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The Cognitive Advantages of BIlingualism: A Focus on Visual-Spatial Memory and Executive Functioning

Author
Grote, Kandice Soraya

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THE COGNITIVE ADVANTAGES OF BILINGUALISM: A FOCUS ON VISUAL-SPATIAL MEMORY AND EXECUTIVE FUNCTIONING

A Dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

PSYCHOLOGICAL SCIENCES

by

Kandice Soraya Grote

Committee in Charge:

Professor Jeffrey Gilger, Chair
Professor Rose Scott
Professor Jack Vevea

2014

The Dissertation of Kandice Soraya Grote is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

Professor Jack Vevea

Professor Rose Scott

Professor Jeffrey Gilger, Chair

University of California, Merced

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Curriculum Vitae

Kandice Soraya Grote
Born: Omaha, NE

University of California, Davis

2005	Bachelor of Arts	Psychology
		Minors: Social and Ethnic Relations Education
2004-2006	Research Assistant	Department of Psychology
2004-2006	Research Assistant	Department of Human Development

University of California, Merced

2006-2012	Teaching Assistant	Psychological Sciences
2007-2008	Graduate Researcher	Psychological Sciences
2012-2013	Teaching Assistant	Social Sciences, Humanities, & Arts
2014	Doctor of Philosophy	Psychological Sciences

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Abstract

The current dissertation examines the cognitive benefits of bilingualism and the possible mechanisms related to advanced cognition by which such benefits operate. Although older balanced bilinguals (proficient in two languages) display several cognitive advantages (Bialystok, 2001; Hakuta, 1987) when compared to monolinguals, less is known about when such benefits begin during early development. In an effort to examine potential advantages of early bilinguals, this dissertation utilizes a series of visual-spatial memory and executive functioning tasks. In addition, this dissertation investigates the influence of several methological factors on cognitive performance including socioeconomic status (SES), age, and language group. A robust finding from these experiments suggests having equal proficiency levels in two languages leads to success on tasks of visual-spatial memory, executive functioning inhibitory control, and executive functioning attentional control. This dissertation addresses these factors through the utilization of a low-SES population, a single early age group (four-year-olds), and two monolingual groups for comparison (English and Spanish).

Introduction

Over the past few decades, the study of bilingualism has been one of great focus, particularly related to cognitive and language development, as well as when and how children should be introduced to a second language (Bialystok, 1988, 1991; Bialystok, Criak, & Luk, 2008; Bialystok, Craik, & Ryan, 2006; Carlson & Meltzoff, 2008; Cummins, 1978; Diaz, 1985; Galambos & Hakuta, 1988; Hakuta & Díaz, 1985; Haritos, 2004). While early research regarding these topics was decidedly negative, suggesting serious disadvantages to being bilingual (Darcy 1953; Eichorn-Jones, 1952; Haugen, 1956), recent studies have challenged these conclusions, pointing instead to possible benefits of bilingualism. Although these studies have revealed a great deal about the cognitive gain of bilingualism, three main questions remain.

The first of these questions pertains to the expression of the bilingual advantage and how early we begin to see these benefits. There has been little focus on cognitive benefits of bilingualism among young populations; making it difficult for research to identify when advantages first emerge. Identifying early cognitive advantages may give further insight into how multiple languages impact cognitive development. The second question addresses the degree of the bilingual advantage. Despite a diverse research background, there are several areas of cognition that have yet to be investigated, making it difficult to know the extent of these cognitive advantages. Finally, although researchers present work to suggest several distinct causal mechanisms for why these cognitive advantages exist, few studies have compared current proposed casual mechanisms to one another (e.g., isolating and independently testing and comparing mechanisms), or with other areas of cognition (e.g. to identify possible relationships with cognitive advantages and existing proposed causal mechanisms). Methodogical inconsistencies further complicate these questions.

In this dissertation, I address perceptions related to bilingualism and development. I also discuss how these findings give way to interests in possible theories of executive functioning mechanisms that attempt to explain the source of the bilingual cognitive advantage, and present inconsistencies with these current theories. Throughout this dissertation, I address the outstanding methological concerns surrounding bilingualism research. I begin by reviewing existing literature on the possible advantages and disadvantages of bilinguals, as well as the outstanding questions in this research. I will present my dissertation work, which examines visual-spatial memory in bilingualism and explores the possible relationship between visual-spatial memory and existing executive functioning mechanisms.

Bilingualism and Cognition

Initial research on the effects of bilingualism was unequivocally negative. Studies showed that bilingualism resulted in reduced vocabulary (Darcy 1953; Haugen, 1956), cognitive and developmental delay (Eichorn-Jones, 1952; Haugen, 1956). It was also believed that bilingualism caused a detrimental cognitive load for children (Haugen, 1956). These negative findings had profound impacts on both education and parenting. Second language training was avoided until high school, and parents were discouraged from exposing their child to a second language.

Earlier studies often reported bilingual vocabulary scores in English and ignored the other language, leading to underestimates of vocabulary knowledge. Differences between bilinguals and monolinguals do show some developmental vocabulary lags in each language for bilinguals. The lag lasts between 3-6 months when compared to monolinguals (Hakuta, 1987; Hamer & Blanch, 1989). This developmental expressive language delay is related to lower receptive vocabulary scores in English during language assessments. Since bilinguals are learning two sets of vocabulary, they are not able to dedicate all their focus to one language over another and therefore only gain receptive vocabulary slightly below monolinguals, displaying weaker vocabulary skills than those for monolingual speakers of each language (Bialystok, Luk, Peets, & Yang, 2010; Bialystok, Luk, 2011; Bialystok, Luk, Peets, & Yang, 2009; Oller, Pearson, & Cobo- Lewis, 2007).

These vocabulary lags also carry over in some speech production tasks, specifically in tasks where an individual must name pictures (Gollan, Montoya, Fennema-Notestine, & Morris, 2005; Gollan, Slattery, Goldenberg, Van Assche, Duyck, & Rayner, 2011). Bilinguals tend be slower and less accurate than monolinguals in simple picture naming tasks, often occurring with the bilinguals' second language. However, there is additional literature to show that the reported negative effects of bilingualism do not all have long-lasting effects, only displaying short-term negative effects, and that second-language learners do eventually catch up to monolinguals (Hakuta, 1987; Hamers & Blanc, 1989). Nevertheless, given the presence of any disadvantages, parents and educators have typically chosen to avoid exposing the child to a second language.

