of fluency in the cognitive

representation of multiple languages (**Esposito & Baker-Ward**; *invited resubmission*), a recurring theme in my research that leads into my planned post-doctoral work.

In addition to investigating the connection between language acquisition and memory, I was able to continue to pursue the question that initially led me to graduate school: how does second-language acquisition through dual-language education affect cognitive development? I conducted an initial exploration of possible benefits of dual-language education for executive function in collaboration with the same rural school system in which I began my teaching career (**Esposito & Baker-Ward**, 2013). Although we found support for our hypothesis of an advantage in controlled attention, we were equally intrigued by results within the same study that did not indicate an advantage. I began to investigate the specific components of tasks in which a bilingual advantage is and is not found and ended up developing a new measure of executive function appropriate for use across the lifespan, regardless of literacy level and language skill (**Esposito**, Baker-Ward, & Mueller, 2013; Mueller & **Esposito**, *invited resubmission*). It is rewarding to go back to my former school of employment and share the results of my research with the teachers I worked with and with parents trying to decide whether dual-language education is right for their children. I have followed up on this research with the design of a longitudinal investigation examining the impact of dual-language education on cognitive development as defined more broadly. The first wave of data collection took place in June, 2013, and I plan to continue my original investigation in my post-doctorate position at Emory University working with Dr. Patricia Bauer.

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my advisor, Dr. Lynne Baker-Ward, for her inspiration, support, and mentoring beginning when I was an undergraduate student and continuing through the completion of this degree. Thank you for laying the foundation that I can now walk on. I would like to thank my committee members, Dr. Thomas Hess, Dr. Jason C. Allaire, and Dr. Agnes Bolonyai, for their advice and support of this dissertation work. Also of great aid in the completion of this work was the technical support of Nathan Stevens and Mark Williams. I would like to thank the Lifespan Developmental Psychology faculty, students, Patsy Collins, and my fellow M&ND lab members for the thought-provoking suggestions. Data collection would not have been possible without the aid of many undergraduate research assistants. I appreciate their interest and hours, especially the contribution of Ruth Sirkin, who has been on this journey with me since the beginning.

I was supported this year by a Pre-doctoral Training Fellowship at the Center for Developmental Science at the University of North Carolina at Chapel Hill provided by the National Institute of Child Health and Human Development (T32-HD07376). I am grateful for this training and the support and guidance of Dr. Jennifer Coffman, the Associate Director for Training and Research.

My great appreciation also goes to the teachers and families that agreed to participate in my research for little incentive other than greater good of education. I am especially grateful for the collaboration with Greene County Public Schools and the facilitation of that relationship by Ms. Stephanie Cain and Dr. Pat MacNeill.

I have also had numerous supports outside the academic world that have made this body of work possible. Thank you to my village that provided child care and logistical support so I could attend class as well as continually reminding me that I could accomplish what I set out to do. Thank you to William Garner and my wonderful siblings-in-law who opened their homes to Ellie and I during the first two years of this degree. Thank you to Monique Williams for challenging me to go for it. Thank you to Addelyn and Ellie for being willing test subjects and giving me the absolute best incentive to get this degree done quickly. Thank you to Uncle Frank for telling me I had more to offer the world.

Thank you to my parents. Dad, you did it first and laid a foundation of education as a priority. You did not let me forget how lucky I am to be pursuing my dream while also being understanding of the challenges. You reacted to each of my accomplishments with pride and support that reminded me to stop and enjoy the moment. Mom, you do it all. You are a coach, a hug, a kick in the butt, and my biggest fan all in one. Thank you for the numerous times I called for a word when they simply would not come to me, for the editing, for open access to your closet, and mostly for the friendship and support that I am so very lucky to have in you. I always knew you would give me a soft place to fall if I reached too far, and yet your confidence in me kept me reaching. So much of who I am today is because of who you both have always been.

TABLE OF CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES	x
CHAPTER 1: Introduction	1
Specific Aims	3
Addressing Specific Aims	8
Summary	12
CHAPTER 2: Dual-language Education for Low-Income Children; Preliminary Evidence of Benefits for Executive Function	13
Introduction	13
Method	17
Results	20
Discussion	23
References Cited	26
CHAPTER 3: Interference Suppression vs. Response Inhibition; an Explanation for the Absence of a Bilingual Advantage in Preschoolers' Stroop Task Performance	29
Introduction	30
Method	32
Results	34
Discussion	36
References Cited	37
CHAPTER 4: Things That Go Bump in our Lives: Immigration, Language Fluency, and Access to Autobiographical Memories	39
Reminiscence Bump and Immigration	41
Fluency and Autobiographical Recall	44
This Study	47
Method	48
Results	53
Discussion	59
References Cited	67
CHAPTER 5: Integrated Discussion	80
Addressing Specific Aims	81
Broader Implications	89
Future Directions and Conclusions	96
REFERENCES	99

LIST OF TABLES

CHAPTER 2

Table 1: Characteristics of the Children in Each Program by Grade Level17

Table 2: Performance Means on the Sun/Moon and Trail Making Tasks of
Children in Each Education Program by Grade Level.....21

CHAPTER 4

Table 1: Language Experiences of the Bilingual Immigrants72

Table 2: Demographic Characteristics by Group for Participants Included in Analyses
of the Reminiscence Bump73

Table 3: Demographic Characteristics; Language-Dependent Recall74

LIST OF FIGURES

CHAPTER 2

Figure 1: Mean time to completion of Trail C22

Figure 2: Mean interference score of Trail B to Trail C23

CHAPTER 3

Figure 1: Stimuli for the Bivalent Shape Task33

Figure 2: Errors by monolingual and bilingual preschoolers on the congruent and incongruent trials in the performance of the Day/Night and Bivalent Shape Stroop ..35

CHAPTER 4

Figure 1: Number of reported memories per age bin by immigration group.....76

Figure 2: Number of reported memories per age bin surrounding the age of immigration for the Cross-Language Immigrant group.....77

Figure 3: Percentage of reported memories surrounding immigration that represented a code-switch.78

Figure 4: Interaction between language of cue word and language fluency.....79

CHAPTER 1: Introduction

It is estimated that over half of the people in the world use more than one language in daily life and that this figure is even higher in some areas, including India and Africa (García & Náñez, 2011; Grosjean, 2010). Despite the prevalence of bilingualism, the majority of psychological research is conducted with monolingual samples with little examination of whether the results generalize to the multilingual majority. Although bilingualism was once thought to cause schizophrenia and mental retardation, important discoveries made over the last fifty years show that second-language acquisition, in contrast to the early assumptions, has positive effects on development and only limited drawbacks (Adesope et al., 2010; Grosjean, 2010; Peal & Lambert, 1962).

The differences between monolingual and multilingual development are found in both linguistic and non-linguistic domains of performance. A linguistic disadvantage is often found when comparing the vocabulary of bilingual versus monolingual children in an individual language rather than considering total vocabulary across known languages (e. g., Bialystok & Craik, 2010; Bialystok & Feng, 2011). In addition, rapid access to vocabulary may be more difficult for bilingual individuals (Gollan & Kroll, 2001; Gollan & Silverberg, 2001). These linguistic disadvantages are thought to be the result of managing multiple languages (Hilchey & Klein, 2011). However, managing multiple languages also tends to confer benefits. In addition to the extensive social and practical advantages conveyed with multilingual fluency, managing multiple languages is also thought to convey cognitive gains. These include linguistic benefits robustly found in metalinguistic and metacognitive awareness (see Adesope et al., 2010 for a review). The more controversial “bilingual

advantage” refers to superior performance in non-linguistic tasks of executive processes for bilingual in comparison to monolingual speakers. Although some investigators report this effect as robust (see Adesope et al., 2010, and Hilchey & Klein, 2011, for reviews with children and adults respectively), others question its existence and disregard the findings as an artifact of socio-economic status differences between groups (Morton & Harper, 2007; Paap & Greenberg, 2013).

My long-term goals are to understand the tasks and contexts in which bilingual and multilingual individuals, in comparison to monolingual speakers, function differently; to identify the mechanisms underlying group differences in performance; and to utilize the advantages of multilingual performance to promote school success. Academic success can create a developmental cascade that supports higher socio-economic status and hence both mental and physical health in adulthood (Adler et al., 1994; Anderson & Armstead, 1995; Halleröd & Gustafsson, 2011; Yu & Williams, 1999). This altered trajectory is especially relevant for children with multiple risk factors such as low socio-economic status and minority racial status or language background, who are at a disproportionate disadvantage for school failure (Flores, Bauchner, Feinstein, & Nguyen, 1999; García & Náñez, 2011). The research included in this dissertation represents a necessary first step toward this goal by aiding in the identification of differences in monolingual and bilingual individuals’ cognitive development and ascertaining the specific circumstances under which differences do and do not emerge.

The format of the dissertation will include five chapters. The first, this introduction, will summarize the gaps in previous research that lead directly to the specific aims of the

combined body of work. The contribution of each of the three included manuscripts to the specific aims will then be outlined. The introduction concludes with a brief summary of how the specific aims are addressed in the included body of research. Chapters 2-4 are the full reprints of the manuscripts presented in the introduction. Chapter 5 is an integrated discussion that begins with an assessment of how well the specific aims were addressed. It then moves to the broader implications that can be drawn from the included body of research, including how the work contributes to our understanding of development. The discussion concludes with suggestions for future directions stemming from the broad results and implications of the included work.

Specific Aims

Aim 1. The majority of the studies regarding comparisons between bilingual and monolingual performance were conducted with individuals who acquired their second language through natural immersion processes, such as exposure to multiple languages from birth or immigration to a country in which the second language becomes the primary mode of communication (e.g., Kovács & Mehler, 2009; Bialystok, Craik, & Luk, 2008; but see Bialystok & Barac, 2012, for an exception). In addition, the research has focused on balanced and highly fluent bilinguals, those who have a similar level of competence in both known languages with a high degree of second language knowledge (e.g., Adesope et al., 2010). The portion of the population that falls into this category, however, is very small (Grosjean, 2010).

The nature of bilingualism is multifaceted and dynamic, with fluency in each language adjusting to the contextual demands of the speaker. Although there are many labels

that attempt to categorize bilingual speakers (e. g., balanced, consecutive, crib), few bilingual speakers fit cleanly into any one category. For example, in situations in which the individual no longer needs the first language to communicate, the acquisition of the second language may be subtractive, or at the expense of the first language (Grosjean, 2010). However, the addition of a native speaker into the home may require a revitalized and subsequent fluency in the native language, such as in the case of a native speaking elderly parent moving into the home for assistance. Other bilingual speakers have a high degree of fluency in one domain only, for example, fluency in the context of the work place but not in informal social situations. There is a paucity of literature that includes the effects of varying levels of fluency and bilingual exposure on cognition.

One important question concerns the extent to which cognitive benefits of second language acquisition can accrue through alternative models of second-language acquisition. Although there is extensive evidence that highly-fluent balanced bilinguals who learned a second language very early in life perform better than monolinguals on some tasks (e.g., Adesope et al., 2010; Grosjean, 2010), it is unclear whether children enrolled in dual-language education would experience similar advantages. Bialystok and Barac (2012) investigated possible benefits from participation in immersion education and found positive results after three years of exposure to this educational model. Dual-language education, however, provides a fraction of the second-language exposure that full immersion education does. Similarly, the effect of cross-language immigration on memory retrieval across the lifespan may differ depending on amount of second language exposure and fluency level, but

these variables have been tightly controlled in the literature rather than systematically examined (e.g., Schrauf & Rubin, 1998; Marian & Neisser, 2000).

The limitations just elucidated from previous literature point out the need for research that examines the effect of quantity and quality of second language experience on cognition. This leads directly to the first specific aim: *Determine how quantity of second-language exposure and second-language fluency affect aspects of cognitive functioning.*

Aim 2. In addition to the high level of second-language fluency included in previous investigations, there is an issue of homogenous sociocultural backgrounds. In the majority of investigations, the bilingual samples have not only been highly fluent, but also middle to upper middle class, with children growing up with parents who have obtained college and often advanced degrees. The majority of the research pertaining to the performance advantage of bilingual in comparison to monolingual speakers in executive function has come out of one laboratory, that of Dr. Ellen Bialystok at York University (Adesope et al., 2010). The monolingual and bilingual groups in her investigations in Canada have been comparably advantaged and at low risk for school failure. At the onset of this research, it was not known whether children with risk factors respond to second-language exposure in the same way as their more advantaged peers do.

This question, of course, is integral to my interest in the possibility that dual-language education can serve as an intervention strategy by enhancing executive function among children at cumulative risk for academic difficulty. Effects observed among advantaged children may not generalize to students who experience inadequate supports for development. Children growing up in poverty traditionally have higher levels of stress and

fewer resources, such as food and an appropriate sleep environment (e.g., Bradley & Corwyn, 2002; El-Sheikh et al., 2012). The lack of resources may restrict their ability to capitalize on the benefits of second language exposure. A hungry, tired child is less likely to learn. Thus, the second aim of the investigation: *Determine whether low-income minority children exposed to a second-language through dual-language education show benefits in executive function.*

Aim 3. Another possible reason to question the generalizability of previous findings is that the bilingual advantage for executive processes is sometimes elusive. A body of research establishes a bilingual advantage across different combinations of languages (e.g., Barac & Bialystok, 2012; Bialystok & Viswanathan, 2009), cultures (e.g., Bialystok & Viswanathan, 2009; Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009), and age groups (e.g., Bialystok, Craik, Klein, & Viswanathan, 2004; Bialystok, Craik, & Ryan, 2006). Nonetheless, null results are also reported and the existence of the bilingual advantage is a subject of on-going debate (e.g., Crane et al., 2010; Morton & Harper, 2007; Paap & Greenberg, 2013). Although second language fluency could certainly influence results, it cannot always explain the null findings. The most likely explanations for the inconsistent results are the specifics of the tasks employed.

Investigations comparing monolingual and bilingual speakers in areas of executive function often use different tasks or different procedures for the same task (e.g., Morton & Harper, 2007, compared with Bialystok, 2009). Executive function is composed of three distinct but related constructs; switching, inhibition, and updating (Miyake et al., 2000). The inter-relation of the components necessitates that tasks designed to measure specific aspects

are not pure; consequently, it is difficult to determine exactly what such tasks are measuring. If the bilingual advantage is specific to one area of executive function or, as some purport, one subcomponent of a component of executive functioning, the specific details of the task and how it is administered become pertinent to whether the advantage materializes. It is imperative, then, to discern what task components differentiate monolingual and bilingual performance under what circumstances rather than dismissing the phenomenon completely when null results are reported. Determining the tasks that expose the advantage would also aid in evaluating whether second-language instruction would benefit areas that support academic performance and can thus be used as an intervention for children at risk for academic failure. Therefore, the third aim of this inquiry is: *Investigate the specific task conditions required to elucidate a difference in performance between monolingual and bilingual speakers.*

Aim 4. Although my long-term goal is to implement dual-language education as an educational intervention, there may be disadvantages to such an educational model because access to stored information may depend on the language of both encoding and retrieval. For instance, if science is taught through Spanish but assessed through English, are dual-language students at a disadvantage? Supporting this possibility are previous studies that found bilingual individuals perform better when the language of test matches that of instruction (Barac & Bialystok, 2012; Marian & Fausey, 2006). There are discrepant results, however, regarding the importance of the language of both encoding and retrieval for autobiographical memory access and distribution (e.g., Marian & Neisser, 2000; Schrauf & Rubin, 1998, 2000). This is relevant not only for educational policy, but also to how languages are

represented cognitively. A theory that has gained much support is that of the single conceptual store for fluent bilingual speakers in which content can be accessed equally easily through either language (de Groot, 1992; Kroll, van Hell, Tokowicz, & Green, 2010).

Understanding the circumstances under which encoding and retrieval are affected by language is important beyond autobiographical memory and is especially applicable in the dual-language classroom where content is presented and tested through different languages. Children in such programs typically begin with little to no second language fluency, but acquire competence in the second language over the course of five to six years of participation. If fluency is required for a single conceptual store to develop, children who have not yet reached that fluency threshold, expected to vary by the individual, may not be able to integrate knowledge learned across language environments or access knowledge taught in one language when being tested in the alternate language. It is important, then, to understand the relationship between encoding, retrieval, and fluency in both languages. Consequently, the final aim of this examination is: *Determine if language of encoding and subsequent retrieval affect access to memory for individuals with emerging second-language competence.*

Addressing the Aims

The proffered aims are addressed through three manuscripts. The manuscripts, for which I am senior author, are all based on studies conducted over the past three years with an underlying common thread of bilingualism and cognition. The following section will introduce each manuscript and explicate its relationship to the specific aims.

1. Esposito, A.G., and Baker-Ward, L. (2013). Dual-Language Education for Low-Income

Children: Preliminary Evidence of Benefits for Executive Function. *Bilingual Research Journal*, 36 (3), 295-310. doi:10.1080/15235882.2013.837848.

Esposito and Baker-Ward (2013) contributed to the achievement of Specific Aims 1, 2, and 3. The investigation addressed several questions pertaining to the conditions in which a bilingual advantage emerges for inhibitory function, an aspect of executive function. Specifically, the study examined whether a bilingual advantage would emerge for low socio-economic status children exposed to a second language through a dual-language program in which half of the subject-based instruction was provided in a second language (Aim 2). The cross-sectional design allowed for an initial examination of the number of years of instruction that are needed for such an advantage to emerge (Aim 1). In addition, the use of two different inhibitory function tasks allowed for the exploration of the possibility that the bilingual advantage is found in tasks of interference suppression rather than response inhibition, both elements of inhibitory control (Aim 3).

A bilingual advantage was found in this low SES sample for children who had been enrolled in the dual-language program for three or more years. This finding offers evidence that the bilingual advantage is not an artifact of SES differences between language groups, as had previously been argued (Morton & Harper, 2007), and that low SES children are capable of benefitting from second-language exposure in similar ways to their more economically advantaged peers. In addition, it provides initial evidence that the relatively limited second language exposure provided through a 50/50 dual-language program is enough to accrue benefits to some areas of executive function. The manuscript also contributes to the body of literature by finding discrepant results between two different tasks within one study. One

measure found a bilingual advantage while the other did not. This discrepancy led directly to a follow-up investigation examining specific elements of the tasks.

2. Esposito, A. G., Baker-Ward, L., and Mueller, S. (2013). Interference Suppression vs. Response Inhibition: Preschoolers Demonstrate a Bilingual Advantage with a New Stroop Task. *Cognitive Development* 28, 354-363. doi: 10.1016/j.cogdev.2013.09.002.

Esposito, Baker-Ward, and Mueller (2013) contributed to Specific Aim 2. The study examined the discrepant findings in the literature regarding a bilingual advantage for Stroop task performance. Although a Stroop task advantage has been found in the performance of the Classic Stroop task and a Stroop variation among bilingual adults (Bialystok, Craik, & Luk, 2008; Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010), an advantage has not been found for versions adapted for use with children (Martin-Rhee & Bialystok, 2008; Siegal, Iozzi, & Surian, 2009). I examined which task elements were common to the studies that found an advantage and attempted to find an existing task for young bilingual speakers containing the identified elements (Aim 2). When no such task was available, I designed a task to meet the criteria. A manuscript [Mueller & Esposito] focusing specifically on the software design and use of the task is under invited resubmission at the *Journal of Open Research Software*, but is not included in the papers that form the basis of this dissertation.

The new task, the Bivalent Shape Task (BST), was administered along with the commonly used Day/Night task to groups of bilingual and monolingual preschoolers. The results showed a bilingual advantage in the BST but not the Day/Night task, as expected. This research helps to identify the specific conditions under which a bilingual advantage can be found and helps to narrow the loci of that advantage.

3. Esposito, A. G., Baker-Ward, L. (under revision). *Things that go Bump in our Lives: Immigration, Language Fluency, and Access to Autobiographical Memories.*

Esposito and Baker-Ward (under revision), addressing Specific Aims 1, 3, and 4, examines the influence of second language acquisition on another area of cognition, autobiographical memory. This study examined two aspects of autobiographical memory: the effect of cross-language immigration on the distribution across the lifetime of recalled memories and language-dependent recall (Aim 4). Specifically, we examined the “remembrance bump,” defined as the over-representation of events that occurred during late childhood through early adulthood in adults’ reports of autobiographical memories (Rubin, 2000). The current study investigated the validity of the existing theories by examining whether cross-language immigration would affect the placement of this bump. The study also addressed a discrepancy in the existence of language-dependent recall. We investigated whether task procedure (Aim 3) and/or second language fluency (Aim 1) explained the discrepancies in performance from previous literature.

The cross-language immigrant participants showed a bump surrounding the age of immigration rather than the early decades of life (the pattern shown by the monolingual non-immigrant participants) and the bump was characterized by a greater number of cross-language memories. These results suggest that there is re-organization of the life story for this significant transition event and that task instructions regarding language can influence what memories are reported. The results of this study support an organizational hypothesis to explain the presence of the reminiscence bump and add to our understanding of the underlying causes of the bump for both monolingual and multilingual individuals. In

addition, language-dependent recall interacted with second language fluency and hence offered an explanation for the conflicting reports of previous studies. Participants with high second language fluency appear to access a single conceptual store and thus are not affected by the language spoken to generate memories. Individuals with low second language fluency, however, did show language-dependent recall. The results point to the importance of second language acquisition and fluency in how languages are coordinated within the cognitive system and in subsequent access to memory through languages other than that of encoding.

Summary

The following body of research addresses unresolved issues regarding bilingual cognitive functioning. The effect of the quantity of bilingual exposure and fluency (Specific Aim 1) are addressed in manuscripts 1 and 3. The generalizability of findings to a sample with low socio-economic status (Specific Aim 2) is addressed in manuscript 1. The conditions under which a performance difference between bilingual and monolingual individuals can be found (Specific Aim 3) is attended to in all three included manuscripts. The effect of the language of encoding and retrieval on subsequent access to memory (Specific Aim 4) is tackled in manuscript 3. All three manuscript help inform the bilingual and cognitive development literature.

CHAPTER 2: Dual-Language Education for Low-Income Children: Preliminary Evidence of Benefits for Executive Function

Bilingual Research Journal, 36: 295–310, 2013
Copyright © the National Association for Bilingual Education
ISSN: 1523-5882 print / 1523-5890 online
DOI: 10.1080/15235882.2013.837848



Dual-Language Education for Low-Income Children: Preliminary Evidence of Benefits for Executive Function

Alena G. Esposito and Lynne Baker-Ward
North Carolina State University

This investigation is an initial examination of possible enhancement of executive function through a dual-language (50:50) education model. The ethnically diverse, low-income sample of 120 children from Grades K, 2, and 4 consisted of approximately equal numbers of children enrolled in dual-language and traditional classrooms. Dual-language students in Grades 2 and 4 performed better on a measure from the Trail Making Task requiring inhibition and rule-switching. The results indicate that the established benefits of bilingual exposure can be generalized across SES and ethnicity and can be acquired within the context of elementary school programs.

INTRODUCTION

Executive function (EF), the ability to deploy cognitive resources effectively (e. g., Miyake et al., 2000), is strongly associated with school success (e.g., Blair & Razza, 2007; Diamond, Barnett, Thomas, & Munro, 2007). Indeed, measures of EF are better predictors of later academic achievement than IQ or entry-level reading and math skills (e.g., Bull & Scerif, 2001; McClelland, Morrison, & Holmes, 2000; Waber, Gerber, Turcios, Wagner & Forbes, 2006). Hence, the identification of influences on the development of EF is of considerable significance. This investigation examines the possible benefits of dual Spanish-English language education on EF in low-income elementary school children.

Native speakers of two languages demonstrate superior performance on measures of EF (Adesope, Lavin, Thompson, & Ungerleider, 2010). These benefits extend into nonlinguistic tasks, indicating domain-general advantages in managing EFs that may be caused by the need to manage two language systems (Hilchey & Klein, 2011). Although this bilingual advantage is well established for native bilingual speakers (e.g., Bialystok, 1988, 1999; Luk, DeSa, & Bialystok, 2011), the potential for bilingual education to serve as a means of enhancing cognitive regulation has only begun to be addressed. Recently, Bialystok and Barac (2012) provided evidence that the

Alena G. Esposito and Lynne Baker-Ward are affiliated with the Department of Psychology at North Carolina State University.