Advantages of Bilingualism

A seminal study by Peal and Lambert (1962) reviewed these earlier studies on the negative effects of bilingualism and identified additional methological limitations including differences between socioeconomic status (SES) among subjects (e.g. bilingualism were from low-SES backgrounds, monolinguals were high-SES backgrounds) and varied levels of proficiency among the bilingual groups in both their first and second language (e.g. 'balanced' bilinguals who were equally proficient in both languages grouped with 'unbalanced' bilinguals who were less proficient in one of their two languages). Once these factors were controlled for, no detriment to learning, or exposure to a second language, was found (Hakuta, 1987; Hamers & Blanc, 1989; Peal and Lambert, 1962). Although there are slight vocabulary delays, researchers have controlled for these possible confounds and several cognitive advantages have been identified; these benefits are summarized below.

Divergent Thinking. Divergent thinking is often measured by providing a person with a starting point for thought and asking them to generate a whole series of permissible solutions (For example, "Think of a paper clip and tell me all the things you could do with it."). In these tasks of divergent thinking, some adaptability on the part of the individual is required. The individual must switch from one solution to another until they reach the correct response for a particular situation. Cummins and Gulutsan (1974) examined divergent thinking among bilingual and monolingual children (Ages 10-13). In this study, children were presented with isolated words of objects (e.g. “rake”) and asked to give as many uses for the object named as possible. The results of their study showed that a French bilingual group performed as well or better than an English only group. In a similar study by Landry (1974), first, fourth, and sixth graders were tested and a significant advantage for balanced bilinguals was found. Overall, it has been well documented that bilingual adolescents and adults have more advanced divergent thinking skills than monolinguals.

Problem Solving, Analogical Reasoning, Classification Skills. Another set of cognitive abilities that have exhibited a bilingual advantage includes problem solving, analogical reasoning, and classification skills (Bialystok, 1988, 1991; Díaz, 1985; Galambos & Hakuta, 1988; Hakuta, 1987; Hakuta & Díaz, 1985; Kessler & Quinn, 1980; Secada 1991; Winsler et al., 1999). Problem solving in the current research refers to both verbal and non-verbal tasks. An example of verbal tasks may include providing definitions of words or resolve mentally a set of arithmetic problems. Non-verbal tasks may involve reproducing patterns of colored blocks or repeating orally a series of numbers (Lauchian, Parisi, & Fadda, 2012).

One of the earliest studies that identified a bilingual benefit on problem-solving tasks was conducted by Peal and Lambert (1962). Researchers found bilinguals did significantly better on both verbal and non-verbal measures, especially on tasks that required mental or symbolic flexibility and concept formation (Peal and

Lambert, 1962). In an analogical reasoning study by Diaz (1985), the performance of Spanish–English bilingual children's performance on a task requiring them to demonstrate their ability to reason by completing analogy structured sentences. In this longitudinal study, Diaz investigated bilingual children (5-7 years of age) by presenting children with incomplete sentences for children to complete (e.g. "Snow is ice, rain is ____"; "The princess is beautiful, the monster is _____".) Diaz found that balanced bilinguals possessed strong analogical reasoning abilities than monolinguals.

Kessler and Quinn (1980) examined bilingual children (ages 10-12), were examined on tasks that required creativity and scientific problem-solving skills. In this study, subjects participated in science inquiry film sessions and discussion sections. In each film session, subjects watched a short film of a single physical science problem and were asked to produce as many hypotheses as possible to explain what they had seen in the film. Afterwards, subjects were asked to generate as many hypotheses as possible and provide solutions to 12 science problems in a controlled period of time. Hypotheses were measured through a Hypothesis Quality Scale Likert Scale, in terms of quality and syntactic complexity. Results showed that bilinguals outperformed monolinguals and produced significantly more hypotheses and hypotheses that used more complex language and metaphors (e.g. in this study metaphors were utilized as indicators of semantic creativity of language use).

Metalinguistic Awareness. Metalinguistic awareness (MA) is the ability to analyze language, particularly language forms, in terms of how they work and integrate into the wider language system. MA is, in effect, knowledge about language. This ability is demonstrated at various levels: Phonological awareness (the understanding of sound units), word awareness, and syntactic (grammatical) awareness (Bialystok, 1987; Bialystok, Craik, Grandy, Chau, Ishii, Gunji, Pantev, 2005; Bialystok and Majumder, 1998; Ricciardelli, 1992).

Bialystok's (1986, 1988) early studies showed that bilingual advantage for metalinguistic tasks extended to tasks detecting grammatical violations and atypical sentences that were grammatically correct. For example, in a grammaticality judgment task, all the children were equally successful in detecting grammatical violations (e.g., "Apples growed on trees"), but bilingual children were more successful than monolinguals in accepting that anomalous sentences ("Apples grow on noses") were grammatically correct (Bialystok, 1986; Cromdal, 1999). For example, in a grammaticality judgment task, all the children were equally successful in detecting grammatical violations (e.g., "Apples growed on trees"), but bilingual children were more successful than monolinguals in accepting that anomalous sentences ("Apples grow on noses") were grammatically correct (Bialystok, 1986; Cromdal, 1999). This judgment requires effortful attention to ignore or inhibit the incorrect meaning in order to make a grammaticality judgment that the sentence is incorrect.

In a study by Ricciardelli (1992), first-grade English monolinguals and Italian-English bilinguals were compared on a battery of cognitive and metalinguistic tasks. In this particular study there were five metalinguistic tasks assessing word awareness, syntactic awareness, and concepts of print. Ricciardelli (1992) found results displaying a bilingual advantage on the syntactic awareness task and one of word awareness tasks among Italian-English bilinguals. The metalinguistic awareness benefits discussed above speak to the possible differences in what cognitive processes may be involved in how bilinguals not only comprehend language.

Neurological Benefits. Several studies have begun to examine the neurological structure differences between bilinguals and monolinguals and have identified both short-term and possible long-term neurological benefits of bilingualism. Studies suggest that the bilingual advantage also extends to neurological processing and structure, including the brain's language networks (Craik, Bialystok, & Morris Freedman, 2010). Data suggests that lifelong bilingualism protects against age-related cognitive decline, and may even postpone the onset of symptoms of dementia (Stern, 2002) and Alzheimer's (Stern Y., Gurland, B., Tatemichi, TK., Tang, MX, Wilder, D., Mayeux, R., 1994). Recent research suggests bilingualism may be one of the factors that contribute to cognitive reserve or brain reserve (Stern, 2002). Cognitive reserve is the idea that engagement in stimulating physical or mental activity can act to maintain cognitive functioning in healthy aging and postpone the onset of symptoms in those suffering from dementia. This flexibility is possibly due to enhanced neural plasticity, compensatory use of alternative brain regions, or enriched brain vasculature.

This cognitive reserve was examined by Bialystok, Craik, & Freedman (2007) through an assessment of hospital records of monolingual and bilingual patients who had been diagnosed with various types of dementia. In spite of being equivalent on a variety of cognitive and other factors, the bilinguals experienced onset symptoms and were diagnosed approximately 3– 4 years later than the monolinguals. More specifically, monolingual patients were diagnosed on average at age 75.4 years, and bilinguals at age 78.6. A replication from a new set of patients all diagnosed with probable Alzheimer's disease (AD) confirmed the results (Craik, Bialystok, & Morris Freedman, 2010).

Spatial Tasks and Memory. The cognitive advantage and increased awareness has been found across several domains of memory tasks (Bialystok, 1991; Díaz, 1985; Galambos & Hakuta, 1988; Hakuta, 1987; Hakuta & Díaz, 1985), and spatial tasks (Bialystok and Majumder, 1998; McLeay, 2003). In a study of spatial reasoning, McLeay (2003) tested bilinguals (grouped 7-8 years of age) using a mental rotation task where subjects were required to mentally rotate different pairs of knotted rope and decide if one of two pairs of knotted ropes (one rope slightly rotated in a different orientation as the other non-rotated rope) are the same or different from each other. Bilinguals were able to correctly identify pairs of rope with better speed and accuracy than monolinguals, especially when knotted ropes pairs became more complex.

In a study by Ransdell and Fischler (1991), bilingual and monolingual college students were compared on three dimensions of self-reported aspects of imagery: control, vividness, and preference as well as a performance measure of spatial manipulation skill (space relation test). During this task, subjects were asked to imagine how a 2-dimensional figure could be unfolded into 3-dimentional shapes. Results from this study showed that bilinguals relied more on imagery than monolinguals when coding information and success on spatial manipulation tasks. These findings propose a possible link between imagery and bilingualism that suggests that bilinguals encode information differently from monolinguals. Success on spatial tasks could be related to how bilinguals rely more heavily on visual or spatial strategies, preferring such non-verbal representations, which are considered less ambiguous than verbal strategies (Ransdell & Fischler, 1991).

While it could be argued that the advantages of bilingualism in problem-solving and spatial ability are fairly well established, very few studies have examined the relationship between bilingualism and memory (Kormi-Nouri, Moniri, & Nilsson, 2003). These studies have mostly involved adults and show that older bilinguals are more successful on digit span tasks (as a measure of working memory) (Bialystok & Martin, 2004; Bialystok & Feng, 2006). In a study by Bialystok, Craik, and Luk (2008) young and older bilinguals (ages 20-68 years of age), completed a battery of tasks measuring working memory, verbal fluency, and executive control. Results of this study indicate both general relationships between the two grouping variables, age and bilingualism, on the three domains of tasks and displayed a bilingual advantage on working memory and executive functioning tasks.

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The research reviewed above makes a persuasive case for a bilingual advantage. However, several open questions remain. First, do these advantages appear across a range of backgrounds such as different levels of SES? Second, do advantages exist in other untested areas such as visual-spatial memory? Third, what is the mechanism that gives rise to these advantages? Fourth, how early do these mechanisms emerge? In the subsequent sections I will discuss these questions in more detail, as they are the focus of the present research.

Executive Functioning- The Bilingual Advantage Mechanism

Where do these bilingual advantages come from? A common assumption among researchers is that bilingualism affects some component of executive function, which in turn leads to wide-ranging benefits. Several different mechanisms involving different components of executive function control have been proposed. These mechanisms can be summarized into three categories: (1) Executive Function-Inhibitory Control, (2) Executive Function-Attentional Control[1], and (3) The inter-relationship of Executive Functions-Inhibitory Control and Attentional Control.

[1] The current literature differs on whether to call this type of executive functioning attentional or selective control. For clarity, I have chosen to use attentional control throughout.

Executive Function-Inhibitory Control. One possible mechanism is inhibitory control. This type of executive functioning involves intentional procedures for focusing attention when there is conflicting information, selecting relevant from irrelevant features, and establishing representations to classify the stimuli (Green, 1998). Research suggests inhibitory control may be involved in the management of multiple linguistic systems, suggesting that bilinguals utilize the same mechanism when using their languages. More specifically, bilinguals attend to the relevant language and inhibit the non-relevant language when speaking (Bialystok, 2001; Green, 1998). It is this active type of inhibitory control of the non-relevant language that also controls the same basic mechanisms that are used to solve tasks with misleading information.

An inhibitory control benefit among bilinguals, when compared to monolinguals, has been well documented (Bialystok, 2001; Bialystok et al. 2004; Bialystok, Crack, & Ryan, 2006; Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008; Hamers & Blanc, 1989; Bialystok, Crack, Luk, 2008; Bialystok & DePape, 2009). These studies require the individual to complete a task in the presence of a distraction. In order to successfully complete the task, the individual must exhibit inhibitory control to suppress the distraction, in order to solve the problem.

Several studies with children show bilinguals outperform monolinguals on conflict tasks that require interference suppression ‘‘inhibitory control” (Bialystok & Senman, 2004; Bialystok & Shapero, 2005). In two studies, bilingual children (ages

7-13) produced faster reaction times in the Simon task. In this specific task, stimuli containing both position and response information are presented with a rule that requires participants to ignore the position and respond only to a relevant target feature (for example, if red, press the left key; if green, press the right key). When the stimulus appears on the same display side as the correct response key, both position and response information converge on the correct response these trials are referred to as congruent. When the position conflicts with the correct response, more effort is required to resist the tendency to respond to the position cue. These trials are called incongruent, and the reliable increment in response time compared with the congruent trials (usually between 20 and 30 ms) is the Simon effect (Bialystok, Craik, &Ryan, 2006; Lu & Proctor, 1995).