Address correspondence to Alena G. Esposito, Department of Psychology, North Carolina State University, Box 7650, Raleigh, NC 27695-7650. E-mail: alena_esposito@ncsu.edu

benefits of second-language exposure on EF may not be limited to native bilinguals but could be acquired through an immersion education model. They reported that the number of years elementary school children from predominantly majority-language English-speaking homes spent in Hebrew or French immersion education predicted their performance on measures of EF.

We extended the results of Bialystock and Barac's (2012) investigation in three important ways. First, we added to the very limited existing examination of the potential benefits of second-language exposure for economically disadvantaged children. Second, we examined the potential benefits of second-language exposure as conveyed through dual-language education rather than minority-language immersion models. Finally, we addressed the unresolved issue of the duration of second-language instruction necessary for EF benefits to accrue.

Potential Benefits of Second-Language Exposure for Economically Disadvantaged Children

Economically disadvantaged children are at greater risk for school failure than their more-advantaged peers (e.g., Gottfried, Gottfried, Bathurst, Guerin, & Parramore, 2003), and efforts that target EF offer promise for reducing the income gap in educational attainment (Blair & Diamond, 2008). Could dual-language education improve EF to the extent that the educational attainment gap between children from low and high socioeconomic status (SES) backgrounds is reduced? An initial step in answering this question is the documentation of the influence of dual-language education on executive function among low-SES children, which was the first objective of this research.

The existing literature on the benefits of second-language education to EF is limited by its inability to generalize across SES and racial groups. Bialystok and Barac (2012) conducted their investigation with upper-middle-class, native English-speaking children in minority-language immersion education. Indeed, the majority of investigations on the bilingual advantage, even outside the classroom, have been conducted with middle-class participants (see Adesope et al., 2010, for a recent review). An exception is a study by Carlson and Meltzoff (2008). Their comparison of EF performance in monolingual, bilingual, and dual-language education kindergarten students included a group of low-income children. However, SES, language group, and ethnicity were confounded in this investigation; the bilingual children were from lower-income, Hispanic American families, whereas the monolingual children and dual-language education students were from middle-income, Anglo-American backgrounds. With only 12 children in the bilingual sample, it is difficult to interpret the absence of group differences in raw scores on measures of EF, although an advantage for bilingual participants emerged when vocabulary and income were controlled. In the present investigation, participants were recruited from traditional and dual-language classrooms in the same schools in a community characterized by pervasive poverty among families from all ethnic backgrounds. Hence, the influence of exposure to a second language on attentional control could be investigated without SES and ethnic confounds, and the extent to which previous findings can be extended to lower-income children was investigated.

Dual-Language Education versus Immersion Education Models

The second objective of the research was to determine if the benefits of immersion education on EF, found when instruction was provided predominantly through a nonnative language

(Bialystok & Barac, 2012), are observed in an education program in which instruction is provided equally in two languages (50:50). We compared the performance of children in traditional classrooms in which instruction was delivered only in English with that of children in a 50:50 dual-language program. In dual-language education, as implemented by the cooperating school system, each classroom contains comparable numbers of language-majority and -minority speakers, and approximately equal amounts of instruction are provided by native speakers of each language. This model differs from minority-language immersion, in which majority-language speakers are educated only in a minority language (Bialystok & Barac, 2012), and also from majority-language immersion, which places language-minority students in an exclusively language-majority educational environment (Barnett, Yarosz, Thomas, Jung, & Blanco, 2007).

In the U.S., in which Spanish-English bilingualism is often associated with socioeconomic disadvantage (U.S. Census Bureau, 2010), there is evidence that majority-language immersion education is not reducing the gap between the educational performance of students who learn English as a second language and native English-speaking European Americans (García & Náñez, 2011). Native Spanish-speaking students in traditional U. S. classrooms often struggle with fluency in English. Moreover, their first language may not be maintained and supported, leading to limited proficiency in both English and Spanish (Christian, 1996). Teachers may mistake the more rapidly acquired Basic Interpersonal Communication Skills (BICS) for full fluency, unaware that Cognitive Academic Language Proficiency (CALP) often lags behind BICS by years (Cummins, 2009). This mistake can lead to termination of needed services designed to aid in the mastery of English, leaving minority-language speakers overrepresented in special education classes and underrepresented in gifted and talents classes, as these distinctions would be based largely on English assessments (Cummins, 2008).

In contrast, Spanish-speaking U. S. children who participate in dual-language education acquire competence in English during the elementary school years and demonstrate comparable levels of academic achievement in comparison to their language-majority peers by the end of elementary school (e.g., García & Náñez, 2011; Genesee, Lindholm-Leary, Saunders, & Christian, 2005; Thomas & Collier, 2004). In addition, their language-majority classmates obtain fluency in Spanish while demonstrating better academic performance than their English-speaking peers in traditional classrooms (García & Náñez, 2011; Thomas & Collier, 2004). Meanwhile, neither language group shows any deficits in English proficiency, even in 90:10 models in which Spanish is the principal language of instruction (Lindholm-Leary, 2001). These benefits have also been found in low SES, predominantly Hispanic communities, indicating that the findings generalize across SES and ethnic distributions (Lindholm-Leary & Block, 2010).

Although it is increasingly clear that dual-language education has benefits for academic achievement, it is unclear if there are advantages for EF. The relatively limited provision of second-language instruction (i.e., 50% rather than 90% or 100%) provided in 50:50 dual-language models may not be sufficient to produce the superior EF linked with minority-language immersion programs (Bialystok & Barac, 2012).

How Many Years Does It Take?

An additional goal of this research was to address the number of years of instruction in a second language that may be necessary to accrue benefits for EF. The use of a cross-sectional,

quasiexperimental design enabled us to compare performance in groups of children with and without exposure to a second language across three grade levels—K, Grade 2, and Grade 4—to explore the cumulative amount of second-language exposure that would be required to demonstrate benefits on EF, should they emerge.

Carlson and Meltzoff (2008) did not find benefits of dual-language instruction on EF in kindergarteners. It is unclear, however, whether this result reflects inherent limits of the educational approach or limited exposure to two languages at the time of the assessment, since their participants had been enrolled in dual-language education for only six months. Suggesting the importance of extended exposure, Bialystok and Barac (2012, Study 2) reported a positive association between amount of second-language education and EF performance for children in Grade 5 but not Grade 2. Based on this pattern of results, we predicted a dose-response relation, with the effects of dual-language education emerging only after Grade 2.

This Study

To address our objectives, we examined differences in aspects of executive performance in children recruited from dual-language versus traditional classrooms in schools in an impoverished community. Both groups included language-minority and language-majority children from each of the three grade levels included in the design. We note that we examined dual-language exposure, operationalized in terms of years of education, rather than second-language fluency. Assessments of the program's effectiveness by the participating school system confirm that children in the program gradually build fluency in their second language.

Two measures were chosen for the investigation based on the following three criteria: use in previous research on second-language exposure and EF, appropriateness for use with children across all represented grade levels and both language groups, and administration time within the constraints specified by the cooperating school system. The Sun/Moon task (Archibald & Kerns, 1999) was selected as a measure of inhibitory control because it does not require reading and is not correlated with vocabulary. Evidence of a benefit in Stroop tasks for those exposed to a second language is mixed. A similar task, the Stroop Picture Naming Task used by Martin-Rhee and Bialystok (2008), did not find an advantage among bilingual preschool children in comparison to their monolingual peers. However, Poulin-Dubois, Blaye, Coutya, and Bialystok (2011) recently found an advantage for toddlers exposed to two languages using an age-appropriate Stroop task. Inclusion of this task may help to clarify the discrepancies in the literature regarding second-language exposure and the Stroop task. The Trail Making Task (Delis, Kaplan, & Krames, 2001) was selected based on a recent study by Bialystok (2010) that utilized this task with school-aged children and found an advantage for children who were fluent in two languages compared to monolingual peers. This task is considered to measure "flexibility of thinking" (shifting and updating) and inhibition and is therefore a general measure of EF (Delis et al., 2001).

We predicted that children from low-SES backgrounds who had extensive exposure to a second language through the dual-language education program would perform better on the Sun/Moon task and the Trail Making Task (TMT) than their traditionally educated peers. Given the equivalent performance of kindergarten children who were educated in monolingual and dual-language programs in Carlson and Meltzoff's investigation (2008), we expected an interaction between

grade and education program, with the benefits of second-language exposure emerging at the upper grade levels, reflecting a dose-response relation.

METHOD

Participants and Design

A total of 120 students were recruited from three grades in a school system located in a rural county in eastern North Carolina and comprised of four schools. Kindergartners ($N = 35$) and Grade 2 ($N = 43$) students in the study attended the system's primary school; the Grade 4 participants ($N = 42$) attended the elementary school. Data from six children who were absent on the testing days and one child who received the lowest possible rating on a measure of engagement during testing are not included in the results. Hence, the final sample consisted of 113 children. In addition, 15 children did not contribute data to one of the variables due to disruptions during testing (including evacuations of the building for a fire drill and a bomb threat), inability to sequence Trails A or B in the TMT, or administrator error. These participants are represented in the analyses for which they contributed data.

The participants as a group can be characterized as low income based on the fact that almost 90% of students in the participating schools met Federal qualifications for receiving free or reduced-price lunches. Reflecting the diversity of the community, African American, Anglo-American, and Hispanic American groups were approximately equally represented in the sample. In addition, the sample consisted almost entirely of either native English- or Spanish-speaking children; as reported by their parents, only two children were exposed to both languages in their homes and considered to be bilingual prior to beginning school. The characteristics of the participants are summarized in Table 1.

TABLE 1
Characteristics of the Children in Each Education Program by Grade Level

	<i>Education Program</i>					
	<i>Dual Language</i>			<i>English Instruction</i>		
	<i>Grade K</i>	<i>2</i>	<i>4</i>	<i>K</i>	<i>2</i>	<i>4</i>
<i>n</i>	18	17	23	16	22	17
Mean Age in Months (<i>SD</i>)	73 (2.92)	96 (3.35)	122 (5.13)	72 (2.57)	104 (5.93)	123 (6.06)
% Male Participants	39	47	50	50	35	41
Ethnicity (% of sample)						
African American (30.1)	4	2	4	10	9	5
European American (43.4)	7	11	9	4	9	9
Latin American (26.5)	7	4	10	2	4	3
Native Language (Parental Report)						
English	12	13	13	15	18	14
Spanish	6	4	9	1	4	2
Bilingual	0	0	1	0	0	1
Number Recruited from Waitlist	—	—	—	0	0	13

A 2 (education program: dual-language or English-instruction) x 3 (grade: K, 2, 4) cross-sectional design was employed. A total of 61 children (28 boys) were recruited from the dual-language program and 59 children (25 boys), enrolled in traditional English-instruction classes within the same schools, comprised the comparison group. Although children were selected for the dual-language program by a lottery, with students not selected remaining on a wait-list while they attended traditional classes, the number of children wait-listed for the dual-language program was not sufficient to constitute a control condition. Hence, additional participants were recruited from the English-instruction classrooms that contained children on the wait-list, resulting in a quasiexperimental design. All participants had experienced exclusively either dual-language or English-instruction educational throughout their schooling and had been enrolled in the same schools with the same class of peers through third grade. Although fourth-grade participants in both education models may have experienced shifting peer groups within their classes, all students in the sample experienced only traditional or dual-language instruction. Positions in the program are filled with children from the waiting list as they open, but there is little attrition, and no children responding to the request for participation had experienced both education models. Curriculum and content is consistent across educational programs, as is staff development. Students enrolled in the dual-language program receive 50% of classroom instruction through each language.

Measures

As indicated above, two measures of EF were administered, the Sun/Moon Task (SMT) and the Trail Making Task (TMT). Both tasks have been used with children aged 6 to 10 years in previous studies and could be administered within the 15-minute time limit requested by the school system. To ensure accuracy, English instructions were translated into Spanish and then back-translated into English by two Spanish-English bilingual researchers.

The Sun/Moon Task has good test/retest reliability ($r_s \geq .82$) and correlates positively and significantly to the Color/Word Stroop ($r = .40, p < .001$), indicating that it is a valid measure for students who are not yet skilled readers (Archibald & Kerns, 1999). Performance is operationalized as an interference ratio representing the number correct on incongruent versus congruent (baseline) trials within a time limit.

The Trail-Making Task is a reliable and valid clinical test of EF designed to measure inhibition, switching, and working memory (see Arbuthnott & Frank, 2000, for recent validation with a switching paradigm; Bowie & Harvey, 2006, for summary of reliability and validity). The version in the Delis Kaplan Executive Function System (Delis et al., 2001) was modified for use with our young participants. We presented 15 rather than 25 stimuli to be connected per trail, which is common for TMT versions used with children (e.g., Bowie & Harvey, 2006; Reitan, 1971). We administered three trails: Trial A, which entails connecting numbers in order as quickly as possible; Trail B, which requires sequencing letters; and Trail C, which necessitates switching between numbers and letters alternately in order (A-1, B-2, C-3, . . . G-8). Including both the number and letter task allowed the examiner to determine if a deficient score on Trail C was due to poor EF or poor mastery of an underlying component skill, such as recognition or ordering skills. Although the task has been used successfully with similarly aged children (e.g., Bialystok, 2010), we were concerned that alphabetical sequencing (Trail B) would not be automatic for some participants in our sample, given the representation of young minority-language children

from economically disadvantaged backgrounds. Hence, to control for the increased difficulty of sequencing letters in comparison to numbers, Trail B was used in calculating the additional demands involved in the switching task (Trail C) (see Yochim et al., 2007, for an example of including letter sequencing as a baseline). Children who could not complete Trails A or B within a specified time limit did not move on to Trail C.

Procedure

Participants were recruited through letters sent home from the school as part of routine communication. In addition to providing written informed consent, parents responded to a brief demographic questionnaire that included items about the language(s) spoken in the home. About 45% and 30% of the parents of potential participants in the dual-language and comparison groups respectively gave their written consent. The names of parents of participating children were entered into a lottery, and two \$50 gift cards were awarded as thank-you gifts.

Four female examiners, including one fluent Spanish speaker, administered the tasks in a quiet classroom at the end of the school year. All examiners tested children from all grade levels and in both the dual-language and comparison groups. Participants were assessed in their preferred language as identified by their parents. One examiner escorted children to and from their classrooms while other examiners were naïve with regard to the child's enrollment status in the dual-language program. Verbal assent was obtained from children upon leaving their classroom and again from the examiner prior to testing. Children were assessed individually in a single session that lasted approximately 15 minutes. Because pilot testing indicated that the children's engagement in the session was greater when the simpler task was presented first, the Sun/Moon task was always administered before the TMT.

In administering the Sun/Moon task, the examiner initially gave the child a practice sheet of pictures with two rows of five items and taught the child two procedures to be followed. First, the examiner demonstrated what would happen if a mistake was made by saying "oops" while pointing to the mislabeled stimulus, and teaching the child to correct the description before moving on to the next item. Second, upon labeling all stimuli on the page, the child was taught to return to the top of the page and continue naming items. Children were then given a page with 10 rows of five items for a total of 50 randomized items and asked to name the pictures ("sun" or "moon") continuously for a 40-second trial (Trial 1; congruent). Children were then told to make the game "silly" by naming the opposite of the picture, i.e., saying "sun" when seeing a picture of a moon (Trial 2; incongruent). Children were given the same practice sheet before beginning and were reminded of the procedures previously described. Trial 2 used a new page with the same number of randomized items and again provided 40 seconds to name as many items in the silly trial as they could. The task took approximately five minutes on average to administer.

The administration of each trail comprising the TMT began with a six-item practice trail with the appropriate stimuli. Mistakes were again corrected with an "oops," and the examiner quickly marked the incorrect line and pointed to where the child should resume. The instructions were repeated if necessary, and corrections were provided as needed. The test trail was presented only when the participant demonstrated mastery of the procedure on the practice trail. To complete each test trail, children were asked to draw lines in a continuous path connecting 15 stimulus items in order as quickly as they could. Trail A (numbers) was followed by Trail B (letters), and the task concluded with Trail C (alternating sequence). Children were stopped if they had not

completed any trail after 4 minutes, which was then recorded as the time for the task, following procedures described in the manual (Delis et al., 2001). This task took approximately 10 minutes on average to administer.

After finishing both tasks, participants were assured that they had done a good job and given small thank-you gifts. Participating students were rated for their engagement during the test session by the examiner. A 5-point scale was used: 1 = unable to finish tasks due to low engagement; 2 = frequent redirection necessary to finish tasks; 3 = some, but not age-inappropriate, redirection needed; 4 = no more than a few redirections needed; and 5 = no redirection needed. Standard procedures were applied in scoring both the Sun/Moon Task (Archibald & Kerns, 1999) and the TMT (Bowie & Harvey, 2006).

RESULTS

Preliminary Analyses

Preceding the primary analyses, we examined preexisting group differences and the influences of participants' background characteristics on the major dependent variable. The results of separate χ^2 analyses provided no evidence of an association between program assignment and the inclusion of male participants, $\chi^2(1, N = 115) = 0.26, p = .61$, or between program assignment and the representation of minority versus majority participants, $\chi^2(1, N = 115) = 0.49, p = .48$. Separate five-way (gender, ethnicity, native language, grade, and education program) ANOVAs were conducted with the Sun/Moon task ratio and the ratio of completion times for Trail B to Trail C as dependent variables. In both analyses, there were no significant main effects, $F_s \leq 2.26, p_s \geq .14$, or interactions involving gender, ethnicity, or native language, $F_s \leq 2.52, p_s \geq .09$. Consequently, levels of these variables were collapsed for the remaining analyses. In addition, months of age were not correlated with performance on the measures of EF within grade, $F_s \leq 2.27, p_s \geq .15$. Examination of the engagement ratings indicated that the children in both language groups were comparably involved in the task, $F(1, 113) = 1.83, p = .18$, and the overall level of engagement was high, $M = 4.19 (SD = 1.05)$ on the 5-point scale.

A limitation of the investigation was the relatively small pool of potential participants, given that the research was designed to be conducted within the context of a specific community. A power analysis using G*Power was conducted to determine if the sample size was sufficient to detect the predicted interactions between grade and education program. Power for the critical trials of the Sun/Moon and Trail Making Measures was low (.20), and an estimated $N = 270$ would have been necessary to detect the predicted interactions. Hence, we proceeded with planned comparisons to examine the effects of educational programs at different grade levels in the absence of an interaction in ANOVAs. In addition, a trend analysis was conducted to compare grade differences in measures of executive functioning within education programs. Given the directional hypotheses, all tests were one-tailed.

Effects of Program Participation and Grade on Sun/Moon Task Performance

Three dependent measures were examined in separate two-way (grade x education program) ANOVAs: score (number correct) on the congruent trial, score on the incongruent trial and an

interference measure [(congruent – incongruent trial) / incongruent trial] defined by Archibald and Kerns (1999). As expected, a significant main effect of grade was observed for both the congruent trial, $F(2, 104) = 71.65, p < .001, \eta^2 = .58$, and the incongruent trial, $F(2, 104) = 65.07, p < .001, \eta^2 = .56$. Children in both the traditional and dual-language education programs did not differ in performance on these measures $F_s \leq 1.17, p_s \geq .14$. There were no significant main effects of grade or education program for the interference measure and no interaction. Performance on the Sun/Moon task is summarized in Table 2.

Effects of Program Participation and Grade on Trail Making Task Performance

Times to complete Trail B and Trail C were analyzed in separate two-way (grade x education program) ANOVAs, allowing a comparison of these results with Bialystok's (2010) findings. The expected grade effect was observed for both measures, $F_s \geq 25.07, p_s < .001$. Post hoc analysis revealed that the performance of kindergarten students was significantly slower than that of the participants in Grades 2 and 4, which did not differ. There was no significant difference in performance between the children in the dual-language program and those in traditional classrooms in the completion of Trails A (numbers) or B (letters). Conversely, children in the dual-language program were significantly faster in completing Trail C than were those in monolingual classrooms, $F(1, 109) = 5.16, p < .01, \eta^2 = .05$. However, as expected on the basis of the power analysis, the grade by program interaction failed to reach significance.

An interference measure was formed between Trail B and Trail C [(Trail C time – Trail B time) / Trail B time] (ratio BC) to control for letter sequencing, visual search, and motor speed. Given that children who were unable to correctly sequence numbers and/or letters would not be able to complete Trail C regardless of EF, 10 children who were equally distributed across the two education programs were omitted from the analysis of this measure. All of these children were kindergarteners who had difficulties with Trail B, resulting in $N = 105$. A two-way (grade x education program) ANOVA revealed significant main effects for grade, $F(2, 95) = 14.31$,

TABLE 2
Performance Means on the Sun/Moon and Trail Making Tasks of Children in Each Education Program by Grade Level

	Educational Program					
	Dual Language Program			English Instruction		
	Grade K	2	4	K	2	4
M Congruent Score (SD)	42.28 (12.18)	59.71 (8.24)	71.00 (11.76)	36.27 (10.30)	58.38 (9.35)	68.53 (11.61)
S/M Incongruent Score (SD)	29.39 (9.87)	48.00 (7.62)	61.21 (12.12)	29.71 (7.24)	48.95 (12.34)	55.94 (12.36)
Trail A Time (SD)	80.28 (77.25)	28.35 (10.78)	19.04 (5.68)	91.00 (80.82)	41.43 (47.22)	23.65 (9.67)
Trail B Time (SD)	110.17 (89.85)	29.94 (11.88)	23.48 (12.27)	105.38 (94.46)	38.04 (45.15)	22.00 (8.00)
Trail C Time (SD)	200.06 (64.62)	71.00 (95.66)	41.96 (17.05)	197.13 (59.30)	110.48 (74.30)	79.47 (78.78)
Trail B C ratio (SD)	3.24 (1.92)	1.52 (0.97)	1.09 (0.91)	3.27 (1.54)	2.85 (2.95)	2.66 (3.07)

$p = .02$, $\eta^2 = .06$, and program, $F(1, 95) = 4.95$, $p = .01$, $\eta^2 = .05$. The interaction between grade and program was nonsignificant, $F(2, 97) = .78$, $p = .17$. Again, kindergarteners performed significantly worse than both Grade 2 and 4 participants, who did not differ from each other. Additionally, children in the dual-language program experienced less impact on performance when the additional EF demands were imposed.

An exploratory analysis was conducted to examine the possibility of effects of multiple years versus a single year of exposure to a second language. Given the absence of a significant difference between Grade 2 and Grade 4 on the TMT measures, data were collapsed across the upper grade levels and compared to the kindergarteners' performance, increasing power. A two-way (dichotomous grade x education program) ANOVA was conducted in order to determine the effect of program on Trail C. Results revealed significant main effects for grade, $F(1, 111) = 105.84$, $p < .001$, $\eta^2 = .49$, and program, $F(1, 111) = 2.85$, $p = .05$, $\eta^2 = .03$, as well as a significant grade by program interaction, $F(1, 111) = 3.74$, $p = .03$, $\eta^2 = .03$. As predicted, the performance of the children in kindergarten was significantly slower than that of the children in the combined Grade 2 and Grade 4 group. Importantly, the older children in the dual-language program were significantly faster than those in monolingual education, whereas program differences were not observed among the kindergarteners (see Figure 1).