Bilingual advantages in the Simon task have been reported for children (Bialystok & Martin, 2003), young adults (Bialystok, 2006), and middle-aged and older adults (Bialystok, Craik, Klein, & Viswanathan, 2004). Surprisingly, the advantage has been found for both congruent and incongruent trials, and not only for the incongruent trials, in which the need for inhibitory control is more apparent. An extension of this finding has been found among older participants between 30 and 80 years old, in which bilinguals performed faster than monolinguals for both congruent and incongruent trials, and the speed advantage increased with age (Bialystok, Craik, Klein, & Viswanathan, 2004).

Executive Function-Attentional Control. Executive functioning-attentional control is another type of model that attempts to explain the bilingual advantage.

Originally presented by Kroll and de Groot (1997), this model suggests that the two languages of a bilingual are accessed by a common conceptual store, thus creating both one-to-many and many-to-one mappings of words and concepts. It is through this arrangement that bilinguals are able to select their attention to select the appropriate option. Notice this is different from executive functioning-inhibitory control in that the flexibility lies in the ability to attend to what is needed to solve a task and to ignore rather than inhibit irrelevant information.

One explanation for this enhancement is that the regular use of two languages requires a mechanism to control attention and select the target language—an experience that may enhance a general control mechanism (Emmorey, Luk, Pyers, Bialystok, 2008). Similarly, Bialystok (1987) states that the skill components that refer to separable aspects of language processing that are involved in all aspects of language use may depend on each skill component to various extents. For example, during attention-impeded conditions, the individual simply abandons or ignores the interference, rather than relying on the use of active inhibition (Yang, Yang, Ceci, & Wang, 2005; Bialystok & DePape, 2009).

The bilinguals' ability to construct explicit representations of linguistic knowledge may result in an increased ability to control and process information. Authors who advocate this theory claim that bilingual children's flexibility is limited to situations involving misleading perceptual information (Bialystok et al., 2004). Bialystok (1999) identifies analysis (representation) and control (attention control) as components of language processing and has shown that control develops earlier in bilingual children when compared to monolinguals. Bilinguals (between the ages of

4-8 years of age) display an advantage when solving experimental problems when high levels of control are required, and are more skilled than their monolingual peers in solving problems that require attentional control to ignoring or inhibiting misleading cues (Bialystok, 1999; Bialystok & Majumder, 1998; Bialystok et al., 2005).

Tasks across various cognitive domains show bilingual children develop control over attention more efficiently than monolinguals (Bialystok, 2001). Specifically, the bilingual advantages for selective and attentional control are apparent when the correct response to a problem are embedded in a misleading context and when the conceptual demands are at a moderate level (Bialystok & Martin, 2004; Carlson & Meltzoff; 2008). Bialystok (2009) describes this as a unique problem for bilinguals who need to correctly select a form that meets all the linguistic criteria for form and meaning but is also part of the target language and not the competing system. This control is at the same time responsible for both the cognitive and linguistic consequences of bilingualism (Bialystok, 2009) and therefore, the bilingual's need to control attention to the target system in the context of an activated and competing system, is the single feature that makes bilingual speech production most different from that of monolinguals.

Attentional control advantages have been identified in older bilingual adults, indicating that earlier executive functioning advantages extend into adulthood. Bialystok et al. (2005) found a similar advantage of attentional control among older bilinguals (ages 22-36), in a set of studies involving a Stroop task. Bilinguals demonstrate a Stroop cost when the irrelevant color word is presented in one language and color naming proceeds in the other. This situation occurs when there is joint activation of both languages, meaning that bilinguals must control attention to the selected language in order to achieve fluent performance in the designated language without intrusions from the other system.

Executive Functioning-Inhibitory Control and Attentional Control. A third possibility is that these benefits arise through the interaction of both attentional and inhibitory control. This ability to involve both types of executive functions relates to identifying the relevant details while excluding/inhibiting irrelevant ones that may appear to be connected to the problem (Jacoby, 1991). Previous research has shown that bilingual children perform better than comparable monolinguals on tasks requiring control of attention to inhibit misleading information by identifying the relevant details and excluding irrelevant ones (Bialystok, Martin, & Viswanathan, 2005). A possible explanation for this advantage is that bilinguals must selectively attend (attentional control) between two languages, while simultaneously inhibiting the language not in use (inhibitory control), and that only through utilizing both types of executive functioning can this be achieved (Bialystok, Martin, & Viswanathan, 2005).

Several studies support an early development of executive functioning among early bilingual populations, and these studies suggest that this may be due to advanced executive functioning in both inhibitory control and attentional control. Bialystok and Martin (2004) examined the relationship between bilingualism and executive functioning of both inhibition and attentional control. In this study, Bialystok and Martin (2004) examined bilinguals and monolinguals ages 4-5 and found that bilinguals outperformed monolinguals on versions of the problem containing moderate representational demands but not on a more demanding condition. The conclusions of this study were that bilinguals have better inhibitory control for ignoring perceptual information than monolinguals do, but are not more skilled in representation (Bialystok & Martin, 2004). The results also identify the ability to ignore an obsolete display feature as critical for solving this task.

Though researchers have investigated all three proposed executive functioning mechanisms, there are still several unanswered questions regarding these theories. Throughout this literature, there are several studies that have put forth their executive functioning theories for why a bilingual advantage exists (i.e. executive functioning-inhibitory control vs. executive functioning selective attention, but many of these studies have neglected to identify possible relationships between these mechanisms (executive functioning) and other areas of cognition. However, (1) researchers have not been clear to what specific component(s) of executive functioning are being tested due to using the same measure to test for both inhibitory control and attentional control and (2) researchers have not tested the effects of either type of executive functioning on separate areas of cognition that shows a benefit. Therefore it remains unclear whether advanced executive functioning or specific components of executive functioning lead to other benefits or are just the benefits themselves.

By studying each theory independently from one another, with tasks that have not been utilized and crossed over to investigate more than one type of executive functioning theory, one can identify if advantages among bilingual populations are still present. This area of research lacks an investigation into how these mechanisms influence specific areas of cognition. More specifically, does the emergence of executive functioning impact the ability to problem solve or display advantages some other types of non-linguistic cognition? In addition, by creating tasks that measure individual types of executive functioning with a specific type of cognition, the possible relationships can be identified.