A second two-way (dichotomous grade x education program) ANOVA was performed in order to determine the effect of program on the ratio of Trail B to Trail C. Results again revealed the

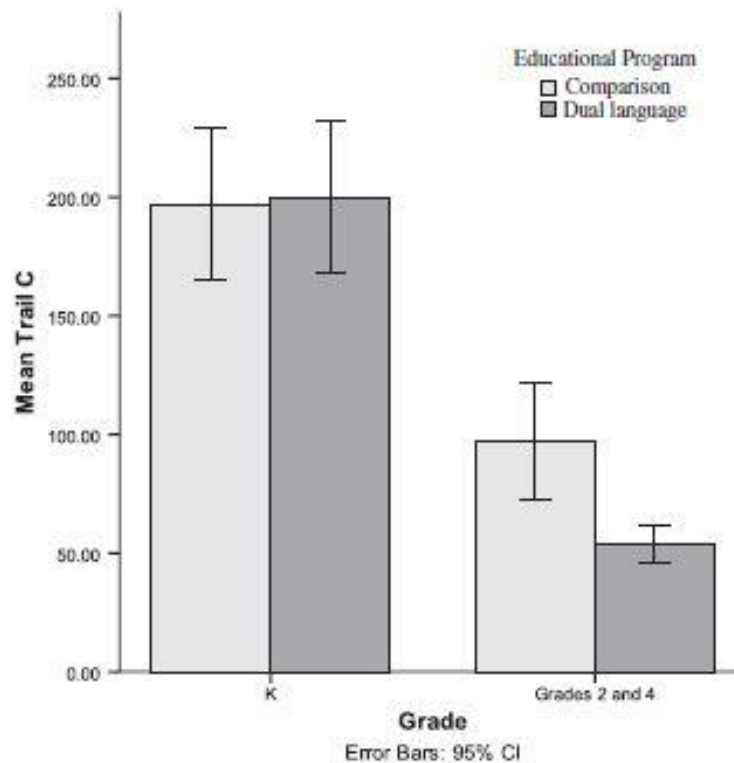


FIGURE 1 Mean time to completion of Trail C.

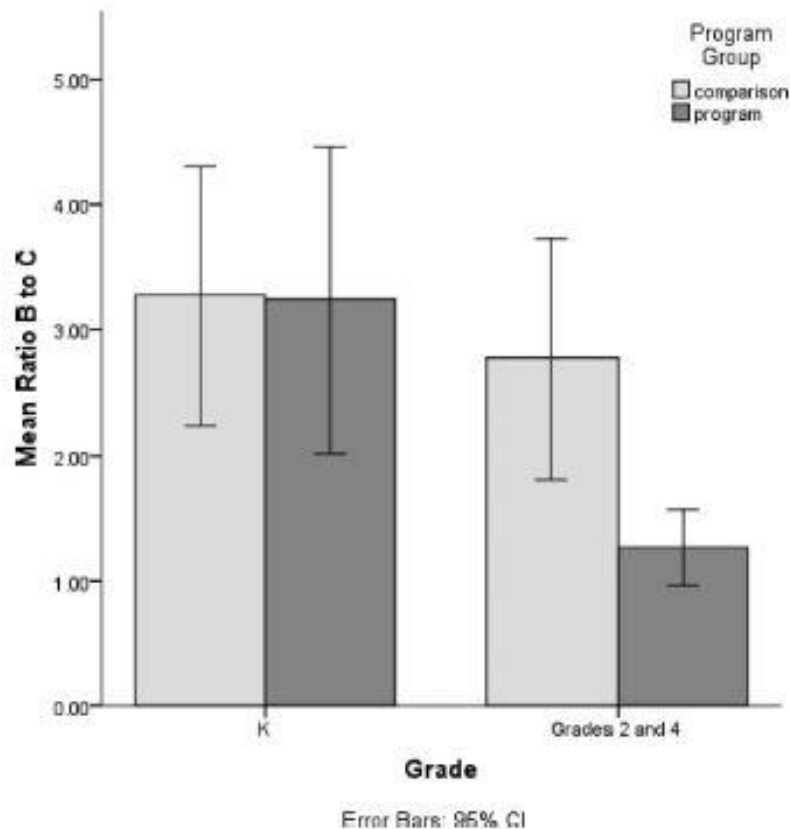


FIGURE 2 Mean interference score of Trail B to Trail C.

expected effect for grade, $F(1, 97) = 6.14, p = .007, \eta^2 = .06$. The main effect of program, $F(1, 97) = 2.34, p = .06, \eta^2 = .02$, and the grade by program interaction, $F(1, 97) = 2.15, p = .07, \eta^2 = .02$ failed to reach significance (see Figure 2).

Trend analysis was used to further explore the possibility of a dose-response relation, which would result in grade-related decreases in response times among the children in the dual-language but not the monolingual program. Given this expectation of alternative patterns of performance, separate analyses were conducted within each educational program. Consistent with the expectation that effects of dual-language exposure would be observed only after extended participation in the program, a significant linear decrease in the TMT interference measure, ratio B/C, across grade was found for the program group, $F(1, 48) = 24.05, p < .001$. In contrast, as predicted, there was no difference across grade on this measure within the comparison group, $F(1, 48) = 2.92, p = .09$.

DISCUSSION

The results of this investigation extend previous research on the benefits of second-language exposure on EF by exploring dual-language versus traditional education at three grade levels in

an economically disadvantaged community. Children exposed to a second language through dual-language education, in comparison to their schoolmates in traditional classrooms, demonstrated advantages on EF as measured by the Trail-Making Task. Specifically, children with extended experience in dual-language education—those in Grades 2 and 4—were better able than traditionally educated children to perform a demanding task (Trail C) that required inhibition and rule-switching. The same pattern of results emerged when other task demands (e.g., motor control and letter sequencing) were taken into account (Ratio B/C). Further, as identified through trend analysis on the ratio measure, children in traditional education perform consistently across grade, whereas in the dual-language education condition, greater exposure to a second language was associated with higher EF performance. No differences on any measure indicated an advantage for traditional in comparison to dual-language education.

The lack of group differences observed on the Sun/Moon task may arise from the component of EF assessed by this measure. The comparability across educational programs in this investigation is consistent with the results of a recent investigation using a similar task with bilingual children. Both Martin-Rhee and Bialystok (2008) and Esposito, Baker-Ward, and Mueller (in press) found that, despite advantages on other measures of EF, monolingual and bilingual children performed comparably on a task measuring response inhibition. *Response inhibition* refers to inhibiting a dominant or prepotent response in a univalent task in favor of a less-dominant response (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002). This distinction is also supported by neuroscience research, which indicates differences in the degree of activation for areas of the prefrontal cortex when individuals perform response inhibition compared to interference suppression tasks (Blasi et al., 2006). Measures of response inhibition do not contain distracting elements to be suppressed, which may be a necessary component of tasks that find a bilingual advantage (Adesope et al., 2010). Bilingual individuals must choose appropriate responses rather than simply inhibit a response; that is, they must suppress interference from a second language, not just refrain from responding. Robust evidence, derived from both behavioral measures and imaging data, indicates that the unused language is still active when bilingual speakers are conversing, supporting the conclusion that bilingual speakers are not utilizing response inhibition (e.g., Costa, Miozzo, & Caramazza, 1999; Kroll, Bob, Misra, & Guo, 2008). The present findings, although not predicted, extend previous findings to an older age group and provide additional support for Martin-Rhee and Bialystok's (2008) conclusions that the bilingual advantage is found only in measures of interference suppression and not in measures of response inhibition.

These results, of course, must be interpreted cautiously. As discussed previously, the investigation lacked the power to detect the predicted interaction between grade and education program, and the results summarized previously were obtained through planned contrasts. Moreover, although children were assigned through a lottery to the dual-language program, the wait-list was not sufficient to comprise the comparison condition. Hence, the investigation is quasiexperimental, and the possibility exists that the observed advantage for dual-language education participants reflects existing group differences rather than the effects of greater exposure to a second language. Nonetheless, we can find no evidence in support of this interpretation.

Questions may arise regarding the possibility that differences between ethnic groups may underline the results, especially since we could not directly examine such effects. Sample sizes of individual ethnic groups by program and grade were too small to allow for analysis; however, inspection of Table 1 does not suggest a pattern that could explain the results. The results cannot be due to an overrepresentation of European Americans in the dual-language program, and

differences by minority group were not systematic across grade and group. In addition, ethnicity did not predict any outcome measures.

The pattern of results suggests that the observed differences represent the effect of increasing bilingual exposure rather than preexisting group differences. Consistent with the possibility of a dose-response relation between language exposure and EF, the kindergarteners in the dual-language and traditional classrooms performed equivalently. Also, there was no difference between children in the dual-language program and in traditional classrooms in performance on the Sun/Moon task and the nonswitching (Trails A and B) portions of the TMT at any grade levels. Hence, it seems unlikely that differences in performance at the upper grades reflect extraneous dissimilarities between children in the two education programs. Further, examiners who were naïve with regard to the children's education program rated task engagement comparably across groups. Moreover, although replication with research using different methods is necessary to allow full acceptance of the present findings, the fact that the programs were in the same schools and that the method of instruction, materials, and curricula are implemented system-wide removes some possible confounds between the education models.

The present investigation extended the understanding of the effects of dual-language education through the comparison of groups of traditionally educated students and dual-language learners with similarly low SES and comparable ethnic diversity. In addition to generalizing the findings to a culturally diverse and economically disadvantaged sample, the results of this investigation suggest that dual-language education may provide sufficient language exposure to convey similar patterns of cognitive advantages as have been reported for minority-language immersion education students. Bialystok and Barac (2012, Study 2) recently reported a benefit of immersion education for upper but not lower elementary students who were learning a second language. Similarly, Carlson and Meltzoff (2008) had previously observed no benefit of dual-language education with a group of kindergarteners. The present study was designed in part to determine if dual-language education provides insufficient, ongoing exposure to two languages to convey the advantages of minority-language immersion programs, or, alternatively, if the kindergartners in the Carlson and Meltzoff (2008) study had not yet had time to accrue possible benefits of dual-language education. The latter possibility is consistent with additional research by Bialystok and Barac (2012, Study 1), which found that the benefits of immersion education on aspects of EF were predicted by years in the program. Our investigation replicated the results of both Carlson and Meltzoff's (2008) and Bialystok and Barac (2012; Study 2) with no differences in education model for kindergarteners and benefits to older dual-language students. Hence, it appears that the emerging benefits of second-language exposure in a school context accrue over the elementary school years and can be obtained through either a dual-language program or a minority-language immersion program.

It is unknown if the specific performance advantage in interference suppression mediates the relationship between educational program and academic performance, but a recent study by Greenberg, Bellana, and Bialystok (2013) suggests that this may be the case. They found a bilingual advantage for a problem-solving task chosen in part because of its resemblance to traditional school activities. Continued research is necessary to delimitate between native benefits and those derived from different models of immersion and dual-language education. A necessary first step will be the development of tasks that are unquestionably age appropriate for elementary-school-aged children, both early and late.

These results, if substantiated by further research, have broad implications for education in the United States. According to the 2010 U. S. Census, 76% of self-identified Hispanics, the fastest-growing ethnic group in the U. S., report speaking primarily Spanish in their homes. As of 2010, 20% of the U.S. school population entered the educational system speaking Spanish as their native language, with limited proficiency in English. Children who enter school without fluency in English and who do not participate in dual-language education typically perform markedly lower than their English-speaking peers on standardized tests (García & Náñez, 2011; Thomas & Collier, 2004). In contrast, minority-language speakers in dual-language education learn English as a second language more effectively than those in immersion education. Moreover, our results indicate that both native English- and Spanish-speaking dual-language students experience the same benefits as do minority-language immersion students (those educated solely through a minority language) for aspects of EF. Hence, dual-language education offers minority-language students an optimal educational approach to acquiring the majority language; provides the benefits of learning two languages to majority- as well as minority-language students; and, in the process, may enhance both groups of children's capacity to regulate attention. Intervention strategies that improve domain general executive function skills in children whose economic background puts them at risk for school failure could have lifelong benefits for academic success. The results of this initial investigation are encouraging to this end, warranting further research into dual-language education as an intervention strategy for at-risk students.

ACKNOWLEDGMENTS

This investigation was made possible by the cooperation of the Greene County School System in North Carolina, the facilitation provided by Stephanie Cain and Patricia MacNeill, and the involvement of students and their parents and teachers. The authors thank Jason Allaire, Patricia Collins, Thomas M. Hess, Agnes Bolonyai, Doug Gillan, and Peter A. Ornstein for helpful suggestions and the Department of Psychology at NC State University for purchase of materials. Appreciation is also extended to Nancy N. Warren and Dorothy Eubanks for assistance in data collection.

REFERENCES

- Adesope, O. O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research, 80*(2), 207–245. doi: 10.3102/0034654310368803
- Arbuthnott, K., & Frank, J. (2000). Trail making test, part B as a measure of executive control: Validation using a set-switching paradigm. *Journal of Clinical and Experimental Neuropsychology, 22*(4), 518–528.
- Archibald, S. J., & Kerns, K. A. (1999). Identification and description of new tests of executive functioning in children. *Child Neuropsychology, 5*, 115–129.
- Barnett, W., Yarosz, D. J., Thomas, J., Jung, K., & Blanco, D. (2007). Two-way and monolingual English immersion in preschool education: An experimental comparison. *Early Childhood Research Quarterly, 22*(3), 277–293. doi: 10.1016/j.ecresq.2007.03.003
- Bialystok, E. (1988). Levels of bilingualism and levels of linguistic awareness. *Developmental Psychology, 24*(4), 560–567. doi: 10.1037/0012-1649.24.4.560
- Bialystok, E. (1999). Cognitive complexity and attentional control in the bilingual mind. *Child Development, 70*(3), 636–644. doi: 10.1111/1467-8624.00046

- Bialystok, E. (2010). Global-local and trail-making tasks by monolingual and bilingual children: Beyond inhibition. *Developmental Psychology, 46*(1), 93–105. doi: 10.1037/a0015466
- Bialystok, E., & Barac, R. (2012). Emerging bilingualism: Dissociating advantages for metalinguistic awareness and executive control. *Cognition, 122*, 67–73.
- Blair, C., & Diamond, A. (2008). Biological processes in prevention and intervention: The promotion of self-regulation as a means of preventing school failure. *Development and Psychopathology, 20*, 899–911. doi: 10.1017/S0954579408000436
- Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78*(2), 647–663. doi: 10.1111/j.1467-8624.2007.01019.x
- Blasi, G., Goldberg, T. E., Weickert, T., Das, S., Kohn, P., Zolnick, B., . . . Mattay, V. S. (2006). Brain regions underlying response inhibition and interference monitoring and suppression. *European Journal of Neuroscience, 23* (6), 1658–1664.
- Bowie, C. R., & Harvey, P. D. (2006). Administration and interpretation of the Trail Making Test. *Nature Protocols, 1*(5), 2277–2281. doi: 10.1038/nprot.2006.390
- Bull, R., & Scerif, G. (2001). Executive functioning as a predictor of children's mathematics ability: Inhibition, switching, and working memory. *Developmental Neuropsychology, 19*(3), 273–293. doi: 10.1207/S15326942DN1903_3
- Bunge, A. S., 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*(2), 301–311.
- Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11*, 282–298.
- Christian, D. (1996). Two-way immersion education: Students learning through two languages. *The Modern Language Journal, 80*(1), 66–76. doi: 10.1111/j.1540-4781.1996.tb01139.x
- Costa, A., Miozzo, M., & Caramazza, A. (1999). Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language, 41*(3), 365–397.
- Cummins, J. (2008). BICS and CALP: Empirical and theoretical status of the distinction. *Encyclopedia of Language and Education, 2*, 71–83.
- Cummins, J. (2009). Basic interpersonal communicative skills and cognitive academic language proficiency. Retrieved from <http://www.wce.wvu.edu/Resources/CIRCLE/Articles/Jim%20Cummins.pdf>
- Delis, D. C., Kaplan, E., & Krames, J. H. (2001). Trail making task. *Delis Kaplan Executive Function System Examiner Manual* (pp. 39–54). San Antonio, TX: The Psychological Corporation Harcourt Assessment Company.
- Diamond, A., Barnett, W. S., Thomas, J., & Munro, S. (2007). Preschool program improves cognitive control. *Science, 318*(5855), 1387–1388. doi: 10.1126/science.1151148
- Esposito, A. G., Baker-Ward, L., & Mueller, S. T. (in press). Interference suppression vs. response inhibition: An explanation for the absence of a bilingual advantage in preschoolers' Stroop task performance. *Cognitive Development*. Retrieved from <http://dx.doi.org/10.1016/j.cogdev.2013.09.002>
- García, E. E., & Nájera, J. E. Sr. (2011). *Bilingualism and cognition: Informing research, pedagogy, and policy* (pp. 57–77). Washington, DC: American Psychological Association. doi: 10.1037/12324-003
- Genesee, F., Lindholm-Leary, K., Saunders, W., & Christian, D. (2005). English language learners in U.S. schools: An overview of research findings. *Journal of Education for Students Placed at Risk, 10*(4), 363–385.
- Gottfried, A. W., Gottfried, A. E., Bathurst, K., Guerin, D.W., & Parramore, M. M. (2003). Socioeconomic status in children's development and family environment: Infancy through adolescence. In M. H. Bornstein & R. H. Bradley (Eds.), *Socioeconomic status, parenting and child development* (pp. 189–207). Mahwah, NJ: Lawrence Erlbaum.
- Greenberg, A., Bellana, B., & Bialystok, E. (2013). Perspective-taking ability in bilingual children: Extending advantages in executive control to spatial reasoning. *Cognitive Development, 28*(1), 41–50. doi: 10.1016/j.bbc.2011.03.031
- Hilchey, M. D., & Klein, R. M. (2011). Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes. *Psychonomic Bulletin & Review, 18*(4), 625–658. doi: 10.3758/s13423-011-0116-7
- Kroll, J. F., Bobb, S. C., Misra, M., & Guo, T. (2008). Language selection in bilingual speech: Evidence for inhibitory processes. *Acta Psychologica (Amst), 128*(3), 416–430. doi: 10.1016/j.actpsy.2008.02.001
- Lindholm-Leary, K. J. (2001). *Dual language education* (Bilingual Education and Bilingualism, Vol. 28). Buffalo, NY: Multilingual Matters.

- Lindholm-Leary, K., & Block, N. (2010). Achievement in predominantly low SES/Hispanic dual language schools. *International Journal of Bilingual Education and Bilingualism*, *13*(1), 43–60.
- Luk, G., DeSa, E., & Bialystok, E. (2011). Is there a relation between onset age of bilingualism and enhancement of cognitive control? *Bilingualism: Language and Cognition*, *14*, 588–595. doi: 10.1017/S1366728911000010
- Martin-Rhee, M., & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition*, *11*(1), 81–93. doi: 10.1017/S1366728907003227
- McClelland, M. M., Morrison, F. J., & Holmes, D. L. (2000). Children at risk for early academic problems: The role of learning-related social skills. *Early Childhood Research Quarterly*, *15*(3), 307–329. doi: 10.1016/S0885-2006(00)00069-7
- 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.
- Poufin-Dubois, D., Blaye, A., Coutya, J., & Bialystok, E. (2011). The effects of bilingualism on toddlers’ executive functioning. *Journal of Experimental Child Psychology*, *108*(3), 567–579.
- Reitan, R. M. (1971). Complex motor functions of the preferred and non-preferred hands in brain-damaged and normal children. *Perceptual and Motor Skills*, *33*(2), 671–675.
- Thomas, W. P., & Collier, V. P. (2004). The astounding effectiveness of dual language education for all. *NABE Journal of Research and Practice*, *2*(1), 1–20.
- U. S. Census Bureau. (2010). *Overview of race and Hispanic origin*. Retrieved from <http://www.census.gov/prod/cen2010/briefs>
- Waber, D. P., Gerber, E. B., Turcios, V. Y., Wagner, E. R., & Forbes, P. W. (2006). Executive functions and performance on high-stakes testing in children from urban schools. *Developmental Neuropsychology*, *29*(3), 459–477. doi: 10.1207/s15326942dn2903_5
- Yochim, B., Baldo, J., Nelson, A., Delis, D. C., Arbuthnott, K., & Frank, J. (2007). D-KEFS Trail Making Test performance in patients with lateral prefrontal cortex lesions. *Journal of the International Neuropsychological Society*, *13*(4), 704–709.

CHAPTER 3: Interference Suppression vs. Response Inhibition: An explanation for the absence of a bilingual advantage in preschoolers' Stroop task performance

Cognitive Development 28 (2013) 354–363



Contents lists available at ScienceDirect

Cognitive Development



Interference suppression vs. response inhibition: An explanation for the absence of a bilingual advantage in preschoolers' Stroop task performance



Alena G. Esposito^{a,*}, Lynne Baker-Ward^a, Shane T. Mueller^b

^a North Carolina State University, Department of Psychology, Raleigh, NC 27696-7650, United States

^b Michigan Technological University, Department of Cognitive and Learning Sciences, Houghton, MI 49931, United States

ARTICLE INFO

Article history:

Received 18 October 2012

Received in revised form 3 July 2013

Accepted 10 September 2013

Keywords:

Bilingual advantage

Inhibition

Preschool

Stroop

Executive function

Interference suppression

ABSTRACT

The well-documented advantage that bilingual speakers demonstrate across the lifespan on measures of controlled attention is not observed in preschoolers' performance on Stroop task variations. We examined the role of task demands in explaining this discrepancy. Whereas the Color/Word Stroop used with adult participants requires interference suppression, the Stroop task typically used with preschoolers requires only response inhibition. We developed an age-appropriate conflict task that measures interference suppression. Fifty-one preschool children (26 bilinguals) completed this new Bivalent Shape Task and the Day/Night task used in previous research. Bilingual in comparison to monolingual children performed better on incongruent trials of the Bivalent Shape Task, but did not differ on other measures. The results indicate that the discrepancy between preschoolers and older individuals in performance on Stroop task adaptations results from characteristics of the task rather than developmental differences. Further, the findings provide additional support for the importance of interference suppression as a mechanism underlying the bilingual advantage.

© 2013 Elsevier Inc. All rights reserved.

* Corresponding author. Tel.: +1 252 412 6606; fax: +1 919 515 1731.

E-mail addresses: alena_esposito@ncsu.edu, alenaesposito@gmail.com (A.G. Esposito).

1. Bilingual advantage

The regular use of two or more languages benefits controlled attention, with advantages found among bilingual preschoolers, school-aged children, and adults on a variety of tasks requiring controlled attention (for reviews, see *Adesope, Lavin, Thompson, & Ungerleider, 2010; Hilchey & Klein, 2011*). This bilingual advantage arises in part from the management of two (or more) linguistic representations, which results in extensive practice in selective attention and cognitive flexibility. Among preschoolers, the differences between bilingual and monolingual children vary across tasks. Bilinguals show an advantage on conflict tasks such as the Simon task (*Martin-Rhee & Bialystok, 2008*), the Dimensional Change Card Sort (*Bialystok & Martin, 2004*), and the Attentional Network Task (*Yang, Yang, & Lust, 2011*). In contrast, comparable performance is found on age-appropriate variants of the Stroop task (*Martin-Rhee & Bialystok, 2008; Siegal, Iozzi, & Surian, 2009*), although Stroop tasks reliably differentiate monolingual and bilingual adults (*Bialystok, Craik, & Luk, 2008; Hernández, Costa, Fuentes, Vivas, & Sebastián-Gallés, 2010*).

Although this pattern of results could have a developmental explanation, it may be attributable to differences among the tasks used to measure the Stroop effect across the lifespan. The studies documenting a bilingual advantage with adults utilized tasks with bivalent stimuli; participants responded to images that contained both relevant and distracting information. Responding correctly thus required suppressing the irrelevant content. The investigations with preschool aged children used the commonly employed Day/Night task (*Gerstadt, Hong, & Diamond, 1994*), which has a univalent display. There is no perceptually distracting information in the stimuli to require suppression, an aspect of attention regulation that contributes to the bilingual advantage.

In this investigation, we examined the role of task demands in explaining the absence of a bilingual advantage in Stroop task adaptations among preschoolers. We developed an age-appropriate task for preschoolers that has bivalent conflict in the stimuli, similar to the classic Color/Word Stroop. We tested for the presence of a bilingual advantage in the performance of this task. In an attempt to replicate previous findings, we also included the Day/Night task. We expected to observe a bilingual advantage only with the new Bivalent Shape Task, providing evidence that age differences in performance are due not to developmental changes but to task requirements.

1.1. Defining Stroop

Stroop (1935) designed the Color/Word Stroop task to measure interference between potentially conflicting stimulus dimensions. The task is bivalent in that color word names are presented printed in colored ink. The test items can be congruent, when the color word is consistent with the color of ink in which it is printed, or incongruent, when the color word and the color of ink do not correspond (e.g., the word "green" printed in blue ink). Participants respond to congruent and incongruent items within the same set of trials (mixed block) and must inhibit the prepotent reading response in order to answer correctly with the color of the ink in which the color name is printed. In comparison to performance on congruent trials, incongruent trials are more challenging, as evidenced by slower response times and lower accuracy.

Gerstadt et al. (1994) developed the Day/Night task as an alternative for young children to circumvent the need for well-developed literacy. In this task, children are presented with univalent pictures of a sun and a moon. Participants are asked to respond to the pictures by saying "night" to the sun and "day" to the moon, representing an incongruent response. A correct response requires the maintenance of task instructions and the inhibition of a dominant response pattern, but does not require inhibiting irrelevant distracting perceptual information.

Existing variations of the Day/Night task are not ideal for work with bilingual preschoolers for several reasons. For instance, both the Sun/Moon task (*Archibald & Kerns, 1999*) and the 4 Pairs task (*Livesey, Keen, Rouse, & White, 2006*) require an opposite response to a univalent picture, but present no distracting perceptual information. The Big/Little Stroop (*Kochanska, Murray, & Harlan, 2000*), and the Shape Stroop (*Poulin-Dubois, Blaye, Coutya, & Bialystok, 2011*) are bivalent in that

they depict small pictures of fruits within larger images of fruits. However, they are designed for use with toddlers and have other limitations, including the absence of a congruent condition and the reliance on rapid vocabulary naming, possibly putting bilingual individuals at a disadvantage (Gollan & Kroll, 2001; Gollan & Silverberg, 2001). The Color/Object Stroop (Prevor & Diamond, 2005) is also bivalent, with line drawings of familiar objects drawn in different ink colors. Congruent trials present a picture drawn in the expected color (e.g., an orange carrot) and incongruent trials show the picture in an unexpected color (e.g., a green carrot). This task also requires rapid picture naming, and the color outline appears to offer little distraction when naming the object (Prevor & Diamond, 2005).

The absence of distracting perceptual information in the stimuli of the Day/Night task may be responsible for the lack of observed differences between language groups. This possibility is consistent with Martin-Rhee and Bialystok's (2008) claim that the suppression of distracting perceptual information is necessary to demonstrate the bilingual advantage. They found a bilingual advantage in preschoolers' performance on the Simon task, which uses location as a distracting element, but no such advantage using univalent tasks with no distracting spatial element. Bunge, Dudukovic, Thomason, Vaidya, and Gabrieli (2002) described the bivalent tasks as employing interference suppression, whereas the univalent tasks required response inhibition. Interference suppression requires the participant to ignore salient perceptual information in a bivalent task while attending to the less salient conflicting information. In the Simon task, this means attending to color while ignoring location. Response inhibition, on the other hand, is inhibiting a dominant or prepotent response in favor of a less dominant response and is required for univalent tasks such as the Day/Night task. There is no evidence of a bilingual advantage in tests designed to measure response inhibition (Bialystok et al., 2008; Robertson, Manly, Andrade, Baddeley, & Yiend, 1997). Similarly, Carlson and Meltzoff (2008) found a bilingual advantage for kindergarten children in inhibitory control tasks with conflicting attentional demands, but not for tasks that relied on impulse control. As discussed by Martin-Rhee and Bialystok (2008), interference suppression tasks correspond to the everyday experience of bilingual speakers in that they require choosing between two active and viable alternatives, rather than refraining from responding or using an opposite term.

Supporting the role of interference suppression in the Stroop Effect, three previous studies found a bilingual advantage utilizing tasks that included distracting perceptual information embedded in the stimuli. Bialystok et al. (2008) utilized the Color/Word Stroop. Hernández et al. (2010) employed a Numeric Stroop in which the numbers 1, 2, or 3 were presented in groups of 1, 2, or 3 digits either congruently (e.g., 22) or incongruently (e.g., 222). Additionally, Poulin-Dubois et al. (2011) used the Shape Stroop to find an advantage in bilingually exposed toddlers. Taken as a whole, these studies suggest that the presence of distracting stimulus elements may differentiate conflict task contexts in which the bilingual advantage can and cannot be observed.

To test this hypothesis, we needed a conflict task that matched the defining characteristics of the original Color/Word Stroop but was suitable for use with bilingual and monolingual preschool age children. Critically, the task must include both congruent and incongruent bivalent test items presented in a mixed block and must not require reading or number knowledge. In addition, because acquiring two languages at once may limit vocabulary development in each language (Bialystok, Luk, Peets, & Yang, 2010), the task must not be dependent on word knowledge. We developed the Bivalent Shape Task, described below, to fulfill these requirements.

1.2. Hypotheses

Consistent with previous research, we expected to find no language group differences in performance of the Day/Night task. In contrast, we expected that the Bivalent Shape Task would produce a larger Stroop effect (in the form of more incongruent compared to congruent errors) for monolingual preschoolers than for bilingual preschoolers. We also expected that on incongruent trials, the bilingual groups would show significantly fewer errors than the monolingual group, but that the groups would not differ in errors on congruent trials. Support for these hypotheses would indicate that the discrepancy in Stroop task performance among preschoolers is explained by task features rather than

developmental changes. In addition, it would provide evidence that bilingual experience more strongly influences interference suppression than response inhibition.

2. Method

2.1. Participants

Participants were healthy, typically developing preschool children with either bilingual (Spanish and English) or monolingual (English) experience. All of the children attended full-time child care centers and none met the age requirement for entry into public school kindergarten. Our final sample included 26 bilingual (16 females; mean age = 49.8 months, SD = 7.5 months, range 37–63 months) and 25 monolingual (12 females; mean age = 50.1 months, SD = 8.6 months, range 37–58 months) children. An additional 28 children were recruited but were not included in the analyses; of these, 23 did not meet criteria for language group classification stipulated below; two were absent during testing; and three declined participation. The final sample reflected the ethnic composition of the community, with about three-fourths of the sample (37 children) of European descent and the remainder with at least one parent of Asian, African, or Latino heritage (as reported by parents). As expected, the bilingual group was more ethnically diverse, $\chi^2(1) = 11.57, p < .001$. Groups did not differ significantly by gender ($\chi^2(1) = 1.80, p = .18$). Although information about income and parental occupation was not available, the school administrators characterized the families they served as middle- to upper-middle class. In addition, the schools charged comparable tuition and reported no subsidized students.

To increase recruitment of bilingual children, we contact local childcare centers offering second language immersion. Two Spanish immersion-only childcare centers, one English monolingual childcare center, and one center offering both Spanish immersion and traditional English monolingual programs participated in the research. Children spent approximately nine hours a day, five days a week, in their centers. Letters sent to parents via the schools explained the study, asked permission for children's participation, and requested information regarding the children's language backgrounds.

Children were categorized as bilingual or monolingual based on parents' reports of language history and use in the home and teachers' reports of language use in the classroom. A participant was categorized as monolingual when both the parent and teacher reported that the child used only English. Children categorized as monolingual and enrolled in an immersion child care program were excluded from analysis because of possible effects of second language exposure (Kovacs & Mehler, 2009). Categorizing children as bilingual was complicated by the observation that some families did not use Spanish in the home, and hence parents with children attending immersion childcare from a young age may not have been aware of their children's Spanish fluency. Consequently, to be classified as bilingual, a child had to be described as using two languages fluently by both the parent and teacher or, alternatively, to be described as fluently using Spanish by a teacher. Children categorized as bilingual by teacher report only were excluded from analysis if they had been enrolled in immersion childcare for one year or less. Among the bilingual participants, 35.7% used English in the home and Spanish in their child-care setting.

2.2. Materials

The Day/Night task stimuli were 3 in. by 3 in. color printed cards depicting either a sun or a moon. Consistent with Gerstadt et al. (1994), there were 18 total stimuli, with one of each stimulus used for training and eight of each stimulus employed in the test.

The Bivalent Shape Task (BST) was developed using Psychology Experiment Building Language (PEBL; Mueller, 2010, 2011). The task utilized a Compaq Presario CQ60 laptop computer attached to a HP Compaq L2105 21.5 in. color touch screen monitor. Two active buttons remained at the bottom of the screen, a red circle and a blue square. Stimuli (circles and squares in either red or blue for four possible test items) appeared above the buttons in the center of the screen (see Fig. 1). Congruent stimuli matched one of the buttons in both color and shape, and incongruent stimuli matched in shape to one button but in color to the other. Participants were directed to match the shape. The manual

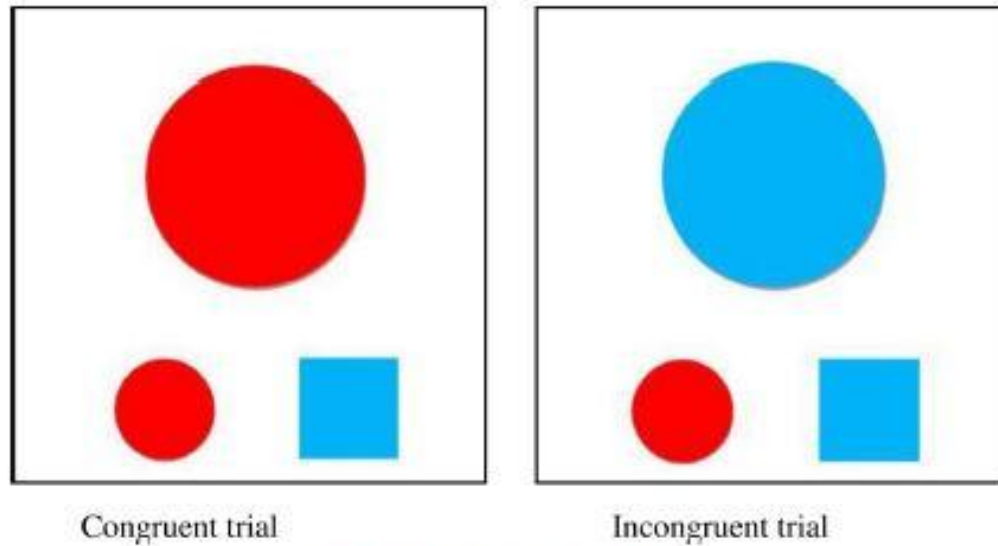


Fig. 1. Stimuli for the Bivalent Shape Task.

response of matching the shape means that no verbal response or vocabulary was required. The test items were bivalent in that participants were required to ignore the very salient color and only respond to the shape. Test items were presented in a fixed but mixed block order.¹

2.3. Procedure

In this within-subjects design, children participated in both the Day/Night task and the BST. The two tasks were presented in counterbalanced order across participants, separated by a vocabulary fluency task and a block game. The order of trials was constant within each task. The procedure for the Day/Night task followed the description by Gerstadt et al. (1994), with the exception of adding a congruent condition, as per Martin-Rhee and Bialystok (2008). Children were first presented with the stimuli and asked to say "day" in response to a picture of the sun and "night" in response to a picture of the moon. Once 100% accuracy was reached on both test stimuli, children were encouraged to move as quickly and accurately as possible through the 16-card block. Following the completion of the congruent block, the researcher said that it was time to make the game "silly" and instructed them to say "day" when presented with the moon and "night" when shown the sun. Children who did not master the instructions after three rounds of practice trials did not continue to the test trials.

An additional task was administered to provide a general comparison between language groups in verbal productivity, which was not expected to be affected by language status (Bialystok, 2010). The task is based on those included in language or verbal sections of ability assessments (NEPSY II, Korkman, Kirk, & Kemp, 2007; McCarthy Scales of Children's Abilities, McCarthy, 1972) and assesses verbal productivity. Children were first asked to name as many animals as they could and then to name as many things to eat and drink as they could. The children were given 60 s to respond to each request. Bilingual children were not given specific language instructions for this task, but no corrections were made if children utilized both languages. The outcome variable was the number of unique correct responses across both trials. The block stacking game was included to minimize task interference and included no measure of performance.

¹ The task, updated for ongoing research by the authors, is available for download free at <http://pebl.sf.net/battery.html>. Updates include modification of practice period, the addition of neutral stimuli and separate block presentation, as well as the ability to manipulate the number of stimuli per block and response time window.

Participation in the BST involved first allowing the children a few minutes to play a simple match-the-picture game to familiarize them with the touch screen's sensitivity and novelty. Upon completion, children were given the following instructions: "The next computer game is the Shape Game. You are going to match the circles to the circle picture at the bottom and the squares to the square picture at the bottom. We are going to practice first. The first few we do will make a 'ding' if you do it correctly and an 'eh' if you do it incorrectly. That way we can make sure you know how to play! The sound will go away after the first few, but that does not mean you are playing it wrong; just keep playing. Let's play the Shape Game!"

The first five trials of the practice included a "ding" sound if the child touched the matching shape or an "eh" sound if the child chose the incorrect shape. The last five trials included no sound. If the child answered correctly on four of the last five trials, comprehension was assumed and the child moved on to the test trials. If 80% accuracy was not achieved, the practice was repeated a second time and, if necessary, a third time before terminating the test. Practice trials contained all four possible test stimuli and were presented in a constant random order. The test contained 20 test items, five of each type, in a constant random order. Children were given 6 s to respond in each trial. Self-correction was not permitted and only the first response was recorded.

Children were tested individually in quiet rooms in their childcare centers by trained undergraduates who were fluent in Spanish and English. Bilingual children were given the choice of receiving instructions in English or Spanish when greeted and the examiner consistently honored the child's preference throughout the assessment. Examiners recorded Day/Night task performance, vocabulary task performance, and notes on interruptions, repeat of practice trials, and any other pertinent information. The computer used to administer the BST recorded the accuracy of each trial and collected response times. Because response time is often more variable in children than in adults and accuracy is considered a better measure for young participants (Diamond & Kirkham, 2005), response time were collected to ensure that responses reflected purposeful intent only.

3. Results

BST trials with a mean response time under 300 ms were removed as they were deemed too fast to represent responses to the test items. These occurred on only 36 of 940 test trials. In addition, a few children were unable to contribute data to one of the two tasks due to interruptions while testing or failure to meet accuracy criteria in practice trials. In these cases, data from the completed task but not the interrupted task were included.

Preliminary analyses determined the variables to be retained in the models used to test the hypotheses. There were no order effects on any dependent variables, so data were collapsed across order for further analysis. Vocabulary fluency (total sample mean = 9.61, $SD = 4.87$; bilingual mean = 9.64, $SD = 5.50$; monolingual mean = 9.58, $SD = 4.20$) was not predicted by language group, $F(1, 51) = 0.36$, $p = .55$, gender, $F(1, 51) = 0.00$, $p = .99$, or race, $F(4, 51) = 0.42$, $p = .79$, when controlling for age. Vocabulary fluency did not predict any dependent variables, $r_s < .28$, $p_s > .06$, controlling for age. In addition, there were no effects of gender, $F(6, 33) = 0.26$, $p = .95$, or race, $F(6, 33) = 1.82$, $p = .13$, on any of the dependent variables when controlling for age. Thus, vocabulary, gender, and race were not included in further models. Months of age was significantly and negatively correlated to errors in both the Day/Night task and the BST, $r_s < -.35$, $p_s < .014$. Therefore, age in months was included as a covariate in the models used to test the hypotheses.

3.1. Day/Night task

Number of errors were analyzed with a mixed model, 2 within-subject (error type; congruent or incongruent) \times 2 between-subject (language group; bilingual or monolingual) analysis of variance (ANOVA) for repeated measures, with age as a covariate. Replicating previous findings, there was a significant overall cost for incongruent trials compared to congruent trials in the form of more errors in the incongruent block than the congruent block, $F(1, 42) = 8.34$, $p = .006$, $\eta^2 = .17$. The relation between congruent and incongruent trials was not qualified by language group, $F(1,$

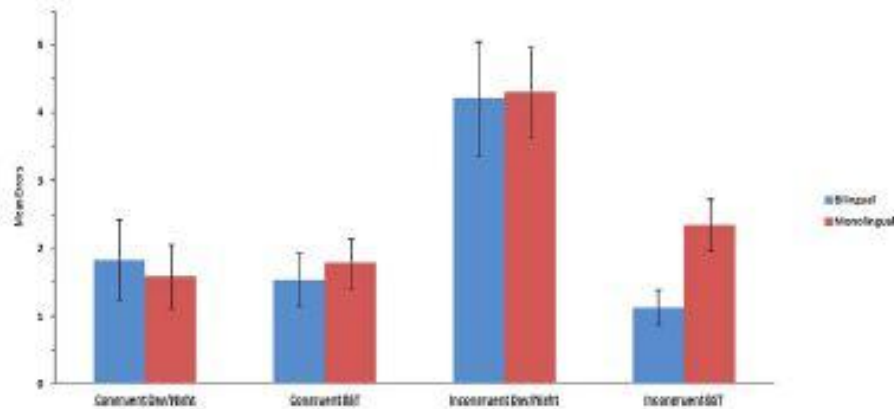


Fig. 2. Errors made by monolingual and bilingual preschoolers on congruent and incongruent trials in the performance of the Day/Night and Bivalent Shape tasks.

42) = 0.01, $p = .91$. There were no differences between bilingual and monolingual participants in number of errors for either trial type and no interaction with error type, $F(1, 41) = 0.07$, $p = .80$ (see Fig. 2).

3.2. Bivalent Shape Task

Number of errors were analyzed in a second, mixed model, 2 within-subject (error type) \times 2 between-subject (language group) repeated measures ANOVA, with age as a covariate. Although there was no significant difference between errors in congruent and incongruent trials on the BST, $F(1, 43) = 1.19$, $p = .26$, the predicted interaction between trial type errors (congruent or incongruent) and language group was observed, $F(1, 43) = 7.79$, $p = .008$, $\eta^2 = .15$. Pairwise comparisons using Bonferroni corrections revealed no difference between language groups in congruent errors, $F(1, 43) = 0.12$, $p = .73$, but monolinguals made significantly more incongruent errors than did bilinguals, $F(1, 43) = 9.69$, $p = .003$, $\eta^2 = .18$. In addition, monolinguals made significantly more errors in the incongruent compared to congruent trials, $F(1, 43) = 4.21$, $p = .046$, $\eta^2 = .09$, whereas error rates for bilinguals did not differ between trial types, $F(1, 43) = 3.59$, $p = .07$. Hence, monolinguals showed greater cost for incongruent as compared to congruent trials than bilinguals (Fig. 2). As expected, response times were too large to reflect meaningful cognitive processing and are thus not included.

3.3. Cross-task correlations

We performed first-order partial correlations controlling for age for the full sample and within each language group to explore the relations between tasks. There were no significant correlations between tasks in the full sample, partial correlations $\leq .19$, $ps \geq .25$. Within the monolingual sample, however, incongruent errors in the BST and the Day/Night task when controlling for age were significantly correlated, partial correlation = .46, $p = .047$. There were no significant correlations between tasks within the bilingual sample, partial correlations $\leq -.29$, $ps \geq .22$.

The incongruent trials may have differed by task in level of difficulty. To test this relation and whether it was consistent across language groups, we analyzed incongruent errors with a mixed model, 2 within-subject (task type; Day/Night task or BST) \times 2 between-subject (language group) repeated measures ANOVA with age as a covariate. The incongruent trials of the Day/Night task were more difficult than incongruent trials of the BST, $F(1, 39) = 6.95$, $p = .01$, $\eta^2 = .15$, and this relation did not differ by language group, $F(1, 39) = 1.08$, $p = .31$.

4. Discussion and conclusions

We replicated previous results in finding no difference between monolingual and bilingual preschoolers' performance on the Day/Night task. We observed the bilingual advantage, however, using a task that incorporated key aspects of the Color/Word Stroop. In performing this task, bilingual preschoolers made significantly fewer incongruent errors in comparison to their monolingual peers, and the incongruent trials were significantly more difficult than congruent trials for monolingual but not bilingual preschoolers. These findings support a methodological explanation for the absence of a bilingual advantage in young children's performance on Stroop task variations in the extant literature.

The characteristics of the participants in this study as well as the usability of the new measure must be carefully examined in evaluating the results. Our designation of bilingual status was limited in that it was based on information provided by parents and teachers rather than by a comprehensive vocabulary assessment including both languages. Nonetheless, our classifications were conservative, and the results attest to the validity of our categories in that language group differences were observed in the predicted pattern.

Another limitation is the comparison of intact language groups, resulting in a quasi-experimental design. There is, however, no reason to assume there were pre-existing differences between the bilingual and monolingual groups other than the effects of language usage. The two groups were of similar socio-economic backgrounds; they lived in middle class neighborhoods, attended the same or comparably priced childcare centers, and did not receive government subsidies. Importantly, the monolingual and bilingual children showed equivalent performance on all measures that did not involve interference suppression, including both congruent and incongruent Day/Night task trials and the congruent trials of the Color/Shape task.

The language groups were also comparable with regard to the fluency task included as an index of vocabulary development. It is possible that our acceptance of answers provided in either language explained the absence of language group differences, but equivalent performance on vocabulary tasks is not unprecedented (Bialystok, 2010). Further, the lack of correlation between the verbal fluency measure and the EF tasks may stem from the fact that the latter were selected to be independent of vocabulary.

Our primary objective in the conceptualization of the BST was to design a measure that, like the Color/Word task, assessed interference suppression rather than response inhibition (as does the Day/Night Task). We recognize, however, that our two EF tasks differed in other regards. Although the Day/Night task utilized cards and the BST task was computerized, it is unlikely that this difference affected performance. Our traditional presentation of the Day/Night task replicated results from a computerized presentation (Martin-Rhee & Bialystok, 2008), and previous research (Piper et al., 2012) has shown similarities in performance on traditional and computerized versions of EF assessments. It is also the case that the BST, like the Color/Word Stroop task, employed a mixed block design, whereas the Day/Night task is a continuous block assessment. Future research must determine the impact of this difference.

Practice trials also differed between tasks, with the BST incorporating more practice than the Day/Night task. This factor may have contributed to the greater difficulty of the Day/Night task. It is also possible that this greater difficulty simply reflects a more robust pattern of higher accuracy in interference suppression tasks. Supporting this interpretation, Bunge et al. (2002) also found more errors among older participants in a response inhibition task than in an interference suppression task. Possibly, more trials with a more restricted period of response would help equate the task difficulty, but the significant difference between congruent and incongruent errors for the monolingual sample confirms sufficient perceptual distraction in the stimuli.

Performance on the two tasks was not correlated in the full sample or in the bilingual group. However, a correlation was found between the incongruent trials of the tasks within the monolingual sample. This pattern of results is consistent with the possibility of a bilingual-specific developmental advantage affecting interference suppression but not response inhibition. Consistent with this interpretation, Luk, Anderson, Craik, Grady, and Bialystok (2010) used fMRI to show differences in neural activation for bilingual and monolingual participants during an interference suppression task, but no

differences during a response inhibition task. Further research is needed to understand the development of these areas of inhibition in both bilingual and monolingual samples, but the pattern of results provides validity for the new task.

The results offer further support for the work of Bialystok and colleagues regarding the role of interference suppression rather than response inhibition in the bilingual advantage. An emerging pattern of results underscores the importance of the inclusion of bivalent stimuli and hence the necessity of interference suppression in invoking the bilingual advantage in conflict tasks. Bialystok and Barac (2012) found a bilingual advantage using a bivalent task designed to measure switching. The task used in this research was very similar to the Dimensional Change Card Sort (Zelazo, 2006), which has also shown a preschool bilingual advantage (Bialystok & Martin, 2004). The BST also requires that children sort bivalent stimuli, but it shows a bilingual advantage in the absence of the switching component. The BST more closely parallels research on the Stroop effect in monolingual and bilingual adults (Bialystok et al., 2008; Hernández et al., 2010). As was the case in this adult research, our results indicated that bilingualism attenuated the cost of incongruent trials in performing a Stroop-like task, supporting the importance of interference suppression.

In conclusion, this study provides evidence for a methodological explanation of the discrepancy for a Stroop-task advantage in adults but not preschool aged children. Bilingual preschoolers showed enhanced performance compared to monolingual preschoolers on a new conflict task that closely matches the defining elements of the Color/Word Stroop. The pattern of results justifies further research with the BST, which may be an option for examining the Stroop Effect in both monolingual and bilingual participants across the lifespan.