The Present Research

Although there is considerable research showing bilingual advantages, it remains unclear how early they emerge in development. Unfortunately, the need for identifying a developmental timeline of non-linguistic cognitive benefits among bilingual children has not been the driving force for the majority of cognition studies. Instead, studies focus on adolescent and adult populations. Only research related to executive functioning has examined younger bilinguals (e.g. ranging from Ages 7-months up to 7-years). Authors have focused on the components of executive control that emerge at different times and the different developmental influences these components have on different age groups (Bialystok & Viswanathan, 2009; Carlson, 2003; Diamond, 2002). Many of these studies have grouped age samples (ex. Ages 4-6), further complicating the identification when advantages first emerge in early development (Bialystok & Viswanathan, 2009). These studies have also focused primarily on middle- to upper-class socio-economic populations, limiting our knowledge of what potential benefits exist among low-SES populations. Research on bilingual advantage has also suffered from several methodological limitations that make it difficult to judge the extent of these benefits.

The methological issues and external validity can be described into three different groups: Language, Socioeconomic Status (SES), and Age. Firstly, previous studies focused on the comparison of two groups, one monolingual, and one bilingual. This approach leaves open the possibility that learning a particular language (i.e. Spanish) might itself give rise to benefits, irrespective of bilingualism. Without both monolingual groups, researchers limit themselves to understanding the role that both languages play in the bilingual advantage. Secondly, socioeconomic status (SES) has not always been controlled for in the studies discussed above. There are two points to consider controlling for SES in these studies. The first is that we can ensure that SES is not a possible confound. Moreover, identifying benefits among various SES groups, specifically low-SES groups, may provide researchers with a better understanding of how bilingualism and second-language acquisition impact cognitive abilities.

Previous studies have found low-SES populations are impacted negatively resulting in diminished cognitive functioning, poorer academic-readiness skills, and lower levels of school achievement (Brooks-Gunn & Duncan 1997; McLoyd, 1998). Examining whether cognitive benefits exist among early bilingual populations, in the face of the disparities of low-SES, may provide new insights regarding early cognitive development for low-SES populations. If advantages exist, there may be some components of bilingualism that may buffer the negative effects of low-SES among early populations.

Finally, previous studies have left many areas of cognition uninvestigated. This limits what is known about the extent of bilingual advantage and how aspects of bilingual cognition are related to each other. Here I focus on an understudied area, visual-spatial memory, and tested a specific age group (age four). The cognitive ability of visual-spatial memory, that is, memory for retrieval of visual-spatial information, is a particular type of cognition that is particularly salient for younger preschool-aged populations (ages 3-5), who may not yet be literate and are beginning to learn about the world around them through this type of cognition.

Visual-spatial memory is a fundamental area of learning that is often utilized throughout formal school training. Specifically, advanced visual-spatial memory has been correlated with improved math performance (i.e. missing numbers in a number sequence) (Campbell, 2005) spelling and reading (i.e. they can visualize the word following the beginning of letter sequence) and may help preschool-aged children (who are visual-spatial learners) with overall learning (Silverman, 2002). Investigating the differences between bilingual and monolingual populations could help identify what cognitive processes are developing in regard to language development and what processes help facilitate visual-spatial memory. In addition, visual-spatial memory lends itself to exploring the direct relationship between inhibitory and attentional control and a specific area of cognition. Specifically, visual-spatial memory inevitably requires an intentional focus on some parts of a display and some aspects of an associated mental representation (Jacoby, 1991).

Although largely unexplored, visual-spatial memory relates to several types of cognition that are found to be advantageous to bilinguals including memory

(Haritos, 2004; Kormi-Nouri, R. et al, 2003) and visual-spatial recognition (Haritos, 2004, McLeay, 2003), and executive functioning (Bialystok, 1988, 1991; Carlson & Meltzoff, 2008; Galambos & Hakuta, 1988; Hakuta & Díaz, 1985). In order to accomplish visual-spatial memory tasks, one must control to selectively attend to specific aspects of a representation, particularly in misleading situations. Further, after identifying the relevant details, one must exclude irrelevant ones that may appear to be connected to the problem. This control is more difficult if some habitual or salient response to the problem contradicts the optimal one and must be overruled (Jacoby, 1991) and suggests why we would see a bilingual advantage.

General Design

The goals and purpose of the current dissertation address the limitations discussed above through three experiments. The overall design of these experiments incorporate and speak to the following limitations: (1) early and low-SES populations (2) previous methological issues and (3) the extent of cognitive advantages. Each experiment includes one age group (four year olds) and low-SES populations. The details of each experiment are discussed below.

Participants. To investigate the relationship between bilingualism and advanced cognition among preschool-aged children, local children were recruited by speaking with parents on-site at a local Head Start and two city preschools. Parents were approached by researchers to ask if they would be interested in having their child participate in an experiment on-site at the preschool. After parents returned their permission consent forms, parents were then provided with an additional consent form to complete a demographics questionnaire to determine if the potential participant met socio-economic status requirements to participate in the experiment. Parents were not compensated for their participation. All methods and procedures are approved by the UC Merced IRB and subjects receive no monetary payment for participation.

The population sample from Experiment 1 attended the same Head Start school, counterbalanced across classrooms. The two samples for Experiments 2 and 3 were counterbalanced across two Merced City preschools located in a low-income neighborhood in Merced City and were within 2.5 miles of each other. Researchers spent an average of 12-15 hours a week in the classrooms to familiarize with potential participants. Children of parents who met the requirements of the demographics questionnaire were subsequently asked if they wanted to play a game with the researcher and were taken to a private room on-site at the school. Children were tested at three different points, the first two with vocabulary assessments, and the third time with the experiment tasks.

All three testing sessions were videotaped. Participants from the three experiments participated in both English and Spanish vocabulary assessments to assure that children did not receive sufficient exposure to another language to be considered bilingual. Once vocabulary scores were evaluated, children were placed into one of three language groups: Monolingual English, Monolingual Spanish, or Bilingual. Each of the three experiments contains an independent sample of 60 participants (20 subjects per language group, 10-female, 10 male). All the subsequent participant and demographic information are presented under each experiment.