Acknowledgements

Research reported in this publication was supported in part by a predoctoral fellowship from the Eunice Kennedy Shriver National Institute of Child Health & Human Development of the National Institutes of Health under Award Number T32HD007376 through the Center for Developmental Science, University of North Carolina at Chapel Hill, to Alena G. Esposito. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. We are grateful to the families and staff of the participating child care centers for their cooperation and generous support of this work.

References

- Adesope, O. O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research*, 80(2), 207–245.
- Archibald, S. J., & Kerns, K. A. (1999). Identification and description of new tests of executive functioning in children. *Child Neuropsychology*, 5(2), 115–129. <http://dx.doi.org/10.1076/chin.5.2.115.3167>
- Bialystok, E. (2010). Global–local and trail-making tasks by monolingual and bilingual children: Beyond inhibition. *Developmental Psychology*, 46(1), 93.
- Bialystok, E., & Barac, R. (2012). Emerging bilingualism: Dissociating advantages for metalinguistic awareness and executive control. *Cognition*, 122(1), 67–73.
- Bialystok, E., Craik, F., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 34(4), 859–873. <http://dx.doi.org/10.1037/0278-7393.34.4.859>
- Bialystok, E., Luk, G., Peets, K. F., & Yang, S. (2010). Receptive vocabulary differences in monolingual and bilingual children. *Bilingualism: Language and Cognition*, 13, 525–531.
- Bialystok, E., & Martin, M. M. (2004). Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science*, 7(3), 325–339.
- Bunge, A. S., 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(2), 301–311. [http://dx.doi.org/10.1016/S0896-6273\(01\)00583-9](http://dx.doi.org/10.1016/S0896-6273(01)00583-9)
- Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science*, 11(2), 282–298.
- Diamond, A., & Kirkham, N. (2005). Not quite as grown-up as we like to think: Parallels between cognition in childhood and adulthood. *Psychological Science*, 16(4), 291–297. <http://dx.doi.org/10.1111/j.0956-7976.2005.01530.x>
- Gerstade, L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3½–7 years old on a Stroop-like day-night test. *Cognition*, 53(2), 129–153.
- Gollan, T. H., & Kroll, J. F. (2001). Bilingual lexical access. In B. Rapp (Ed.), *The handbook of cognitive neuropsychology: What deficits reveal about the human mind* (pp. 321–345). New York, NY, US: Psychology Press.
- Gollan, T. H., & Silverberg, N. B. (2001). Tip-of-the-tongue states in Hebrew-English bilinguals. *Bilingualism: Language and Cognition*, 4(1), 63–83. <http://dx.doi.org/10.1017/S136672890100013X>

- Hernández, M., Costa, A., Fuentes, L. J., Vivas, A. B., & Sebastián-Gallés, N. (2010). The impact of bilingualism on the executive control and orienting networks of attention. *Bilingualism: Language and Cognition*, 13(03), 315–325. <http://dx.doi.org/10.1017/S1366728909990010>
- Hilchey, M. D., & Klein, R. M. (2011). Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes. *Psychonomic Bulletin & Review*, 18(4), 625–658.
- 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(2), 220–232.
- Korkman, M., Kirk, U., & Kemp, S. L. (2007). *NEPSY II. Administrative manual*. San Antonio, TX: Psychological Corporation.
- Kovacs, A. M., & Mehler, J. (2009). Cognitive gains in 7-month-old bilingual infants. *Proceedings of the National Academy of Science*, 106, 6556–6560. <http://dx.doi.org/10.1073/pnas.0811323106>
- Livesey, D., Keen, J., Rouse, J., & White, F. (2006). The relationship between measures of executive function, motor performance and externalizing behavior in 5- and 6-year-old children. *Human Movement Science*, 25(1), 50–64. <http://dx.doi.org/10.1016/j.humov.2005.10.008>
- Luk, G., Anderson, J. A., Craik, F. I., Grady, C., & Bialystok, E. (2010). Distinct neural correlates for two types of inhibition in bilinguals: Response inhibition versus interference suppression. *Brain and Cognition*, 74(3), 347–357.
- 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(01), 81–93. <http://dx.doi.org/10.1017/S136672890700322>
- McCarthy, D. (1972). *McCarthy Scales of Children's Abilities*. New York, NY: Psychological Corp.
- Mueller, S. T. (2010). A partial implementation of the BICA cognitive decathlon using the Psychology Experiment Building Language (PEBL). *International Journal of Machine Consciousness*, 2, 273–288.
- Mueller, S. T. (2011). *The Psychology Experiment Building Language (Version 0.11)* [Computer software]. Available from <http://pebl.sourceforge.net>
- Piper, B. J., Li, V., Eiwaz, M. A., Kobel, Y. V., Benice, T. S., Chu, A. M., et al. (2012). Executive function on the psychology experiment building language tests. *Behavior Research Methods*, 44(1), 110–123.
- Poulin-Dubois, D., Blaye, A., Coutya, J., & Bialystok, E. (2011). The effects of bilingualism on toddlers' executive functioning. *Journal of Experimental Child Psychology*, 108(3), 567–579. <http://dx.doi.org/10.1016/j.jecp.2010.10.009>
- Prevor, M. B., & Diamond, A. (2005). Color-object interference in young children: A Stroop effect in children 3½–6½ years old. *Cognitive Development*, 20(2), 256–278. <http://dx.doi.org/10.1016/j.cogdev.2005.04.001>
- Robertson, I. H., Manly, T., Andrade, J., Baddeley, B. T., & Yiend, J. (1997). "Oops!": Performance correlates of everyday attentional failures in traumatic brain injured and normal subjects. *Neuropsychologia*, 35(6), 747–758. [http://dx.doi.org/10.1016/S0028-3932\(97\)00015-8](http://dx.doi.org/10.1016/S0028-3932(97)00015-8)
- Siegal, M., Iozzi, L., & Surian, L. (2009). Bilingualism and conversational understanding in young children. *Cognition*, 110(1), 115–122. <http://dx.doi.org/10.1016/j.cognition.2008.11.002>
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18(6), 643–662. <http://dx.doi.org/10.1037/h0054651>
- Yang, S., Yang, H., & Lust, B. (2011). Early childhood bilingualism leads to advances in executive attention: Dissociating culture and language. *Bilingualism: Language and Cognition*, 14(3), 412–422.
- Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature Protocols*, 1, 297–301. <http://dx.doi.org/10.1038/nprot.2006.46>

CHAPTER 4: Things that go Bump in our Lives: Immigration, Language Fluency, and Access to Autobiographical Memories

This investigation examined two controversies in the autobiographical literature: how cross-language immigration affects the distribution of autobiographical memories across the lifespan and under what circumstances language-dependent recall is observed. Both Spanish/English bilingual immigrants and English monolingual non-immigrants participated in a cue word study, with the bilingual sample taking part in a within-subject language manipulation. The expected bump in the number of memories in early life was observed for non-immigrants but not immigrants, who reported more memories for events surrounding immigration. The findings support an organized retrieval explanation for the reminiscence bump and offer an explanation for previous discrepancies. Bilinguals with high second language fluency appear to access a single conceptual store through either language while individuals with lower second language fluency were more likely to show language-dependent recall. Internal language was consistently related to the age at encoding regardless of fluency level. The final language-dependent recall multi-level model, including fluency, age of immigration, internal language, and cue word language, explained $\frac{3}{4}$ of the between-person variance and $\frac{1}{5}$ of the within-person variance.

Things that go Bump in our Lives: Immigration, Language Fluency, and Access to Autobiographical Memories

In research on autobiographical remembering, the likelihood that a participant will report any specific memory in response to a cue word depends in part on the point in the lifespan at which the remembered event occurred (Rubin, Wetzler, & Nebes, 1986). The typically observed distribution of autobiographical memories includes more memories from adolescence and early adulthood than would occur if the individual sampled from different age levels equally often (Rubin, 2000). Although the ages for which the bump is observed differ for remembered events with different characteristics (Koppel, 2013) and for memory distributions elicited with alternative techniques (Rubin, Berntsen, & Hutson, 2009; Rubin & Schulkind, 1997), the effect is generally considered to be robust. The over-representation of early life events is not only found repeatedly (Rubin, 2000) but also cross-culturally (Conway, Wang, Hanyu, & Hague, 2005), and the phenomenon extends beyond the recall of the personal past, characterizing the identification of favorite music recordings and judgments of sports players (Janssen, Chessa, & Murre, 2007; Janssen, Rubin, & Conway, 2012).

As discussed below, the mechanisms that underlie this *reminiscence bump* are not completely understood. Some proposed explanations emphasize developmental phenomena that result in the enhanced coding of events that occur at this point in the lifespan; others reflect the operation of a retrieval structure derived from the expected timing of life experiences or major life transitions. Research with samples of cross-language immigrants offers an opportunity to better understand the memory distribution of autobiographical

memories and the possible origins of this distribution. At present, however, the few extant investigations report conflicting results. We examined the reminiscence bump among immigrants and non-immigrants in an attempt to reconcile these findings and to better understand the reasons for the effect. The involvement of cross-language immigrants in this investigation also allowed us to examine the relation between language and memory access. Building on previous research, we were especially interested in the role of second language fluency in language-dependent recall.

Reminiscence Bump and Immigration

Despite the universality of the reminiscence bump, there is no consensus regarding the responsible underlying mechanisms. One set of explanations emphasizes the possibility of the enhanced encoding of early life events. The events of adolescence and early adulthood may be more richly encoded than those that occur during other periods of life because they are pivotal to the formation of identity, and thus particularly distinctive (Conway, 2005). Events that transpire during the period characterized by the reminiscence bump could also be better encoded simply because they occur during a time of optimal cognitive functioning (Janssen & Murre, 2008).

Alternative explanations for the reminiscence bump focus on processes that occur during retrieval. The life script perspective (Berntsen & Rubin, 2004; Thomsen & Berntsen, 2008) hypothesizes an organizational structure that identifies some events as normative within a given cultural context and guides the retrieval of these central experiences. The reminiscence bump results at least in part from the fact that a disproportionate number of events in the life script transpire during adolescence and early adulthood. Another

perspective emphasizing retrieval is transition theory, which posits that autobiographical memory is organized by temporal landmarks that cause enduring changes to daily life (Brown, Hansen, Lee, Vanderveen, & Conrad, 2012). Many, but not all, of these transitions are included in the cultural life script (Brown et al., 2012). Processes that operate at encoding would increase the availability in memory of some experiences from the early portion of the life span. Alternatively, retrieval processes would result in the greater accessibility of some events in memory. As discussed by Koppel (2013), this distinction is important, because of its implications for understanding whether accessibility or availability conveys an advantage to some material in long-term memory.

Research with cross-language immigrants provides a unique opportunity to examine the mechanisms that underlie the reminiscence bump. Cross-language immigration is a novel event that represents a major life transition, involving changes in culture and social relationships as well as language. Further, because it is not an expected life event in most cultures it is not a component of the life script. If the bump is determined largely by the greater availability of early life events in memory, cross-language immigration after the peak period for cognitive performance and identity formation in late adolescence should not affect the location of the bump. Hence, the distribution of autobiographical memories across age should not differ between monolingual individuals who remain in their country of origin and cross-language immigrants. In contrast, if the bump reflects the operation of an organizational structure that guides retrieval, cross-language immigration should impose a framework that facilitates access to memories for contemporaneous experiences. If this is the case, cross-language immigrants should show a bump in the recall of events that occurred

during the period surrounding immigration, regardless of whether the traditional bump is observed.

To date, only a limited number of investigations have capitalized on cross-language immigration in exploring explanations for the distribution of autobiographical memories, and the extant literature is characterized by conflicting results. In two separate studies, Schrauf and Rubin (1998, 2001) examined the impact of immigration on the distribution of memories in a sample of older adults who had immigrated to the U. S. from Spanish-speaking countries approximately 30 years earlier. All participants reported high functional fluency in English. Using the cue word method, Schrauf and Rubin (1998) presented 50 words from each language to the 12 participants and found that the bump corresponded to the early (age 20-24), middle (26-30), or late (34-35) age of immigration (AoI) of the participants. They then followed up using the life story method with a sample of 10 of these individuals, again categorized as having immigrated during one of three age spans (Schrauf & Rubin, 2001). Replicating their previous results, the bump was again predicted by the timing of immigration rather than age.

Marian and Neisser (2000) also used the cue word method in two studies, presenting 8 English and 8 Russian words to a combined sample of 44 college students who had immigrated from Russia to the US during adolescence. In contrast to Schrauf & Rubin (1998, 2001), they found a dip in the number of memories reported for the time period surrounding immigration rather than a bump. The authors discuss the possibility that the events surrounding immigration were more poorly encoded than were events from other portions of the lifespan, reflecting new immigrants' lack of a scheme for the novel experiences

associated with the cultural relocation. If so, further research should replicate the absence rather than presence of an immigration bump. But Marian and Neisser (2000) also point out that the pattern of results could be an artifact of their method, which restrained participants' response to the language in which the cue word was presented.

It could also be the case that the fluency levels across the Schrauf and Rubin (1998, 2001) and Marian and Neisser (2000) investigations contributed to the results. A criterion for participation in the former investigation was residence in the US for at least 30 years, and the participants rated their competence in spoken English as very high (92.9 on a 100 point scale). Although the immigrants in the Marian and Neisser (2000) research were described as fluent in English, they had only been in the US for 6 years on average, and fluency was assumed because the participants were attending a university in which English was spoken. It may well be that the levels of fluency and personal comfort with spoken English contrasted among the participants in the different investigations. In addition, the college students varied from the participants in the Schrauf and Rubin (1998, 2001) studies in other potentially important regards, including their present ages and AoI. To determine the influence of these factors, we examined the distribution of autobiographical memories in an investigation involving a diverse sample of cross-language participants in which we used the cue word method with unrestrained language use.

Fluency and Language-dependent Recall

Bilingual fluency is important in autobiographical recall because bilinguals with different levels of competence in a second language may have varying accessibility to memories encoded in their alternate languages. A commonality across several theoretical

perspectives on the representation of languages is the postulation of a single conceptual store for individuals who are highly fluent in both languages (de Groot, 1992; Kroll, van Hell, Tokowicz, & Green, 2010). If sufficient fluency is not established, the second language may not initially be linked to the conceptual store and may require translation through the first language (Kroll, van Hell, Tokowicz, & Green, 2010). The mother-tongue hypothesis (Schrauf, 2000), consistent with the encoding specificity principle (Tulving & Thomson, 1973), asserts that memories are more easily recalled through the language of their encoding. This hypothesis thus conflicts with the idea of a single conceptual store, at least for highly fluent individuals.

There is mixed support for the mother-tongue hypothesis in existing literature. In a series of cue word studies, Schrauf and Rubin (1998, 2000) found evidence for this hypothesis for the language of thought. Internal language and the age at the time of the reported memory were related, with events that occurred prior to immigration more likely to be thought in Spanish, and after in English. This pattern suggests that memories are more likely to be recalled in the language of encoding regardless of the language of the interview. However, in contrast to a prediction based on the hypothesis, the language of the cue word was not related to the age at which the remembered events transpired; that is, Spanish cue words did not elicit earlier memories. These studies used the same small, highly fluent Spanish/English bilingual samples described above. A study with a similar sample of 20 Danish/Polish fluent bilingual participants, also older adults who immigrated decades prior, found the same results (Larson, Schrauf, Fromholt, & Rubin, 2002).

In contrast, Marian and Neisser (2000), in the studies discussed above involving US college students originally from Russia, found that the language of the cue significantly affected what was remembered. Russian cues were more likely to elicit Russian memories from before the AoI, whereas English cues elicited English memories from after immigration. In another study involving Japanese/English bilingual college students who immigrated in adolescence, the language of the cue also significantly predicted the participant's age at the time of the remembered event (Matsumoto & Stanny, 2006). In addition, the more skilled English speakers were more likely to think in English when given English cues than those less skilled. The results thus suggest an effect of language fluency on the pattern of language-dependent access to memory. Individuals with very low fluency may be translating cue words into their native language, and thus may not show language-dependent recall because the memories they report are in effect always cued in the first language. In contrast, speakers whose second language fluency allows them to think in the second language, but who lack the high fluency necessary for a single conceptual store, will likely exhibit language-dependent recall. Among highly fluent individuals, access to memory is possible through either language, and accordingly recall is not language-dependent.

Both Marian and Neisser (2000) and Matsumoto and Stanny (2006) found that the language of the cue word predicted the age at which the memory was encoded (AaE). Consistent with the mother-tongue hypothesis, they attribute this effect to state-dependent learning. In this case, communicating in the original language aided in recreating the atmosphere of encoding and hence facilitated memory retrieval. In contrast, Schrauf and Rubin (1998, 2000) and Larsen et al. (2002) did not find the same language-dependent

access. Their sample, as previously described, contained only highly fluent bilinguals who would be expected to have developed a single conceptual store, allowing access to memories through either language. The present investigation evaluated whether the inconsistencies in the importance of the external language between studies can be explained by differences in characteristics of the participants. Although a moderating effect of fluency was predicted, we also examined the possible influences of participant age, AoI, daily exposure, years of bilingual fluency, and length of time in the US.

This Study

This study utilized the cue word method to explore the role of immigration and language fluency in the distribution of memories across the lifespan and the effects of language-dependent recall. We expected that our sample of monolingual, non-immigrant participants would show a bump between the ages of 5-20, replicating the results of previous studies using the cue word method (e.g., Janssen, Rubin, & St. Jacques, 2011; Janssen & Murre, 2008; Rubin & Schulkind, 1997). In contrast, we expected that cross-language immigrants would show a bump that correlated to the AoI, reflecting a difference in the organization of the life story as a result of this salient life altering transition. Further, with participant language use unconstrained, we expected to find a higher number of instances in which the participant responded through two languages or in a different language than that of the interviewer in reporting events that occurred during the period of immigration. Schrauf and Rubin (2000) posit that “cross-over” memories, those which come to the participant in an alternate language than that which is being spoken, are important because they represent especially strong linguistic memories to be recalled against the language of the test session.

We expect that code-switches will be more prevalent for cross-over memories due to the difficulties of simultaneous translation (Christoffels, de Groot, & Kroll, 2006). The restriction of language may limit the report of these memories and offer a possible explanation for the discrepant findings regarding the distribution of memories from the period of time surrounding immigration (cf. Scrauf & Rubin, 1998, 2001; Marian & Neisser (2000).

With regard to language-dependent recall, we predicted an interaction between the language of the cue and second-language fluency in a sample of adults with functional fluency. Specifically, we expected that the language of the cue word would only be related to the AaE among participants with relatively low second language fluency. The use of multi-level modeling (Raudenbush & Bryk, 2002) made it possible to test the cross-level interaction between memory-level and person-level variables.

METHOD

Participants

Forty-seven potential participants, including both Spanish/English bilingual U.S. immigrants (BI) and English-speaking monolingual non-immigrants (MNI), were recruited through schools offering Spanish immersion education. All participants were teachers in the same schools within 2 school systems in Eastern North Carolina. Recruitment through the schools ensured that the two groups would have generally equivalent levels of education and similar demographic characteristics. Prior to recruitment, principals confirmed that the teachers who were native Spanish speakers had functional fluency in English, as demonstrated by their participation in professional interactions conducted in English,

including parent conferences and staff development. Group assignments, which were initially made on the basis of self-reports, were confirmed at the conclusion of the interview by participants' responses to the Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumefeld, & Kaushanskaya, 2007). As verified by this measure, the MNI group members had no more second language exposure than a high-school education requires, whereas the BI participants had functional use of both languages. A total of 11 participants were eliminated because their language histories as elicited by the LEAP-Q did not meet the criteria for inclusion (e. g., absence of immigration; bilingual fluency at the time of immigration), resulting in a sample of 36, 23 of whom were BI. The language history characteristics of the BI group are described in Table 1; Tables 2 and 3 provide information about the backgrounds of the participants in each group. As described below, not all 36 participants contributed data to all analyses. The interpretation of the Reminiscence Bump included MNI and BI participants, but only those who had not immigrated within the most recent two years ($n = 34$; see Table 2). The examination of language-dependent recall included only BI who completed the within-subject language manipulation ($n = 17$; see Table 3).

Materials

Autobiographical Memory Measure. A cue word recall task was chosen because it allowed for a within-subjects manipulation of two different languages for bilingual participants. Words were chosen from a list of 100 cue words, determined to be comparable in frequency and imageability prior to their use in a previous study of Spanish/English bilingual autobiographical memory (Schrauf & Rubin, 1998). Thirty of these words were

selected for the present study on the basis of the research team's subjective assessments of high frequency, equivalency of frequency, concreteness, imageability, and connotation across language contexts. Each word was then evaluated for frequency, concreteness, and imageability using the MRC Psycholinguistic Database (Wilson, 1988). Two lists of 15 words each were then created and the comparability of the three variables was established, again using the MRC Psycholinguistic Database (Wilson, 1988). Ratings were then obtained from an independent sample of 10 Spanish/English bilingual volunteers and 30 English monolingual volunteers which confirmed that the frequency, concreteness, and imageability were equivalent across lists and languages. The order of the words remained the same for each participant; however, language was counterbalanced for those participating in the within-subject language manipulation. The dependent variable resulting from the cue word task was the estimated age at which each remembered event reported in response to each cue word took place, labeled the Age at Encoding (AaE).

Fluency measure. The Language Experience and Proficiency Questionnaire (LEAP-Q; Marian, Blumenfeld, & Kaushanskaya, 2007) was utilized to assess the bilingual language status of all participants who had more second language experience than a general high school degree in the state requires (2 years of introductory courses) or a history of immigration. The questionnaire was developed specifically to be a reliable and valid self-report measure for adults with a predictable relationship to behavioral measures (Marian, Blumenfeld, & Kaushanskaya, 2007). Across two studies with different samples, Marian, Blumenfeld and Kaushanskaya (2007) established both internal and criterion-based validity for the measure using factor analysis, multiple regression, and correlation analysis with a battery of standard

behavioral linguistic measures. The questionnaire contains questions regarding personal history (including immigration history), past and present language exposure, and language competence across all languages spoken.

The fluency measure utilized in this study was the percentage of the time that the individual would choose to speak in English to a person who knew Spanish and English equally well, presented as “When conversing with another individual who knows both Spanish and English equally well, what percentage of the time would you choose to speak in English?”. This measure was chosen because it incorporated both frequency and fluency and avoided self-evaluation of formal language abilities that might erroneously lead to low fluency self-reports for individuals whose language was socially acquired (Grosjean, 2010). Other fluency measures, listed in Table 1, were used as exclusion criteria as described above, and for follow-up analyses to assess the specificity of our findings.

Code-switching Measure. Code-switching is the use of an alternate language than that of the speaker (i.e. responding to a Spanish question in English) or the use of more than one language within one phrase (i.e. “alguien llevo a preguntarme ‘*What’s up?*’”). The language or languages used by the participant for each memory title were recorded. Titles that contained more than one language or that were provided in a language other than that of the interviewer were coded as code-switches.

Procedure

Individual interviews took place in a quiet work area in the school in which the participant was employed and were conducted by one of three female college students with native or native-level Spanish and English fluency. All interviewers interviewed participants

from all groups. The interviewer first obtained written consent in the language of preference from the participants. The interviewer then told the participants that they were going to be given 30 word cues across two blocks of trials and asked to associate each word cue with a specific memory from anytime throughout their life. They were asked to report a “title” for the memory for the interviewer to write down (e. g., “My sister’s wedding”) so they would be able to identify which memory they were recalling if they came back to it later. All BI participants were given the option of taking part in the within-subjects language manipulation; however, 6 opted out and completed the study in Spanish only. The remaining 17 BI group members completed one list in each language in counterbalanced order.

In responding to the cue word, participants were encouraged to report the first memory that came to mind without evaluating their responses. To encourage such unfiltered memory reporting, the interviewer activated a timer as soon as she said the cue word and stopped it when the participant completed the “title” of the memory. Interviewers recorded the time, the title of the memory, and the language(s) the participant spoke in.