The parent's socio-economic status (SES) was measured using a demographic questionnaire (see Appendices I, J). The last question was used to determine eligibility for participation in experiments, specifically parents who report an income below $40,000 were considered eligible. These cutoffs were based on reports of California's eligibility requirements to participate in the National School Breakfast and Lunch Program. According to the reported eligibility scales for 2011-2012 as reported by the Department of Education by the state of California, a family of four with a household income of $41, 348 are eligible to receive government assistance based on income and number of persons per household (See Appendix C) (http://www.cde.ca.gov/ls/nu/rs/scales1112.asp). Parents who reported an income of $39,999 or lower were considered low-SES.

Peabody Picture Vocabulary Test (Fourth Edition) PPVT. Materials consisted of the Peabody Picture Vocabulary Test (Fourth Edition) and a translated Spanish version of the Peabody Picture Vocabulary Test. The PPVT is a standardized test of English vocabulary comprehension abilities (Dunn, Dunn, & Williams, 1997) and has been utilized across several bilingual experiments. The Spanish version of the PPVT is not a standardized Spanish version. This is because the standardized previous version of the TVIP (Test de Vocabulario en Imagenes Peabody) is based on content from older versions of the PPVT and contains different items than the current version. Instead, a Spanish PPVT was adapted from the current English

PPVT (Version IV) and created for these studies. In order to create a vocabulary assessment for the PPVT in Spanish, a stimulus item was randomly selected from one of the four stimulus items for each individual set (e.g. Set 1-12) of the Peabody, and was translated in agreement, by two Spanish-speaking research assistants. Research assistants, independently of one another, translated all stimulus items. Both of these research assistants were born and raised in Merced County and are native Spanish speakers. Once translated, and the vocabulary words were tested for reliability by comparing independent translations to one another. If a consensus could not be reached for the term or if there was a discrepancy of the randomly selected item, another item was chosen at random from the remaining three possible stimulus items. This occurred 3 out of 576 cases, and there was no discrepancy once a second item was chosen. Once stimulus items had been translated, a scoring sheet was created so that children's responses could be easily recorded during testing (Please refer to Appendix D, E for the scoring sheet for both English and Spanish PPVT).

Children were labeled English monolinguals if they scored a raw score of 20 or less on the Spanish PPVT and a score over 40 on the English PPVT out of 144 possible. Spanish monolinguals scored a raw score of 40 or over on the Spanish PPVT and less than 28 on the English PPVT. The cutoffs were determined based on their age norms and the standardized vocabulary norms of the English PPVT. However, only raw scores were utilized from the English PPVT and Spanish PPVT. Note that the raw score cutoff for English was slightly higher because children are exposed to more English vocabulary than Spanish, often resulting in slightly higher raw scores even though they were not considered proficient in English. Children who received a 40 or more on both English and Spanish PPVT were considered balanced bilingual. If the child's score did not meet the vocabulary cut-off for either language, they were not asked to participate in future experiments. Participants from all six experiments were also counterbalanced in what version of the Peabody, Spanish or English they were tested in first and second. Finally, due to the fact that the PPVT for the Spanish was not a standardized measure, the bilingual raw scores of the PPVT English and the translated PPVT Spanish were correlated for each experiment. These correlations are reported within each experiment. All sessions were recorded. Please refer to Appendix O for the camera placement set-up.

Procedure. Children were tested in three different sessions at least five days apart to ameliorate possible practice effects. In the first two sessions, children were tested with two different experimenters, one for each language (English and Spanish). In the final experiment, children were tested by the same experimenter who administered the English vocabulary assessment if they were either monolingual English or Bilingual, and by the experimenter who administered the Spanish vocabulary assessment if they were monolingual Spanish.

Strategy Coding. In addition to participating in a demographics questionnaire and vocabulary assessment, all experiments were evaluated for possible observed strategies exhibited by participants. In order to identify what strategies should be coded, behaviors are observed and then coded into categories of different kinds of strategy use. Random selections of 10-15 videos (per experiment) were utilized to identify possible strategic behaviors. Once viewed, observations were listed and used to identify whether there were any overlaps or repetition of particular behaviors. Once these behaviors were identified a coding schema was created along with definitions of each type of code and at least 1-2 examples. Coding for strategies was based on frequency, or the number of times an individual child used the strategy. Videos were coded by two trained coders who agreed on the use of strategies 86% of the time. Coders were also blind to whether or not the children were monolingual or bilingual. All strategies were observed post-hoc and coded for each experiment. Strategies were not analyzed in depth but are present for the complete overview of the dissertation. The individual descriptions and mean frequencies of these strategies are reported in Appendices D-F.

Experiment 1: Visual-Spatial Memory
Concentration and Colorforms

Experiment 1 investigated whether bilinguals show an advantage on visual-spatial memory tasks. To address this question, monolingual and bilingual 4-year-olds were tested on two visual-spatial memory tasks: Concentration and Colorforms. Concentration, also referred to as the game of memory, is a visual-spatial memory task in which the participant has to find several paired matching cards from a 4x3 grid of cards, turning only two cards at each turn, as quickly as possible. In this game, all of the cards are laid face down on a flat surface and only two cards are flipped-over, face up, each turn, displaying different pictures shapes (Appendix L).

The object of this game is to turn over pairs of matching cards. This game draws on visual-spatial memory because children need to use the spatial grid of cards as a visual cue to remember the locations of different shapes. Once matches are found, they are eliminated from the remaining cards. In addition, when matches do not occur, cards are returned to the face down position.

Colorforms is another visual-spatial memory game involving several pictures displaying different configurations of various colored shapes (Appendix M). Colorforms are paper-thin, vinyl sheet images and shapes that can be applied to a slick cardboard panel. The shapes stick to the cardboard panel via static cling and can be repositioned to create different picture designs. In this particular experiment, a task involving seven pictures was created. Each picture contained a total of four shapes of different sizes and two different colors. Pictures were presented to the child one at a time and then removed in order to remove one shape and then presented back to the child. The goal of this task is to identify the missing shape, including the color of the shape, and place it on the previous location.

There are two possible outcomes for the Concentration task: (1) if the bilingual advantage is present, bilinguals will produce fewer card-flip errors and complete the tasks faster than their monolingual counterparts and (2) if there is no bilingual advantage present, we should not see a significant difference between the three groups, or monolinguals would outperform bilinguals on the task and produce fewer card-flip errors.