There was a break after the presentation of the first 15 cue words, during which participants were asked to complete three computerized cognitive tasks (not considered in this report). The second block of 15 words followed, with the interviewer speaking in the alternate language and using the alternate language cue word list for those participating in the language manipulation. After completing the title for all 30 memories, participants were asked to date the memories, to the best of their ability, with age in years and months at the time of the event. Interviewers helped participants narrow down the time frame of the event

by presenting such questions as “Were there family members present?”, “Was it near a holiday?” and “Do you remember the location?”.

In addition, all BI were asked to identify the language of thought. Participants were told “the language in which you first thought about the event may not have been the same as the language you used to tell me about the event. We are going to go through the memories you reported and I would like you to tell me which language the memory first came to you in.” These instructions made sense to all bilingual participants and they were able to respond that the memory came to them in Spanish, English, neither (such as a visual memory), or both. After completing the interview, all participants answered demographic questions and BI participants completed the LEAP-Q.

RESULTS

The Bump

Prior to analysis of the Reminiscence Bump, data from individuals who had immigrated within the most recent two years were eliminated, leaving a final sample for this portion of the analyses of 34 participants (13 MNI and 21 BI). Memories from the most recent 2 years were eliminated for the remaining participants. Both of these measures were taken to avoid the intrusion of the recency effect on results. There were no differences between language groups in gender, $F(1, 34) = 2.64, p = .11$, education, $F(1, 34) = .08, p = .78$, or participant age, $F(1, 34) = 2.37, p = .13$. The BI group was predominantly Latino/a compared to a predominantly Caucasian MNI group, $F(1, 34) = 61.54, p < .001, \eta^2 = .66$. Preliminary multi-level modeling (MLM) analysis conducted in SAS revealed no effect of the order of language presentation, participant age, sex, years of education, or race on the

dependent measure, AaE, $F_s(1, 30) < 3.63, p > .07$. Data were collapsed across these variables for further analysis with the exception of participant age, which was included as a covariate due to the difference, though not significant, between groups and the variance within the total sample. Because race was strongly associated with language group, it could not be used as a covariate. All analyses of the reminiscence bump were two-tailed and run using SPSS software.

Following the example of Janssen, Rubin, and St. Jacques (2011), the number of memories reported per five year bin was tallied to create the lifespan distribution. First, because we expected the bump to appear for MNI between the ages of 5 and 20, we combined the number of memories reported during that period into one bin and compared it to number reported for the 15 years immediately following, controlling for participant age. A paired sample t-test comparing the bins representing AaEs 5-20 versus 20-35 revealed that MNI reported significantly more memories dating from ages of 5-20 than from ages 20-35, $t(11) = 3.24, p = .008$, Cohen's $d = 1.95$. To test whether cross-language immigration affected the bump, we ran a 2 (MNI vs. BI) between-subject by 2 (ages 5-20 vs. 20-35) within-subject analysis of variance with participant age as a covariate and Bonferroni adjustments in the follow-up analysis. The results revealed a significant between- by within-subject interaction, $F(1,30) = 5.52, p = .03, \eta^2 = .16$, in that the BI reported significantly fewer memories between the ages of 5-20 compared to the MNI, $F(1,30) = 4.40, p = .04, \eta^2 = .13$, but the groups did not differ with regard to the number of memories reported between the ages of 20-35, $F(1,30) = 1.24, p = .27$. In addition, the MNI group had significantly more memories between the ages of 5-20 than 20-35, $F(1, 30) = 15.31, p < .001, \eta^2 = .34$, whereas

the immigration group did not show a significant difference in the number of memories reported during these time periods, $F(1,31) = 1.33, p = .26$ (see Figure 1).

These analyses confirmed the expected bump for MNI and indicated that immigration affected the bump; however, they could not confirm a bump for the period of immigration. To do so, following Schrauf and Rubin (2001), we tested for a bump at the period of immigration with each participant's memories centered around their AoI (see Figure 2). The 10-year period surrounding immigration was compared to the 10-year age bins before and after immigration in a Repeated Measures analysis of variance. Mauchly's test indicated that the assumption of sphericity had not been violated $\chi^2(5) = .384, p = .58$. There was a significant main effect of age bin on the number of memories reported, $F(3, 24) = 6.62, p < .002, \eta^2 = .45$. Pairwise comparisons revealed that the periods of 20 years prior to immigration, 10 years prior to immigration, and 10 years after immigration all contained significantly fewer memories than the 10-year period surrounding immigration.

To test whether the number of code-switches that occurred during the 10 years surrounding immigration was significantly different from the number observed in reporting memories from other time periods, we compared the 10-year period surrounding the year of immigration to all the other time bins combined in a paired sample t-test. Only those BI participants ($n = 14$) who contributed data to all 4 time bins (20 years prior, 10 years prior, immigration, and ten years after) could be included in this analysis. The results revealed that there were significantly more code-switches during the 10-year period surrounding immigration than during all other time periods combined, $t(13) = -2.41, p = .03$, Cohen's $d = 1.34$ (see Figure 3).

Language-dependent Recall

Language-dependent recall was examined as the relationship between AaE and internal language and AaE and cue word language. This portion of the data included only the BI participants who agreed to participate in the within-subject language manipulation, meaning they received one list of cue words in English and one list in Spanish ($n = 17$). T-tests were conducted in SPSS to replicate previous work (e. g., Schrauf & Rubin, 1998). Multi-Level Modeling was conducted using SAS.

Participants reported that memories “first came” to them in Spanish, English, both, or no language. Across participants, 66% of the memories were thought in Spanish, 23% in English, 9% were non-linguistic, and 2% were thought in both languages. The hypotheses only addressed memories that were represented linguistically and in one language. Although descriptive in nature due to the small number of memories reported, the distribution of non-linguistic and both memories shows a peak at immigration, and thus follows the same pattern as single language linguistic memories.

T-tests. Previous literature has tested for language-dependent recall using t-tests (Schrauf & Rubin, 1998) to compare the difference in AaE for Spanish-cued and English-cued memories. In this BI sample, Spanish-cued memories did not date from earlier portions of the lifespan than English cued memories; mean AaEs = 25.44 ($SD = 4.97$) and 26.23 ($SD = 5.48$), respectively, $t(15) = .95, p = .37$. There was, however, a significant relationship between internal language and AaE, $t(12) = 5.56, p < .001$, Cohen’s $d = 3.21$, revealing that memories thought in Spanish ($M = 23.13, SD = 4.36$) were significantly earlier than

memories thought in English ($M = 32.22$, $SD = 1.24$). These findings replicate the results of Schrauf and Rubin (1998, 2000).

MLM. In order to account for the within-person variance resulting from the nesting of memories, we employed Multi-Level Modeling (MLM) to determine whether either the language of the cue word or the internal language were related to the AaE. An additional benefit of using MLM is the vertical data structure that allows for the analysis of all contributed data rather than only complete cases. Following guidelines for the use of MLM (e.g., Nezlek, 2001; Raudenbush & Bryk, 2002), an initial analysis was conducted to determine if there was sufficient variability at both Level 1 (memory level) and Level 2 (person level) to warrant a multi-level analysis. The results of this null model indicated that 18% of the variance was between people ($\tau_{00} = 17.72$, $z = 2.35$, $p = .009$) and 82% was within-person ($\sigma^2 = 82.88$, $z = 15.20$, $p < .001$). Hence, there was sufficient variability to warrant further analysis.

In addition to testing for main effects of memory level predictors, the use of MLM enabled the testing of cross-level interactions. To determine if the relationship between AaE and language of the cue word or internal language depended on the participant's English fluency or AoI, we included language of the cue and internal language at the level of the memory and fluency and AoI at the level of the person in one model and tested for cross-level interactions. Both fluency and AoI were grand mean centered to prevent issues of multicollinearity. The equations were:

$$\begin{aligned} \text{Level 1: } AaE_{it} &= \beta_{0it} + \beta_{1it}(\text{language of cue}) + \beta_{2it}(\text{internal language}) + r_{ij} \\ \text{Level 2: } \beta_{0i} &= \gamma_{00} + \gamma_{01}(\text{AoI}) + \gamma_{02}(\text{Fluency}) + \gamma_{03}(\text{AoI} * \text{Fluency}) + u_{0i} \end{aligned}$$

$$\beta_{1i} = \gamma_{10} + \gamma_{11}(\text{AoI}) + \gamma_{12}(\text{Fluency}) + \gamma_{13}(\text{AoI*Fluency}) + u_{1i}$$

$$\beta_{2i} = \gamma_{20} + \gamma_{21}(\text{AoI}) + \gamma_{22}(\text{Fluency}) + \gamma_{23}(\text{AoI*Fluency}) + u_{2i}$$

Main effects of language of the cue word and internal language replicated the results of the t-tests. MLM yielded a nonsignificant result for language of the cue as a predictor of AaE, $\gamma_{10} = -1.11, t = -1.14, p = .25$. Internal language was a significant predictor of AaE, indicating that Spanish thought memories were earlier than English thought memories, $\gamma_{20} = -5.89, t = -4.18, p < .001$. In addition, we found a main effect of AoI, $\gamma_{01} = .85, t = 4.48, p < .001$, so that those who immigrated earlier tended to report earlier memories than those who immigrated later. Although there was not a main effect of Fluency, $\gamma_{02} = 0, t = -.05, p = .96$, there was a significant cross-level interaction with language of the cue word, $\gamma_{12} = .12, t = 2.39, p = .02$, such that participants with low fluency tended to report earlier memories for Spanish cue words than for English whereas there was no effect of language of cue for those with higher fluency (see Figure 4). There were no other significant interactions. This model explained 73% of the between-person variance and 10% of the within-person variance.

Follow-up Analyses

Given that the two measures were highly correlated, $r = .59, p = .01$, it was possible that the identified effect of AoI actually represented participant age. However, only AoI was correlated to AaE, $r = .72, p = .001$; participant age was not related to the points in the lifespan referenced by the reported memories. Unfortunately, participant age could not be included in the model predicting AaE because the sample size limited the person-level variables that could be included in the model to two (see Raudenbush & Bryk, 2002). The

hypothesis concerned second language fluency and AoI rather than participant age, prioritizing those variables. In order to be confident in concluding that the effects reported were due to AoI and not participant age, the model was run again with participant age included instead of AoI. In this model, there was no significant main effect of participant age, $\gamma_{01} = -.39$, $t = -.76$, $p = .46$, or any significant interactions with participant age.

In order to further explore the contributions of individual differences and the specificity of our chosen variables, the model was also run with number of years of residence in the US instead of AoI. There were no significant main effects or interactions with years of residence in t US. To examine the specificity of the fluency measure, the model was run three additional times with the following alternative measures of fluency, also derived from the LEAP-Q, substituting for the original variable: years fluent in English, percentage daily English exposure, and self-rated speaking English fluency. Although internal language and AoI remained significant predictors, none of these models resulted in any additional main effects or interactions.

DISCUSSION

The present findings resolve a discrepancy in the literature regarding the effect of immigration on the reminiscence bump. Consistent with Schrauf and Rubin (1998, 2001), we found an increase in the number of memories that dated from the period surrounding the bilingual participants' immigration to the United States. This difference was apparent when we centered memories around the age at which immigration occurred, allowing us to include all the participants in comparing the number of memories contained in 10-year bins that alternatively preceded, included, or followed their relocation. The absence of differences in

the number of immigrants' memories from ages 20-35, during which most moved to the US, and 5-20, before many had immigrated, does not contradict the finding of an immigration bump. Some of the participants immigrated before or near age 20 and hence their immigration bump substantially overlapped with the traditional bump. In addition, not all participants were old enough to contribute memories to the full 15-year age bin.

The results not only provide support for Schrauf and Rubin's (1998, 2001) results but suggest an explanation for the absence of the immigration bump in Marian and Neisser's (2000) investigation. The paucity of memories from the period surrounding immigration that Marian and Neisser (2000) reported was likely an artifact of their method. In their study, participants were required to respond in only the language in which they were addressed by the interviewer. For many individuals, the period surrounding immigration would be characterized by a language transition, with some events encoded in English and some events encoded in Spanish. In contrast, events that took place both before and after immigration could be expected to be more likely to be encoded in the dominant language of the cultural environment. If memory reports are restricted to the language of the interviewer, participants may activate a filter at recall that would limit the accessibility of memories from life periods in which memories were not consistently encoded in the language of the interviewer. All memories would be available and translation is certainly, as we saw, very possible. However, the language restriction may inadvertently make language a salient cue that directs recall and limits the number of memories reported during the language transition. Consistent with this assumption, Marian and Neisser (2000) found language-dependent recall in that Spanish-cued were earlier than English-cued memories, indicating that cue word language

was salient during recall. We observed an immigration bump when language was not restricted and therefore no filter was applied to the participants' recall. Also supporting a period of language transition, there were a greater number of code-switches when participants reported memories surrounding immigration than from all other time periods combined. The restricting of code-switches in the Marian and Neisser (2000) study may have inadvertently restricted the reporting of memories from this time period, acting as a filter directing the recall of memories from a life period in which the language was consistently used.

The present findings provide evidence that the immigration bump results from the operation of recall rather than encoding processes. Marian and Neisser (2000) speculated that the relative lack of memories they observed surrounding participants' immigration reflected limited encoding of the novel events surrounding the transition. The present documentation of more extensive recall during the period of immigration, of course, contradicts this interpretation. Moreover, our findings argue against preferential encoding as the mechanism responsible for a reminiscence bump for memories dating from early life. If that were the case, the traditionally-observed bump should have also been present for the immigrants in our sample, given that all the immigrants in this study immigrated after the peak of the traditional bump found for individuals who remained in their country of origin (age 10). It appears, however, that immigration was such a salient transition that it caused a reorganization of the previously-encoded memories of the life story, as argued by Brown et al. (2012), with immigration at the center of the bilingual participants' life history.

Supporting this explanation, participant age at immigration and length of time in the US did not predict the distribution of memories.

This interpretation is consistent with the role assigned to the cultural life-script in memory search. Berntsen & Rubin (2004) argue that the life-script provide a context within which to search for memories based on a general timeline of expected life events, resulting in the typical reminiscence bump in the opening decades of life among non-immigrants. Immigration is not part of the cultural life script, but creates a salient division between two contexts and thus marks the life as before and after, trumping the cultural life-script and dominating the organization of the individual life story. In this regard, immigration is one of several highly salient life events that can dominate the life story, such as the experience of military occupation (e.g., Conway & Haque, 1999).

Other theoretical perspectives on the reminiscence bump, emphasizing encoding rather than recall processes, may also be consistent with the increase in the number of memories dating from the period of immigration. Identity theory (Conway, 2005) would predict the bump be unchanged by immigration because the formation of identity resulting in preferential encoding is a life task performed in adolescence through early adulthood. It may be the case, however, that the transition between cultures and the resulting acculturation process might provoke a re-examination of the conceptualization of the self, resulting in preferential encoding of events surrounding this transition. Memories for these redefining events may then override the identity forming events of adolescence.

It could also be argued that the present findings regarding the immigration bump represent the priming of a period of life through language. Mace and Clevinger (2013) found

that priming a specific age period resulted in more memories reported from that period in a subsequent free recall. Our results, however, are not consistent with this possibility. If linguistic priming had occurred, a bimodal distribution would most likely have been observed, with Spanish-cued memories peaking earlier and English cued memories peaking later. This was not the case. Further, the results of the language-dependent recall analysis do not support that the immigration bump reflects priming through the language in which the cue was presented.

The main effect of internal language on AaE replicated Schrauf and Rubin's (1998, 2001) findings, and the additional discovery of an interaction with fluency may explain why other studies (Marian & Neisser, 2000; Matsumoto & Stanny, 2006) reported discrepant results. Language may only be connected to recall for those bilinguals whose second language fluency is not yet functionally activating a single conceptual store. Providing support for this possibility, Morrison and Conway (2010) found that adults recalling early memories associated with cue words showed a systematic lag between the age that the word was acquired and the age of the earliest memory associated with that word. They interpreted this lag as the amount of time it takes for conceptual knowledge to form. A similar interpretation may apply to the finding that second-language fluency moderates the relation between the language in which the cue word is presented and the AaE of the reported memories. This finding is also consistent with the Revised Hierarchical Model (Kroll, Bobb, Misra, & Guo, 2008), because it appears that as fluency increases, the conceptual store can be accessed equally by both languages, and hence language-dependent recall decreases.

This finding is somewhat at odds with that of Matsumoto and Stanny (2006). Although they speculated that fluency affected language-dependent recall, they proposed a positive correlation between fluency and reliance on language-dependent recall. The results of the present investigation, in conjunction with Matsumoto and Stanny (2006), support a curvilinear relationship between fluency and language-dependent recall. Those whose fluency requires internal translation to access memories would not likely show language-dependent recall because they are, in essence, receiving all of their cues in the first language. Individuals who are capable of accessing memories without translating will show language-dependent recall only until their fluency reaches the point of a single conceptual store. This pattern would explain why Matsumoto and Stanny (2006) found an increased dependency on language-dependent recall for participants who were more likely to think in English; their sample may have represented the lower to mid-point of the curve. The participants in the current investigation, although varying in fluency levels, were all functionally fluent professionals and may have represented the mid- to latter-end of the curve. The participants in the Schrauf and Rubin studies, all highly fluent after three decades in the US, likely represented the far end of the curve.

The fluency measure predicting the results of this study appears to be very specific. Years of fluency, daily second language exposure, and self-rated speaking ability did not interact with the language of the cue word and the age at which the reported event transpired. The measure chosen, the extent of English preference given the option of speaking Spanish, was thought to incorporate both fluency and frequency but also indicated a level of personal comfort with English. Although the ideal operationalization of bilingual status is beyond the

scope of this study, the results support that both fluency and frequency be included. This interpretation is supported by recent research showing bilingualism is made up of at least two factors, fluency and frequency (Luk & Bialystok, 2013). Future research may also reveal a factor relating to level of comfort with the language.

This investigation, like most research involving significant life transitions, involved a number of limitations. The follow-up analyses, however, eliminated two possible confounds, age at immigration and length of time in the US. The study was limited by a predominantly female sample, as might be expected when recruiting through United States elementary schools. In addition, the necessary range in English fluency reduced the sample size for some analyses because not all participants were comfortable completing the within-subject language manipulation. This reduction limited the number of variables that could be included at the participant level of the analyses, although the elimination of participant age does not appear to have affected the results. An older sample with immigrants who had only immigrated past the age of the traditional bump might have been advantageous in examining the bump, but the study was designed to have a wide age range to help understand discrepant results between previous studies with college age and older adults with earlier and later AoIs. The results replicated those with older adults (Schrauf & Rubin, 1998, 2001), despite a younger mean participant age by about 30 years. The previous language-dependent recall studies differed in participant age, AoI, and fluency, and this study was designed to identify the participant characteristics that might explain the circumstances in which language-dependent recall emerges. The final model accounted for a large amount, nearly $\frac{3}{4}$, of the between-participant variance.

The focus of this investigation was the effect of cross-language immigration on the distribution of memories and language-dependent recall. The results indicate that the reminiscence bump is a product of organization at recall rather than preferential encoding. This explanation, however, does not necessarily apply to the typically-observed reminiscence bump for events that occurred in the opening decades of life among non-immigrants. Future research is needed to further elucidate the multiple influences that determine the distribution of autobiographical memories and the broad significance of these memories in individuals' lives.

REFERENCES

- Berntsen, D., & Rubin, D. C. (2004). Cultural life scripts structure recall from autobiographical memory. *Memory & Cognition*, 32(3), 427-442.
Doi:10.3758/BF03195836
- Brown, N. R., Hansen, T. G. B., Lee, P. J., Vanderveen, S. A., & Conrad, F. G. (2012). Historically defined autobiographical periods: Their origins and implications. *Understanding autobiographical memories: Theories and approaches*, 160-180.
- Christoffels, I. K., de Groot, A., & Kroll, J. F. (2006). Memory and language skills in simultaneous interpreters: The role of expertise and language proficiency. *Journal of Memory and Language*, 54(3), 324-345. <http://dx.doi.org/10.1016/j.jml.2005.12.004>
- Conway, M. A. (2005). Memory and the self. *Journal of memory and language*, 53(4), 594-628. <http://dx.doi.org/10.1016/j.jml.2005.08.005>
- Conway, M. A., & Haque, S. (1999). Overshadowing the reminiscence bump: Memories of a struggle for independence. *Journal of Adult Development*, 6(1), 35-44. doi: 10.1023/A:1021672208155
- Conway, M. A., Wang, Q., Hanyu, K., & Haque, S. (2005). A Cross-Cultural Investigation of Autobiographical Memory On the Universality and Cultural Variation of the Reminiscence Bump. *Journal of Cross-Cultural Psychology*, 36(6), 739-749. doi: 10.1177/0022022105280512
- de Groot, A. D. (1992). Bilingual lexical representation: A closer look at conceptual representations. *Orthography, phonology, morphology, and meaning*, 94, 389.
- Grosjean, F. (2010). *Bilingual: Life and reality*. Harvard University Press.

- Janssen, S. M., Chessa, A. G., & Murre, J. M. (2007). Temporal distribution of favourite books, movies, and records: Differential encoding and re-sampling. *Memory*, *15*(7), 755-767. DOI: 10.1080/09658210701539646
- Janssen, S. M., & Murre, J. M. (2008). Reminiscence bump in autobiographical memory: Unexplained by novelty, emotionality, valence, or importance of personal events. *The Quarterly Journal of Experimental Psychology*, *61*(12), 1847-1860. DOI: 10.1080/17470210701774242
- Janssen, S. M., Rubin, D. C., & Conway, M. A. (2012). The reminiscence bump in the temporal distribution of the best football players of all time: Pelé, Crujff or Maradona?. *The Quarterly Journal of Experimental Psychology*, *65*(1), 165-178. DOI: 10.1080/17470218.2011.606372
- Janssen, S. M., Rubin, D. C., & Jacques, P. L. S. (2011). The temporal distribution of autobiographical memory: changes in reliving and vividness over the life span do not explain the reminiscence bump. *Memory & cognition*, *39*(1), 1-11. Doi: 10.3758/s13421-010-0003-x
- Koppel, J. (2013). The Reminiscence Bump for Public Events: A Review of Its Prevalence and Taxonomy of Alternative Age Distributions. *Applied Cognitive Psychology*, *27*(1), 12-32. DOI: 10.1002/acp.2865
- Kroll, J. F., Bobb, S. C., Misra, M., & Guo, T. (2008). Language selection in bilingual speech: Evidence for inhibitory processes. *Acta psychologica*, *128*(3), 416-430. doi:10.1016/j.actpsy.2008.02.001.

- Kroll, J. F., Van Hell, J. G., Tokowicz, N., & Green, D. W. (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition*, *13*(03), 373-381.
- Larsen, S. F., Schrauf, R. W., Fromholt, P., & Rubin, D. C. (2002). Inner speech and bilingual autobiographical memory: A Polish-Danish cross-cultural study. *Memory*, *10*(1), 45-54. DOI: 10.1080/09658210143000218
- Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, (ahead-of-print), 1-17. DOI: 10.1080/20445911.2013.795574
- Mace, J. H., & Clevinger, A. M. (2013). Priming voluntary autobiographical memories: Implications for the organisation of autobiographical memory and voluntary recall processes. *Memory*, *21*(4), 524-536. DOI: 10.1080/09658211.2012.744422
- Marian, V., Blumenfeld, H. K., & Kaushanskaya, M. (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language and Hearing Research*, *50*(4), 940.
- Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General*, *129*(3), 361. doi: 10.1037/0096-3445.129.3.361
- Matsumoto, A., & Stanny, C. (2006). Language-dependent access to autobiographical memory in Japanese-English bilinguals and US monolinguals. *Memory*, *14*(3), 378-390. DOI: 10.1080/09658210500365763

- Morrison, C. M., & Conway, M. A. (2010). First words and first memories. *Cognition*, *116*(1), 23-32.
- Nezlek, J. B. (2001). Multilevel random coefficient analyses of event-and interval-contingent data in social and personality psychology research. *Personality and social psychology bulletin*, *27*(7), 771-785. doi: 10.1177/0146167201277001
- Raudenbush, S. W., & Bryk, A. S. (2002). *Heirarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA: Sage Publishing.
- Rubin, D. C. (2000). The distribution of early childhood memories. *Memory*, *8*(4), 265-269. Doi: 10.1080/096582100406810
- Rubin, D. C., Berntsen, D., & Hutson, M. (2009). The normative and the personal life: Individual differences in life scripts and life story events among USA and Danish undergraduates. *Memory*, *17*(1), 54-68. DOI:10.1080/09658210802541442
- Rubin, D. C., & Schulkind, M. D. (1997). Distribution of important and word-cued autobiographical memories in 20-, 35-, and 70-year-old adults. *Psychology and aging*, *12*(3), 524. doi: 10.1037/0882-7974.12.3.524
- Rubin, D. C., Wetzler, S. E., & Nebes, R. D. (1986). Autobiographical memory across the adult lifespan. In D. C. Rubin (Ed.), *Autobiographical memory* (pp. 202-221). Cambridge: Cambridge University Press.
- Schrauf, R. W. (2000). Bilingual autobiographical memory: Experimental studies and clinical cases. *Culture & Psychology*, *6*(4), 387-417. doi: 10.1177/1354067X0064001
- Schrauf, R. W., & Rubin, D. C. (1998). Bilingual autobiographical memory in older adult immigrants: A test of cognitive explanations of the reminiscence bump and the

- linguistic encoding of memories. *Journal of Memory and Language*, 39(3), 437-457
<http://dx.doi.org/10.1006/jmla.1998.2585>
- Schrauf, R. W., & Rubin, D. C. (2000). Internal languages of retrieval: The bilingual encoding of memories for the personal past. *Memory & Cognition*, 28(4), 616-623.
Doi: 10.3758/BF03201251
- Schrauf, R. W., & Rubin, D. C. (2001). Effects of voluntary immigration on the distribution of autobiographical memory over the lifespan. *Applied Cognitive Psychology*, 15(7), S75-S88. DOI: 10.1002/acp.835
- Thomsen, D. K., & Berntsen, D. (2008). The cultural life script and life story chapters contribute to the reminiscence bump. *Memory*, 16(4), 420-435. DOI: 10.1080/09658210802010497
- Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological review*, 80(5), 352. doi: 10.1037/h0020071
- Wilson, M.D. (1988) The MRC Psycholinguistic Database: Machine Readable Dictionary, Version 2. *Behavioural Research Methods, Instruments and Computers*, 20(1), 6-11.

TABLES

Table 1

Language Experiences of the Bilingual Immigrants

LEAP-Q Measures	Mean (<i>SD</i>)	Range
Self-Rated English Fluency (0-10)	6.86 (1.85)	2-9
Years Fluent in English	10.31 (8.09)	0-25.33
% Time Choosing to Speak in English	30.87 (22.19)	0-65
% Time Daily Speaking English	41.74 (23.63)	0-90
Age of Immigration	26.02 (5.71)	14.75-38.17
Years in the US	8.85 (6.27)	1-29

Table 2
*Demographic Characteristics by Group for Participants Included in Analyses
of the Reminiscence Bump*

Demographic Variables	Monolingual Non-immigrants		Bilingual Immigrants	
	Value	Range	Value	Range
<i>N</i>	13		21	
Mean Age in Years (SD)	40.40 (12.53)	22-63	35.24 (7.08)	28-59
Mean Education in Years (SD)	17.31 (2.21)	12-21	17.05 (2.77)	13-23
Sex	10 female (78%)		20 female (95.2%)	
Race	9 Caucasian (69%)		18 Latina(o) (85.7%)	

Table 3

Demographic Characteristics; Language-Dependent Recall

Demographic Variable	Value	Range
<i>N</i>	17	
Mean Age in Years (SD)	35.4 (7.55)	28-59
Mean Education in Years (SD)	18 (2.98)	13-23
Sex	16 female	94.1
Race	13 Latina(o)	76.5

FIGURE CAPTIONS

Figure 1. Number of reported memories per age bin by immigration group.

Figure 2. Number of reported memories per age bin surrounding the age of immigration for the Cross-Language Immigrant group.

Figure 3. Percentage of reported memories surrounding immigration that represented a code-switch.

Figure 4. Interaction between language of cue word and language fluency.

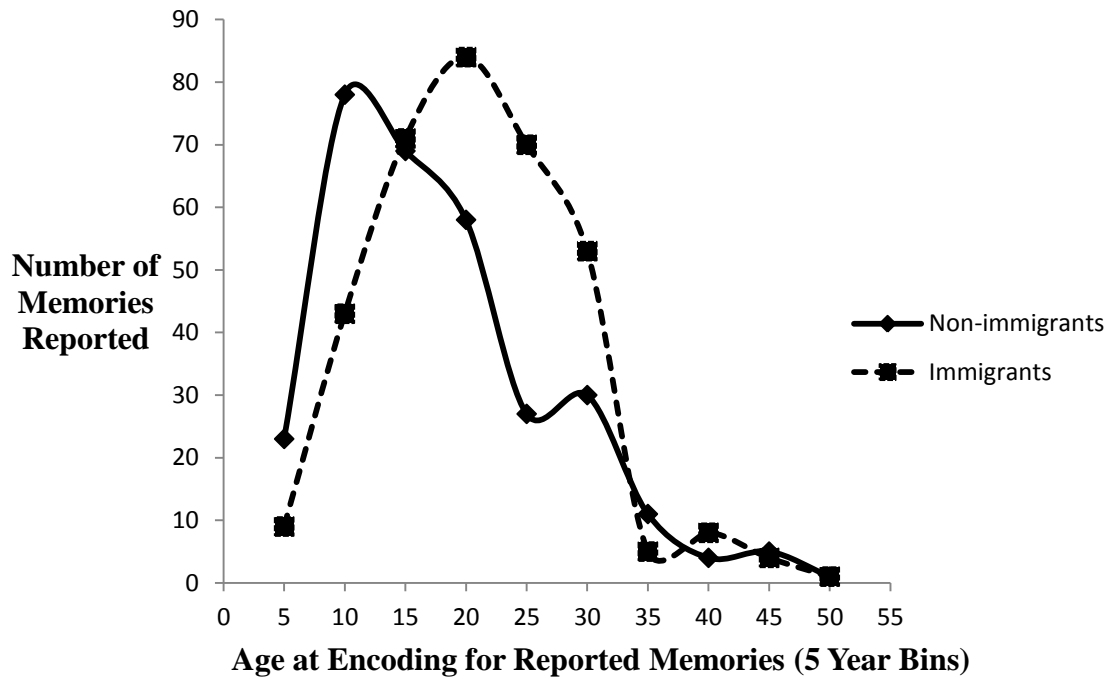


Figure 1. Number of reported memories per age bin by immigration group.

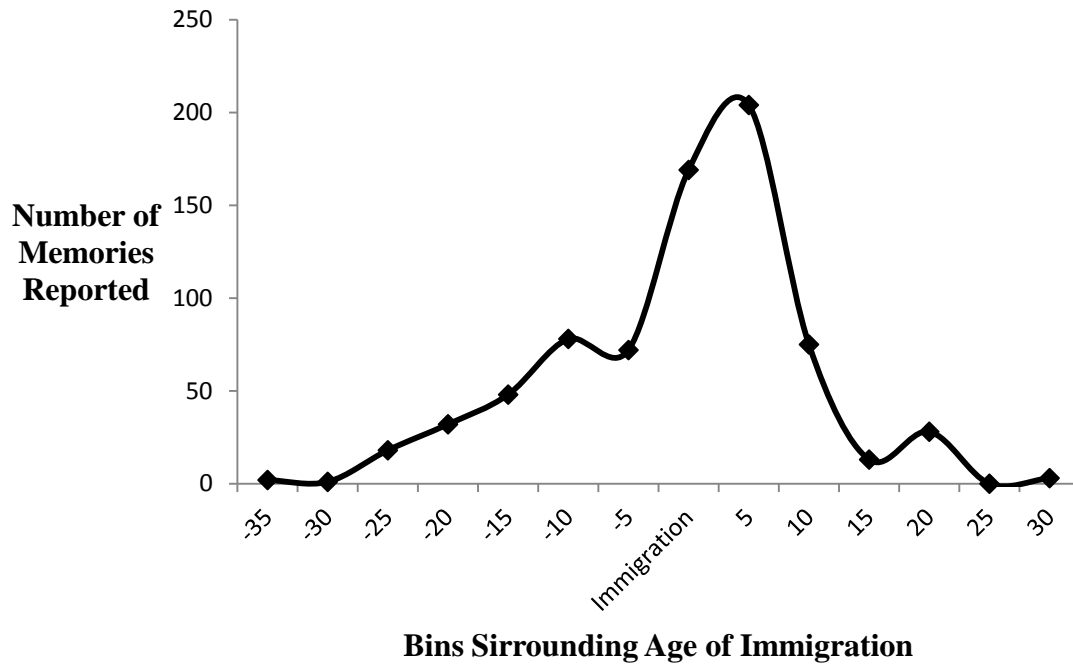


Figure 2. Number of reported memories per age bin surrounding the age of immigration for the Cross-Language Immigrant group.

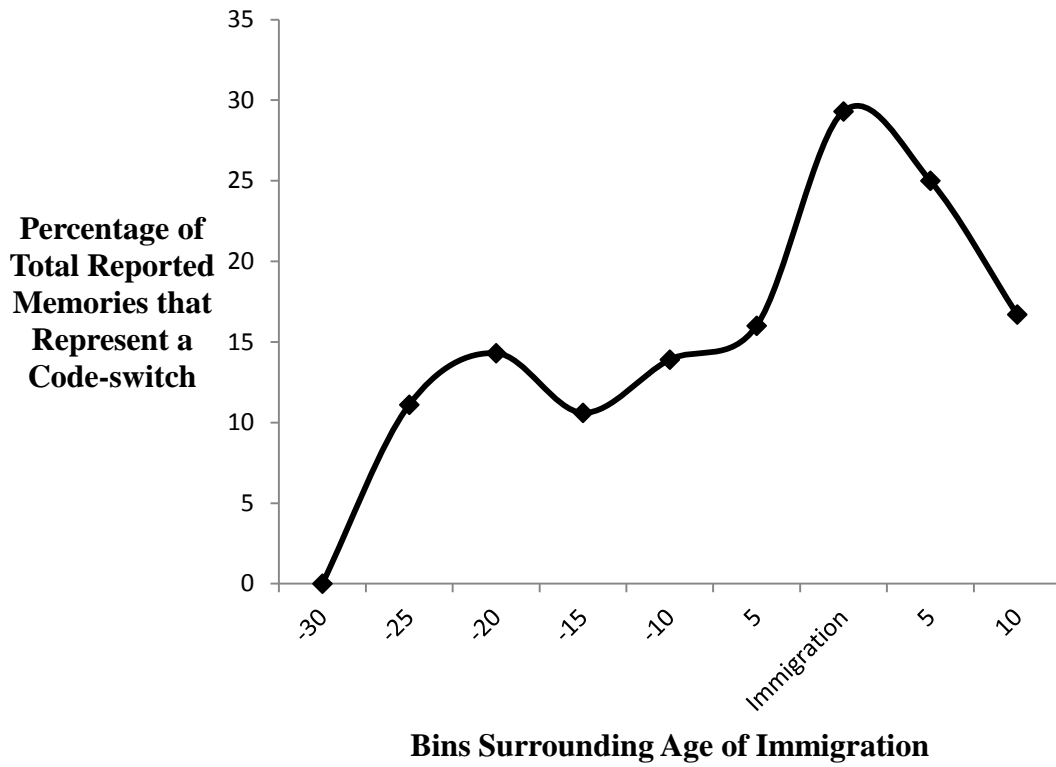
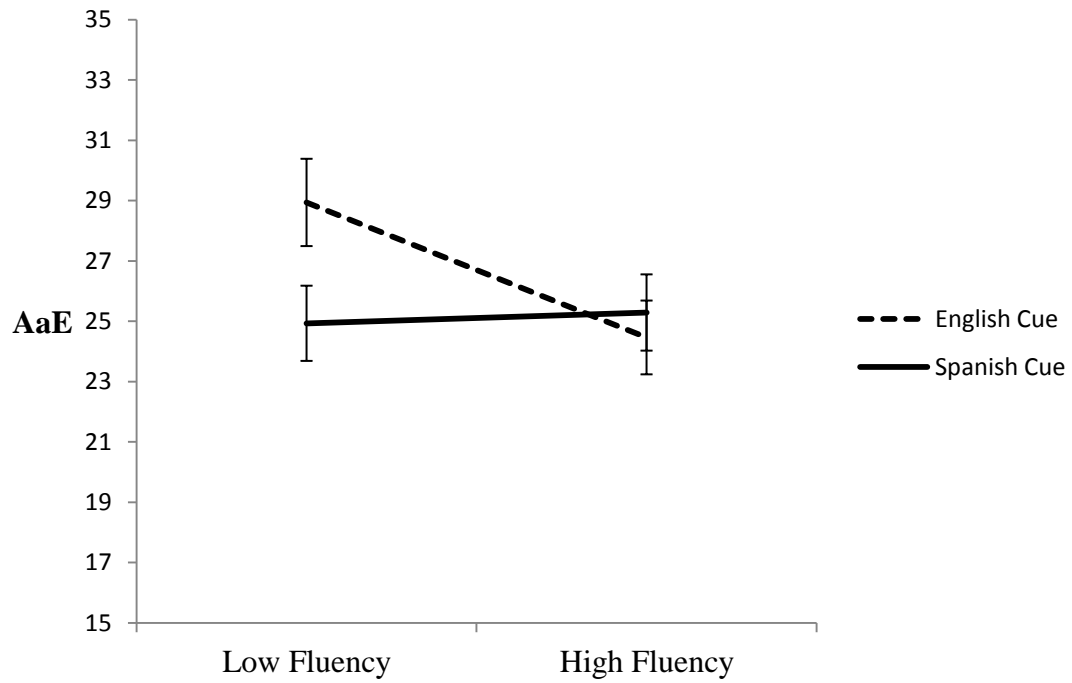


Figure 3. Percentage of reported memories surrounding immigration that represented a code-switch.



Note: High and Low Fluency values represent 1 *SD* above and below the mean respectively.

Figure 4. Interaction between language of cue word and language fluency.

CHAPTER 5: Integrated Discussion

Broadly, the results of the three manuscripts that comprise this dissertation point to the significant influence that second-language acquisition has across the lifespan. Further, they provide support for the assertion that the multilingual majority should not be ignored or excluded from psychological research. Esposito and Baker-Ward (2013) and Esposito, Baker-Ward, and Mueller (2013) both found an advantage in interference suppression in children exposed to a second-language, regardless of whether that exposure began in infancy or after many years of dual-language education. Esposito and Baker-Ward (under review) found that cross-language immigration altered the expected distribution of recollected events from across the lifespan and that access to memory through a language other than that of encoding is moderated by the individual's language fluency. These manuscripts all contribute to the body of literature examining the influence of second-language acquisition and fluency on cognitive development. The participants in each study were of different ages and had acquired, or been exposed to, their second-language through different means and at different periods of their life, and yet all showed an influence of second language acquisition on as aspect of cognitive function.

In the following integrated discussion, I will first examine the extent to which this body of work achieved the Specific Aims outlined in Chapter 1. Then, I will consider the broader implications of the work; namely, its contributions toward addressing the challenges of measurement in multilingual research and its potential for the provision of insights regarding the general understanding of development. The chapter will close with a

summation of the future directions implicated by this body of research and a delineation of the conclusions that can be drawn.

Addressing the Specific Aims

Specific Aim 1

Specific Aim 1, to determine how quantity of second-language exposure and second-language fluency affect aspects of cognitive functioning, was addressed in Esposito and Baker-Ward (2013) and Esposito and Baker-Ward (under review), Chapters 2 and 4. Although there are limitations, the manuscripts were able to offer insights that inform both current understanding and directions for future research.

Esposito and Baker-Ward (2013) addressed only a portion of this aim because of the lack of a measure of second-language fluency in the study. Anecdotally, teachers reported significant increases in Spanish fluency across the elementary years for native English speakers, but there was no systematic measure of Spanish fluency development in place in the school system and we were not able to measure Spanish fluency within the time limitation. The school system does measure the English fluency of non-native speakers. From their report, we are aware that native Spanish speakers were acquiring English fluency, but these measures were not available for inclusion in the model and there are individual and educational program differences in the rate of English acquisition. The lack of a fluency measure leaves no way of delimiting the influence of exposure verses fluency on interference suppression. This is a major limitation of the work that will require future research.

What can be gained from Esposito and Baker-Ward (2013) is that second-language experience conveys cognitive benefits even in relatively small doses in comparison to the

extent of experience examined in previous investigations. As described in the manuscript, the bilingual performance advantage in areas of controlled attention has been tested in children exposed to two languages since birth and enrolled in second-language immersion programs (see Bialystok 2009 for a review of controlled attention in bilingual children; see Bialystok & Barac, 2012, for research on the effects of immersion). Other investigations of the effects of intensive second-language immersion programs have found emerging benefits in metalinguistic awareness similar to those found in native bilingual speakers (Bialystok, Peets, & Moreno, 2012; Hermanto, Moreno, & Bialystok, 2012), further supporting the assumption that cognitive advantages associated with bilingualism may be available through immersion education. The present manuscript found an advantage in cognitive control for a group of children with markedly less second-language experience (between 2 and 3 school days, or 14-21 hours, a week rather than the 5 days, or 35 hours, typical in immersion programs). We were able to ascertain that the reduced amount of second-language experience influenced interference suppression. Although fluency was not measured in this study, Bialystok and Barac (2012) found that time in the immersion program was a better predictor of cognitive control than fluency. Future work will examine the contributions of quantity of exposure verses second-language fluency in dual-language programs to ascertain whether the same pattern of results is found when children have less exposure to the language.

Esposito and Baker-Ward (under revision) were able to address Specific Aim 1 more fully through the inclusion of multiple language measures that gave insight into the quantity of exposure to languages, degree of fluency in both first- and second-languages across the

lifespan, and the level of comfort in speaking each language. The results found an impact of all three of these variables, but only when considered together rather than separately. This study investigated both the immigration bump and language-dependent recall. The latter portion of the investigation pertained to Specific Aim 1. Interestingly, the predicting variable was a combination of fluency, exposure, and comfort with the language. Neither self-rated fluency nor daily exposure predicted the outcomes alone. The results urge caution when interpreting null findings related to these variables and further indicate the need to avoid examining these variables separately. The results also indicate the complexity inherent in quantifying bilingualism and the importance of the use of a range of measures that capture not only fluency and exposure, but the comfort level of the individual in using the language.

The composite findings reported in these manuscripts indicate that language fluency may be more important to advantages in language dependent measures, such as access to content through specific cue words, and that duration of second-language exposure may be a more powerful predictor of domain-general cognitive control advantages. This possibility is also supported by the work of Bialystok and Barac (2012), who found that fluency predicted metalinguistic awareness advantages but time in the program predicted executive control advantages.

Specific Aim 2

Specific Aim 2, to determine whether low-income minority children exposed to a second-language through dual-language education show benefits to executive function, was addressed in Esposito and Baker-Ward (2013) (included as Chapter 2). The extent to which this aim was addressed depends on the extent to which we accept two assumptions made in

the literature that both require further research. First, the study was cross-sectional and hence the group differences we reported do not represent *development*. Therefore, whether the children enrolled in dual-language education benefitted from second-language exposure or had a pre-existing advantage in controlled attention cannot be determined. As discussed in Esposito and Baker-Ward (2013), however, there are no indications that the performance differences found are the result of inherent group differences. This conclusion is further supported by the equivalent performance across education program groups on all measures not expected to be affected by second-language exposure. However, the results should be interpreted cautiously and longitudinal research is needed to confirm the effect of second-language acquisition on executive function.

Second, although community level socio-economic status (SES) showed pervasive poverty in the included sample, with nearly 90% of the enrolled students qualifying for free or reduced lunch, there was no measure of individual SES in the study (although see Bradley & Cornwyn, 2002, for a discussion of the effects of community-level poverty on health, academic, and socio-emotional outcomes that are similar to those of individual level poverty). The assumption, anecdotally supported by the school administration and teachers, is that both traditional and dual-language education groups included a large portion of children from low socio-economic status backgrounds.

To the extent that both of these assumptions are accepted, the results indicate that children from low socio-economic backgrounds can benefit cognitively from second-language exposure in a manner consistent with the effects of bilingualism on the more advantaged samples included in previous research (see Adesope et al., 2010 for a review). A

recent investigation supports these results. Engel de Abreu, Cruz-Santos, Tourinho, Martin, and Bialystok (2012) examined whether low SES Portuguese bilingual immigrant children living in Luxemburg would have advantages in cognitive control compared to same age and SES peers still in Portugal. They found cognitive advantages to bilingualism consistent with those reported in their work with high SES French Canadians. Esposito and Baker-Ward (2013) found the advantage for low SES minority children exposed to a second language later in life (at school entry rather than infancy) and in smaller quantities (school exposure rather than pervasive community exposure) compared to Engel de Abreu, Cruz-Santos, Tourinho, Martin, and Bialystok (2012). Together, the findings of these studies suggest that low SES children are capable of benefiting from second language exposure, just like their economically-advantaged peers. Given that both studies were cross-sectional and correlational, longitudinal research including SES is needed to corroborate the results found thus far, but the results support the possibility that dual-language education can serve as an intervention for children with socio-economic risk factors for academic failure.

Specific Aim 3

Specific Aim 3, to investigate the specific task conditions required to elucidate a difference in performance between monolingual and bilingual speakers, was addressed in all three included manuscripts to some extent. The full achievement of this aim will likely take the devotion of many careers, and each piece of the puzzle acquired will inevitably generate a multitude of additional questions. Nonetheless, the manuscripts make contributions to the literature by resolving previously discrepant findings and supporting the existence of the controversial bilingual advantage.

Esposito and Baker-Ward (2013), Chapter 2, made its contribution inadvertently. The goal of the investigation was to determine if dual-language education would impact the executive function of a sample of low-income and racially diverse children. We predicted that a bilingual advantage would emerge for two tasks measuring inhibitory control, a hypothesis based on the literature at the time that indicated the advantage lay in conflict tasks (e.g., Bialystok & Martin, 2004; Bialystok & Viswanathan, 2009; Carlson & Meltzoff, 2008). Although not the main aspiration of the study, the discrepant findings between tasks within one sample of children did contribute to the literature by supporting a bilingual advantage under *some* task conditions but not *all*. The results encourage further research to understand the circumstances under which the bilingual advantage emerges rather than dismissing its existence based on null findings.

The purpose of Esposito, Baker-Ward, and Mueller (2013), Chapter 3, was well aligned with Specific Aim 3. The objective was to test for a bilingual advantage in response inhibition and interference suppression. We expected task conditions, specifically having a bivalent display introducing conflict into the response and using a mixed block design, would differentiate when the bilingual advantage was found. The expected difference was found, adding support to the assumption that interference suppression more closely matches the experience of being bilingual than response inhibition and is therefore more likely to elicit an advantage. The Bivalent Shape Task (BST), in which a performance advantage was found, relied on stimuli with two values in comparison to the univalent display of the Day/Night task. I expect that this is a contributing factor to performance differences, as elaborated upon in the manuscript. There is a pattern in the literature of bivalent displays finding the

bilingual advantage and univalent displays not finding an advantage in bilingual performance, as discussed in Esposito, Baker-Ward, & Mueller (2013). Also, the BST was a mixed block of both congruent and incongruent targets compared to the continuous blocks in the Day/Night task. This presentation is also a likely contributing factor because it requires the rapid switching and management that characterize having two languages that are always active. The mixed block likely has a higher cognitive load, which may also contribute to the advantage as more difficult executive function tasks more readily distinguish between bilingual and monolingual speakers (e.g., Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009). I expect that the mixed block adds necessary difficulty to the task, but is not sufficient to differentiate between bilingual and monolingual performance without the addition of a bivalent display. Future research should examine how each of these factors, bivalent display and block presentation, contribute and interact to reveal a bilingual advantage.