In the Colorforms task, the two possible outcomes are as follows: (1) if the bilingual advantage is present, bilinguals will correctly identify the color, shape, and location of the missing shape, completing the trials with greater accuracy than monolinguals and (2) if there is no bilingual advantage present, we should not see a significant different between the three groups, or monolinguals would outperform bilinguals, correctly identifying more colors, shapes, and locations across the six trials of the Colorforms task.

Method

Participants. Demographic characteristics and PPVT scores for the Monolingual English, Monolingual Spanish, and Bilingual groups are listing in (See Appendix A). All subjects from Experiment 1 were recruited from classrooms at the same Head Start. For bilinguals, the scores on the PPVT are slightly lower than monolingual English (L2) because they have shared vocabulary with Spanish. English and PPVT Spanish were correlated $r(58) = .45$, $p < .05$. Please refer to Appendix A for participant demographics and vocabulary scores.

Materials and Procedure. For both tasks, children were placed across from the experimenter at a table and given instructions of how to play the game. All trials were videotaped in the same way as PPVT sessions (camera placed diagonally from the left side) so that responses and strategies could be coded at a later time (See Appendix L for set-up). Cameras were located slightly behind the right side of the researchers. Children were not accustomed to the camera.

Concentration. Children were told that they were allowed to turn over only two cards at a time in an attempt to find a total of eight matching pairs of cards. Every card had two sides, one side that was a plain solid blue color and the other side that displays a shape of some kind in the center of the card. Children were then presented with a 4x4 card dyad with every card placed upside down so that the back of the card was visible and the child could not view the other side of the card. Children were given one practice game by an experimenter and six counted games that were coded at a later time. All children understood how to play the game after the initial practice game.

Cards were shuffled in between each game to create a new random card dyad for each game. If children flipped over two cards that did not match, they are instructed to flip them back over to the blue side and try again. However, if children chose two cards that did match, the experimenter removed them from the card dyad. Card-flip errors were measured if the participant turned over two cards that did not match. If the participant turned over cards that were not a match, it was counted as 1 error. In view of the fact that the final card flip of each game would result in a match, and the initial flip was not counted because it was at chance. Lastly, the time for each game was measured.

Colorforms. In this task, four different shapes of two different colors were placed on the board in a series of different pictures totaling seven pictures, one for practice and six for counted test trials. Prior to the presentation of the pictures, children were told that they would be looking at several pictures and would be asked questions about them. For each trial, children were presented with a picture and asked to look at the picture and at the different colors, shapes, and where they are in the design. Each picture consisted of four shapes with two different colors (e.g. a triangle (yellow), a circle (yellow), a square (red), and a rectangle (red)). After 10 seconds, the experimenter removed the picture from sight of the child and removed one of the four pieces. The experimenter then presented the same picture back to the child, asked if this picture was the same picture the child had seen before or if it was different. If the child indicated that the picture was different, the child was asked if some pieces were missing. If the child said yes, the experimenter presented the child with three choices of missing pieces including: the correct missing piece, a piece that was of the same color but a different shape, and a piece that was the correct shape but different color. If the child said 'Yes' (i.e. offered the shape and the child had to put it back), if the child said 'No', (i.e. did not see the picture as different and missing a shape) they received a score of 0 for the game. If the child said 'Yes', the child was asked to place the piece of their choice in the location of the missing piece. Children then must rely on the remaining pieces (visual-spatial memory) to remember the missing piece and its location.

Analyses. All videos of the concentration task were coded for number of card errors (i.e. turning over two cards that did not match = 1). The game was played six times and the completion time for each counted game was coded from the time the first card was touched to the last match. All videos of the Colorforms task were coded for (1) if they said 'no' they received a 0, if they said 'yes' they then had the chance to earn up to 3 points – one each for identifying the correct shape, color, location. (2) the amount of time it took the child to complete the trial (total of six games). Time intervals were recorded between when children were first presented with a picture (with missing shape) to when they placed a shape (from force-choice options) onto the picture.

Results

Concentration. Figure 1 shows the mean number of card-flip errors (summed across games, then averaged across games), separately by language group. A repeated measures ANOVA with Greenhouse-Geisser corrected degrees of freedom was conducted on the mean card-flip errors with game as a within-subject factor and language group as a between-subject factor. This ANOVA revealed a significant effect of language group, $F(2,57) = 13.305$, $p < .05$ with bilinguals making fewer card-flip errors (M= 8.25, SD= 3.06) than both monolingual English (M= 12.09 , SD= 6.10) and monolingual Spanish (M=10.33 , SD=.4.21) groups. See Table 1 for mean scores across all six games.

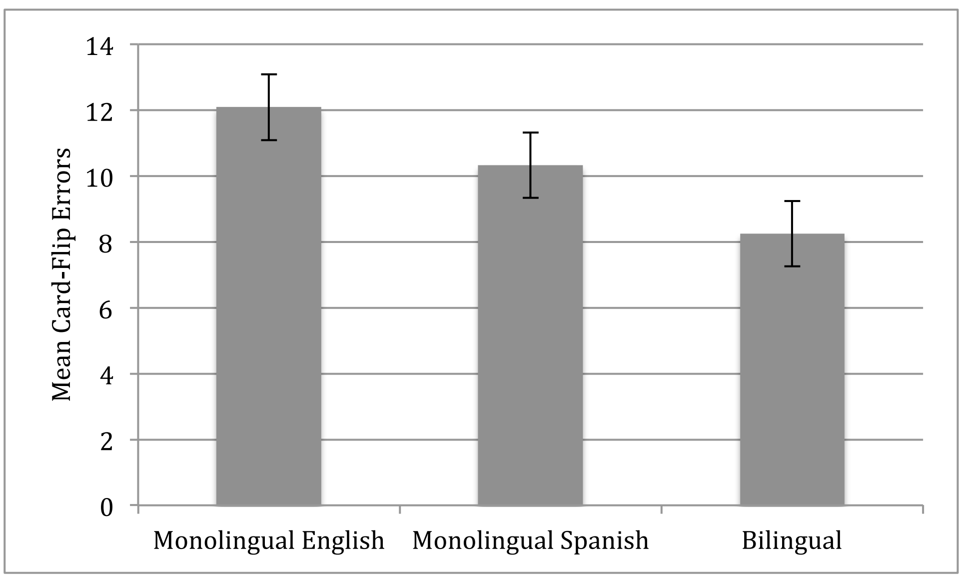


Figure 1. Mean number of card-flip errors in the Concentration task of Experiment 1, separately by language group

There was not a main effect for time $F(2,57) = .716$, $p = .592$, $\eta 2 = .058$ and no significant interaction for time and language $F(2,57) = 1.751$, $p = .082$, $\eta 2 = .058$.