Esposito and Baker-Ward (under revision) made a contribution to Specific Aim 3 in a different area of cognitive functioning, that of autobiographical recall. While the traditional distribution of memories across the lifespan for monolingual non-immigrants shows a larger representation of memories from the late adolescent period compared to other time periods, Marian and Neisser (2000) found a dip during this time period when it coincided with the time of participant immigration. This difference was thought to either be a result of poor memory encoding during the period surrounding immigration or an effect of restrictions on the language of report influencing the time period from which memories were reported. Esposito and Baker-Ward (under revision) were able to support that language restriction was

the reason for the discrepancy between a bump and a paucity between monolingual and bilingual participants, thus identifying task conditions under which there are monolingual and bilingual performance differences. The finding that language restriction affects bilingual report has broader implications for how research with multilingual speakers is conducted.

As a whole, the manuscripts offer many suggestions for factors that contribute to the bilingual advantage. Task characteristics, such as the suppression of distracting elements and cognitive load, as well as individual language experiences certainly make a contribution. In addition, how language is utilized in the administration of the tasks likely affects performance, especially in tasks of a linguistic nature such as requesting a narrative. It is unlikely that there will be a specific conglomeration that dictates the exact circumstances under which the bilingual advantage emerges because of the contribution of the individual to the model and the experience of bilingualism is unique to each individual.

Specific Aim 4

Specific Aim 4, determining how access to memory is affected by the languages of encoding and retrieval and if fluency moderates this relationship, was tackled in Esposito and Baker-Ward (under review). We found that memories are more often recalled in the language of encoding, but that access to those memories through another language is dependent on language fluency. The fluency measure we used included second-language knowledge, exposure, and comfort in using the language. The results supported the common conceptual store (as proposed by Kroll, Bobb, Misra, & Guo, 2008) for those who have well-developed second-language fluency as determined by our measure, giving them access to memories regardless of language of the cue word. Individuals who did not depict this

conglomeration of high second-language fluency showed a pattern of language-dependent recall.

This study investigated access to knowledge well-known by the participants, their own autobiographical memories. Future research needs to address whether the findings generalize to academic content as well. Given the growing implication of dual-language models of education, understanding how language experience affects access to content provided through different languages has great practical importance.

Broader Implications

Measurement

Issues of measurement arise in all areas of research and bilingual research is no exception. The challenges are not unique. Two such obstacles are categorizing a variable that does not naturally fall into categories and the reliability of self-report. Also, the language used and treatment of language can affect the results of the investigation and need to be carefully thought out. All of these issues are of great importance to the body of research included here as well as developmental literature as a whole.

The three manuscripts included in this dissertation had a different method of categorizing participants as bilingual, yet all three studies were able to find differences in cognitive functioning in the area of interest based on the categories utilized. To some extent, the categorization should follow the questions of the study. However, if there is no standardization or agreement on what these measures are or what these terms (e.g., fluency) mean, then it is nearly impossible to compare findings across studies and come to a unified developmental understanding. In addition, if we are to urge researchers outside this area of

interest to include or control for the effects of second-language experience, and I believe we should, we need to be able to direct them in *how* this would be done in a manner that represents a general consensus from the field. A recent investigation by Luk and Bialystok (2013) found bilingualism was best represented by a two-factor model that included both fluency and frequency of exposure. Although helpful, the results of the Esposito and Baker-Ward (under revision)(seeChapter 4) suggest that there may be at least a third factor that was not measured in Luk and Bialystok (2013), that of comfort with the language. Both investigations agree that variables describing bilingualism are not categorical and are best treated as continuous variables. Continuous measures allow for the identification of such findings as the interaction in Esposito and Baker-Ward (under revision) that would not have been found if language experience had been operationalized as a dichotomous variable (bilingual vs. monolingual).

Another common issue in psychology research that is particularly challenging in studies examining the influence of bilingualism is the reliability of self-report. Self-report is preferable because measures of language fluency may capture only academic language rather than the social language that is commonly acquired first (Cummins, 2009) and measures of frequency of use are cumbersome to obtain behaviorally. However, individuals with experience in two languages have varying ideas of what denotes bilingual status. Self-classification is often based on a comparison to a monolingual native speaker (Grosjean, 2010). In the data collection for Esposito and Baker-Ward (under revision), as well as in data collection with college students not included here, when asked “Do you consider yourself bilingual?,” we hear responses such as “I am not bilingual. I have an accent,” and “I do not

speak English as well as Spanish, so not bilingual yet.” On the other hand, some participants report being bilingual with a very small working vocabulary, such as the ability to count in alternate languages, which is unlikely to convey the cognitive benefits or re-organization of the life story that was the purpose of the research here contained. Clearly, bilingual status cannot be based upon the simple question of whether individuals consider themselves bilingual. Esposito and Baker-Ward (under revision) attempted to get around the self-judgment that is often included in a self-report by asking, among many other questions, how often the individual would choose to speak in each language when engaged with a speaker who knew both languages equally. We believe that this measure includes fluency, frequency, and comfort with the language without encouraging participants to compare themselves to native speakers of the language. The predicted interaction was found, supporting our theory and the further use of similar self-report measures.

Finally, an issue of measurement identified in Esposito and Baker-Ward (under revision) pertains to the use of language in interview settings. The language of the interviewer influenced the responses from participants who reported low fluency (as characterized by the measure discussed above). Also, the restriction of languages accepted from the participant may also impact what is reported. Marian and Neisser (2000) restricted participants to the language being spoken by the interviewer and found a paucity of memories surrounding the period of immigration. Our unrestricted interview had a significant effect in the opposite direction and the significant use of codeswitches coinciding with that period of time favors the explanation that the difference in results was due to differences in language restrictions. This has very real implications for how psychological

research is conducted. Often, interviews or other task administration is performed by monolingual research assistants. Although language restriction is not a planned strategy, bilingual and multilingual participants *are restricted in any study in which the interviewer is not a competent speaker of the same languages*, which may alter their performance. The results argue that we need to be aware of the inherent limitations we are imposing on subjects with access to multiple languages.

Research including and pertaining to bilingual and multilingual individuals is relatively new to psychology. As the field develops, a consensus needs to be reached regarding terms describing the bilingual experience. We also need to move toward a general understanding of how to measure the language histories of participants in a way that allows for comparisons across studies. Those conducting research outside this area should be aware of the effects their methods have on the response of bilingual participants. Further, they should be aware that bilingual experience can alter cognitive functioning in ways that could impact their research results.

Bilingual Research Informing our Understanding of General Development

In spite of the above challenges, research with bilingual participants is worth the effort because it not only contributes to our understanding of the development of the multilingual majority but also extends the context in which development has typically been studied, informing our understanding of development more broadly. The specific aims pertained to how the included manuscripts could inform our knowledge of emerging bilingualism as a developmental issue. However, the extension of the context in which development is being examined can extend, for example, our understanding of the

developmental relationship between cognitive structures and the role of experience in development.

The body of research here included as well as other developmental research including bilingual participants can aid the understanding of the developmental relationship between structures. For example, monolingual research with preschool age children has found a relationship between Theory of Mind, the ability to understand that another individual has thoughts, perspective, and knowledge that differs from one's own, and executive function. However, it has been very difficult to pare the two apart in ways that would establish whether the development is co-occurring, whether one skill depends on the other, or if the development is co-dependent. Moreover, this development has not been examined independently of verbal and non-verbal intelligence (Carlson, Moses, & Breton, 2002). The precocious development of some aspects of executive function in preschool age bilingual children found in Esposito, Baker-Ward, and Mueller (2013), findings supported by additional literature, provides a different developmental context to examine the development of these structures. The bilingual advantage does not extend to intelligence measures (see Adesope et al., 2010, for review), meaning that the influence of precocious executive control on Theory of Mind can be examined in bilingual children without a general intelligence confound, informing the developmental relationship between these two structures.

Bilingual research also allows for an examination of how practice and experience can influence the development of cognitive skills. For example, multilingual individuals have constant practice in managing two or more active language systems. They must choose and adjust their speech according to the context on a moment-to-moment basis and do so with

minimum mistakes (Grosjean, 2010). The subsequent benefits to executive function after a second language is learned, called the bilingual advantage, point to executive function as malleable across the lifespan. This finding adds support to a general consensus that practicing domain specific skills yields improvement in those skills only, while domain general activities may have a greater influence on numerous areas of performance.

The malleability of executive function is of great importance given the connections between EF and education. Both that executive function is considered malleable and domain general increase the interest in it as a possible area for school based intervention. EF is related to academic outcomes (e.g., Blair & Razza, 2007; McClelland, Morrison, & Holmes, 2000; Waber et al., 2006), long-term career and relationship success (Moffit et al., 2011), and physical and mental health (Adler *et al.*, 1994; Anderson & Armstead, 1995; Halleröd & Gustafsson, 2011; Yu & Williams, 1999). Currently, there are many interventions targeting this domain-general capacity with the hope that such purposeful experience will yield results similar to the benefits found in naturally occurring variations in EF abilities (see Diamond & Lee, 2011, for a review of current interventions). These interventions can be costly and cumbersome. Second-language exposure through a school program could be an economical and productive way of increasing the executive control capacities of youth in ways that would lead to greater success in academics, careers, and health status (Bialystok, 2009; Esposito & Baker-Ward, 2013).

Another area in which including bilingual participants can inform development more broadly is the reminiscence bump. The research including cross-language bilingual immigrants added to our understanding of the reminiscence bump. The results of Esposito

and Baker-Ward (under review) support the transition theory of the reminiscence bump (Brown et al., 2012) over a maturational or biological explanation (Janssen & Murre, 2008). Other non-scripted transition events would most likely yield the same results, but events such as war and political upheaval affect cohorts broadly and make it difficult to distinguish cohort from culture from transition effects. Bilingual immigrants, except in the case of refugees, represent an individual and non-scripted transition event and cultural shift that we can capitalize on to investigate the influence of culture and context in other areas of development as well, such as cognitive and perceptual aging.

Individuals with bilingual experience represent an extreme in state-dependent learning that can inform not only how emerging and established languages are represented cognitively, but also generalized learning mechanisms. The findings of Esposito and Baker-Ward (under review) suggest a period during emerging language fluency when access to memories encoded in an alternate language may be more difficult than access to memories encoded in the language of recall. This pattern has applications to education for minority language speakers and dual-language participants who are routinely encoding and retrieving information across language contexts. It also has implications for children in traditional education models who are expected to access information encoded through different learning experiences and in different contexts. The mechanisms that allow dual-language students with emerging second-language fluency to utilize information across language contexts (which encompasses different teachers, classrooms, and materials as well as the language differences) could also be applied to develop good teaching practices for traditional

education students who might struggle to integrate information gained from different contexts (such as textbooks and class demonstration).

In summary, research including bilingual and multilingual speakers is of great importance and offers insight into development broadly. All three of the manuscripts included in this body of work inform multilingual development and development at large regarding the interaction of developing structures and influence of experience. The research also has broader implications for educational policy and practice.

Future Directions and Conclusions

The body of research addressed several unresolved issues regarding bilingual cognitive functioning. The research points to quantity of exposure as predicting cognitive control advantages and language fluency as a predictor of linguistic performance, such as in access to content through a verbal cue. Children from a low socio-economic status background appear to be able to benefit in areas of cognitive control from second language exposure. Although several aspects of tasks, administration, and individual experiences appear to contribute to performance differences between bilingual and monolingual individuals, the circumstances under which this advantage can be found are becoming increasingly clear. Finally, language dependent recall, at least in the context of autobiographical memory, appears to depend on language fluency.

These breakthroughs spur further questions both within the multilingual community and developmental science more broadly. Within multilingual development, further research is needed regarding the loci of the bilingual advantage, such as an examination of how block presentation and bivalent/univalent display contribute to the bilingual advantage. In

addition, longitudinal work is needed to track the bidirectional relationship between emerging language fluency and both executive function and memory access. This work would ideally include language fluency measures that include vocabulary, quantity of exposure, and comfort with the language as well as measures of SES and general intelligence to compare groups. Most specifically pertaining to my own goals would be longitudinal research within dual-language education that also includes measures of access to content across language contexts.

More broadly applicable to developmental science is an investigation of the developmental relationship between cognitive structures. For example, examining the relationship between Theory of Mind and Executive Functions in preschool age children provides an opportunity to examine the effects of precocious executive function without a confound with general intelligence measures. Although my own interests have favored the earlier part of the lifespan, people become bilingual at all ages due to immigration or economic necessity. The effect becoming bilingual has on cognition creates a context in which the relationship between cognitive structures can be examined that is not traditional. Researchers can capitalize on this opportunity in older adults as well, such as examining how bilingualism might protect against dementia symptom onset in older adults.

Finally, and perhaps most urgent, is the need for a consensus regarding how language experience should be measured and quantified across studies and research domains. This is a necessity in order to share, compare, and create an integrated model of multilingual development. It is also pertinent to provide a clear and precise method of measuring and

interpreting language experience to researchers outside the multilingual research community, especially as research participants become increasingly more multilingual.

The current sociohistorical period (Bronfenbrenner, 1998) of greater interaction between cultures and language groups, likely increasing the percentage of individuals seeking fluency in multiple languages, indicates the rising relevance of second language exposure. This implies that even the traditionally utilized monolingual samples of convenience (college students and children of affluent families) are shifting toward a greater amount of second language experience. Regardless of the time or method of second language exposure, an effect was found for an area of cognitive functioning in all of the included manuscripts. The influence of second language exposure was found specifically on executive function and memory retrieval. Together with a wider body of corroborating research, the implications are that investigations in these domains, at minimum, should routinely include measures of language experience. I posit that second language experience should be included in research models even if it is not the specific focus, much as gender and age are routinely controlled.

REFERENCES

- Adesope, Olusola O., Lavin, T., Thompson, T., & Ungerleider, C. (2010). A systematic review and meta-analysis of the cognitive correlates of bilingualism. *Review of Educational Research*, 80 (2), 207-245. doi: 10.3102/0034654310368803
- Adler, N. E., Boyce, T., Chesney, M. A., Cohen, S., Folkman, S., Kahn, R. L., & Syme, S. L. (1994). Socioeconomic status and health: the challenge of the gradient. *American psychologist*, 49(1), 15.
- Anderson, N. B., & Armstead, C. A. (1995). Toward understanding the association of socioeconomic status and health: a new challenge for the biopsychosocial approach. *Psychosomatic Medicine*, 57(3), 213-225.
- Bialystok, E. (2009). Bilingualism: The good, the bad, and the indifferent. *Bilingualism: Language and Cognition*, 12(01), 3-11.
- Bialystok, E., & Barac, R. (2012). Emerging bilingualism: Dissociating advantages for metalinguistic awareness and executive control. *Cognition*, 122(1), 67-73.
- Bialystok, E., & Craik, F. I. (2010). Cognitive and linguistic processing in the bilingual mind. *Current Directions in Psychological Science*, 19(1), 19-23.
- Bialystok, E., Craik, F., & Luk, G. (2008). Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, memory, and cognition*, 34(4), 859-73. doi:10.1037/0278-7393.34.4.859
- Bialystok, E., Craik, F. I., & Ryan, J. (2006). Executive control in a modified antisaccade task: Effects of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 32(6), 1341.

- Bialystok, E., Craik, F. I., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology and aging, 19*(2), 290.
- Bialystok, E., & Feng, X. (2011). Language proficiency and its implications for monolingual and bilingual children. *Language and literacy development in bilingual settings*, 121-138.
- Bialystok, E., & Martin, M. M. (2004). Attention and inhibition in bilingual children: evidence from the dimensional change card sort task. *Developmental Science, 7*(3), 325–39.
- Bialystok, E., Peets, K., & Moreno, S. (2012). Producing bilinguals through immersion education: Development of metalinguistic awareness. *Applied Psycholinguistics, 1*(1), 1-15.
- Bialystok, E., & Viswanathan, M. (2009). Components of executive control with advantages for bilingual children in two cultures. *Cognition, 112*(3), 494-500.
- Blair, C., & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78*(2), 647-663. doi:10.1111/j.1467-8624.2007.01019.x
- Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual review of psychology, 53*(1), 371-399.
- Bronfenbrenner, U., & Morris, P. A. (1998). The ecology of developmental processes.
- Brown, N. R., Hansen, T. G. B., Lee, P. J., Vanderveen, S. A., & Conrad, F. G. (2012). Historically defined autobiographical periods: Their origins and implications. *Understanding autobiographical memories: Theories and approaches*, 160-180.

- 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*(2), 73-92.
- Carlson, S. M., & Meltzoff, A. N. (2008). Bilingual experience and executive functioning in young children. *Developmental science, 11*(2), 282-298.
- Costa, A., Hernández, M., Costa-Faidella, J., & Sebastián-Gallés, N. (2009). On the bilingual advantage in conflict processing: Now you see it, now you don't. *Cognition, 113*(2), 135-149.
- Crane, P. K., Gruhl, J. C., Erosheva, E. A., Gibbons, L. E., McCurry, S. M., Rhoads, K., ... & White, L. (2010). Use of spoken and written Japanese did not protect Japanese-American men from cognitive decline in late life. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 65*(6), 654-666.
- Cummins, J. (2009). Basic interpersonal communicative skills and cognitive academic language proficiency.
- de Abreu, P. M. E., Cruz-Santos, A., Tourinho, C. J., Martin, R., & Bialystok, E. (2012). Bilingualism Enriches the Poor Enhanced Cognitive Control in Low-Income Minority Children. *Psychological science, 23*(11), 1364-1371.
- de Groot, A. D. (1992). Bilingual lexical representation: A closer look at conceptual representations. *Orthography, phonology, morphology, and meaning, 94*, 389.
- Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function in children 4 to 12 years old. *Science, 333*(6045), 959-964.

- El-Sheikh, M., Bagley, E. J., Keiley, M., Elmore-Staton, L., Chen, E., & Buckhalt, J. A. (2012). Economic Adversity and Children's Sleep Problems: Multiple Indicators and Moderation of Effects.
- Esposito, A.G., and Baker-Ward, L. (2013). Dual-Language Education for Low-Income Children: Preliminary Evidence of Benefits for Executive Function. *Bilingual Research Journal*, 36 (3), 295-310. doi:10.1080/15235882.2013.837848.
- Esposito, A.G., Baker-Ward, L. (under review). *Things that go Bump in our Lives: Immigration, Language Fluency, and Access to Autobiographical Memories.*
- Esposito, A. G., Baker-Ward, L., and Mueller, S. T. (2013). Interference Suppression vs. Response Inhibition: Preschoolers Demonstrate a Bilingual Advantage with a New Stroop Task. *Cognitive Development* 28, 354-363. doi:10.1016/j.cogdev.2013.09.002.
- Flores, G., Bauchner, H., Feinstein, A. R., & Nguyen, U. S. (1999). The impact of ethnicity, family income, and parental education on children's health and use of health services. *American journal of public health*, 89(7), 1066-1071.
- García, Eugene E. Náñez, José E., Sr. , (2011). Bilingualism and cognition: Informing research, pedagogy, and policy. , (pp. 57-77). Washington, DC, US: American Psychological Association, vi, 242 pp. doi: [10.1037/12324-003](https://doi.org/10.1037/12324-003)
- Gollan, T. H., & Kroll, J. F. (2001). Bilingual lexical access. In B. Rapp (Ed.) , *The handbook of cognitive neuropsychology: What deficits reveal about the human mind*, 321-345. New York, NY US: Psychology Press.

- Gollan, T. H., & Silverberg, N. B. (2001). Tip-of-the-tongue states in Hebrew–English bilinguals. *Bilingualism: Language and Cognition*, 4(1), 63-83.
doi:10.1017/S136672890100013X
- Grosjean, F. (2010). *Bilingual: Life and reality*. Harvard University Press.
- Halleröd, B., & Gustafsson, J. E. (2011). A longitudinal analysis of the relationship between changes in socio-economic status and changes in health. *Social science & medicine*, 72(1), 116-123.
- Hermanto, N., Moreno, S., & Bialystok, E. (2012). Linguistic and metalinguistic outcomes of intense immersion education: how bilingual?. *International journal of bilingual education and bilingualism*, 15(2), 131-145.
- Hernández, M., Costa, A., Fuentes, L. J., Vivas, A. B., & Sebastián-Gallés, N. (2010). The impact of bilingualism on the executive control and orienting networks of attention. *Bilingualism: Language and Cognition*, 13(03), 315–325.
doi:10.1017/S1366728909990010
- Hilchey, M. D., & Klein, R. M. (2011). Are there bilingual advantages on nonlinguistic interference tasks? Implications for the plasticity of executive control processes. *Psychonomic Bulletin & Review*, 18(4), 625-658.
- Janssen, S. M., & Murre, J. M. (2008). Reminiscence bump in autobiographical memory: Unexplained by novelty, emotionality, valence, or importance of personal events. *The Quarterly Journal of Experimental Psychology*, 61(12), 1847-1860. DOI:
10.1080/17470210701774242

- Kovács, A. M., & Mehler, J. (2009). Cognitive gains in 7-month-old bilingual infants. *PNAS*, *106*, 6556-6560. doi: 10.1073/pnas.0811323106
- Kroll, J. F., Bobb, S. C., Misra, M., & Guo, T. (2008). Language selection in bilingual speech: Evidence for inhibitory processes. *Acta Psychologica (Amst.)*, *128*(3), 416-430. doi: 10.1016/j.actpsy.2008.02.001
- Kroll, J. F., Van Hell, J. G., Tokowicz, N., & Green, D. W. (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition*, *13*(03), 373-381.
- Luk, G., & Bialystok, E. (2013). Bilingualism is not a categorical variable: Interaction between language proficiency and usage. *Journal of Cognitive Psychology*, (ahead-of-print), 1-17. DOI: 10.1080/20445911.2013.795574
- Marian, V., & Fausey, C. M. (2006). Language-dependent memory in bilingual learning. *Applied Cognitive Psychology*, *20*(8), 1025-1047.
- Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General*, *129*(3), 361. doi: 10.1037/0096-3445.129.3.361
- 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*(01), 81-93. doi:10.1017/S136672890700322
- McClelland, M. M., Morrison, F. J., & Holmes, D. L. (2000). Children at risk for early academic problems: The role of learning-related social skills. *Early Childhood Research Quarterly*, *15*(3), 307-329. doi:10.1016/S0885-2006(00)00069-7

- 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.
- Moffitt, T. E., Arseneault, L., Belsky, D., Dickson, N., Hancox, R. J., Harrington, H., ... & Caspi, A. (2011). A gradient of childhood self-control predicts health, wealth, and public safety. *Proceedings of the National Academy of Sciences, 108*(7), 2693-2698.
- Morton, J. B., & Harper, S. N. (2007). What did Simon say? Revisiting the bilingual advantage. *Developmental Science, 10*(6), 719-726.
- Paap, K. R., & Greenberg, Z. I. (2013). There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive psychology, 66*(2), 232-258.
- Peal, E., & Lambert, W. E. (1962). The relation of bilingualism to intelligence. *Psychological Monographs: general and applied, 76*(27), 1-23.
- Rubin, D. C. (2000). The distribution of early childhood memories. *Memory, 8*(4), 265-269.
Doi: 10.1080/096582100406810
- Schrauf, R. W., & Rubin, D. C. (1998). Bilingual autobiographical memory in older adult immigrants: A test of cognitive explanations of the reminiscence bump and the linguistic encoding of memories. *Journal of Memory and Language, 39*(3), 437-457
<http://dx.doi.org/10.1006/jmla.1998.2585>
- Schrauf, R. W., & Rubin, D. C. (2000). Internal languages of retrieval: The bilingual encoding of memories for the personal past. *Memory & Cognition, 28*(4), 616-623.
Doi: 10.3758/BF03201251

- Siegal, M., Iozzi, L., & Surian, L. (2009). Bilingualism and conversational understanding in young children. *Cognition, 110*(1), 115–22. doi:10.1016/j.cognition.2008.11.002
- Waber, D. P., Gerber, E. B., Turcios, V. Y., Wagner, E. R., & Forbes, P. W. (2006). Executive functions and performance on high-stakes testing in children from urban schools. *Developmental Neuropsychology, 29*(3), 459-477. doi:10.1207/s15326942dn2903_5
- Yu, Y., & Williams, D. R. (1999). Socioeconomic status and mental health. In *Handbook of the sociology of mental health* (pp. 151-166). Springer US.