Tukey's HSD revealed significance for language group, between bilinguals and monolingual English ($p < .05$) and between bilinguals and monolingual Spanish ($p < .05$); however monolingual English and Spanish did not significantly differ from each other ($p = .056$).

Table 1

Mean count card-flip errors in the Concentration task of Experiment 1, separately by language group and for each game in Experiment 1.

		Language Group	
	Monolingual English	Monolingual Spanish	Bilingual
Game (Errors)			
Game 1 M (SD)	11.50 (6.91)	12.10 (4.81)	6.05 (2.42)
Game 2	12.05 (6.45)	9.10 (2.67)	9.15 (3.15)
Game 3	11.70 (5.95)	11.80 (5.19)	8.25 (2.43)
Game 4	11.10 (5.25)	9.55 (4.15)	8.10 (2.53)
Game 5	13.80 (6.53)	9.30 (3.51)	9.70 (4.18)
Game 6	12.40 (5.54)	10.15 (4.93)	8.25 (3.68)

An additional repeated measures ANOVA with Greenhouse-Geisser corrected degrees of freedom was conducted on the time completion (seconds) as a within-subject factor, across the six games, and language group as a between-subject factor. This ANOVA revealed no significant effect of language group, $F(2, 57) = 2.825$, $p = .068$, $\eta 2 = .090$ but did show a slight trend for bilinguals ($M=91.91$, $SD=4.53$) having faster completion times than monolingual English ($M=102.54$, $SD=4.09$) and monolingual Spanish ($M =110.10$, $SD = 4.48$). There was not a main effect for time $F(2,57) = 2.513$, $p = .054$, $\eta 2 = .042$ and no significant interaction for time and language $F(2,57) = .741$, $p = .652$, $\eta 2 = .025$. See Table 2 for time completion scores across all six games.

Table 2

Time completion means (in seconds) for the Concentration task of Experiment 1, by language group.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Time Seconds			
Trial 1 M (SD)	109.75 (48.69)	115.46 (48.09)	89.90 (49.53)
Trial 2	100.10 (47.78)	126.46 (50.71)	101.20 (48.87)
Trial 3	88.80 (33.88)	95.26 (33.93)	77.31 (32.66)
Trial 4	106.56 (29.78)	95.60 (32.10)	97.07 (34.19)
Trial 5	111.25 (59.79)	109.26 (43.56)	106.40 (67.44)
Trial 6	98.76 (42.01)	118.55 (39.19)	118.55 (39.19)

Colorforms. An ANOVA conducted on the number of features correctly identified with language group as a between-subjects factor revealed a significant main effect of language group, $F(2,57) = 13.630$, $p < .05$, $\eta 2 = .32$. Tukey's post hoc procedures indicated bilinguals (M=11.55, SD=3.25) recalled more features (e.g. shapes, colors, and locations) than both monolingual English speakers (M=7.70, SD=2.62) and monolingual Spanish speakers (M=7.40, SD=2.48). Mean scores of performance identifying shapes, colors, and location are reported in Figure 2. There was not a significant difference in the number of correct target items recalled between monolingual English and monolingual Spanish speakers. In addition a separate ANOVA was carried out to identify whether the three language groups recalled one of the three item-features (e.g. colors, location, shape) more often. No significant differences were identified.

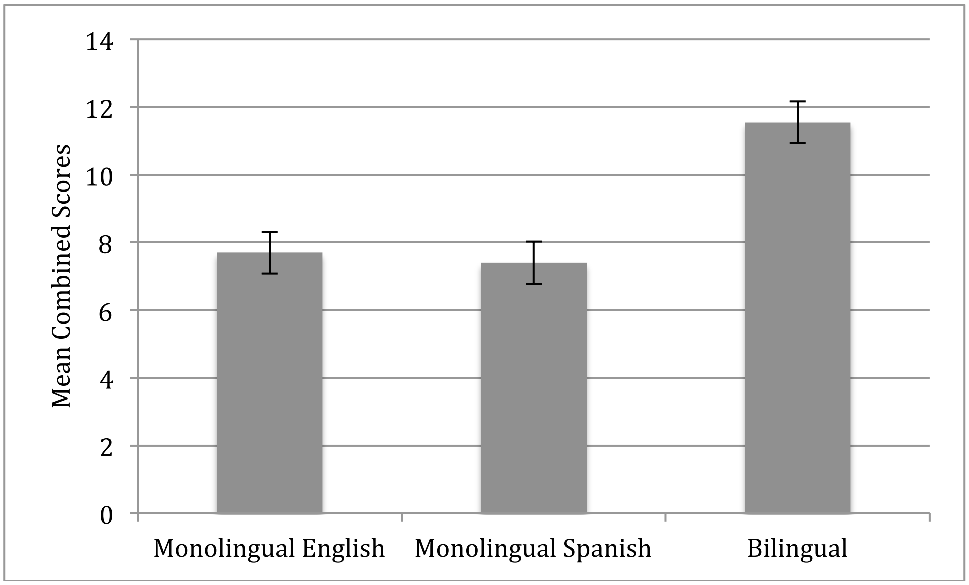


Figure 2. Means of combined scores of Shape, Color, and Location in the Colorforms task of Experiment 1, separately by language group.

Comparison Between Tasks. An additional analysis was conducted to identify if there was a significant relationship between successful performances on the Concentration Task (e.g. fewer card-flip errors) and Colorforms Task (e.g. successfully identified more shapes, colors, and locations). There was a significant negative relationship between the Concentration Task (Total Card Flip Errors) and Colorforms Task (Total Combination score for Colorforms), $r(58) = -.41$, $p < .05$. These results support the validity of these visual-spatial memory tasks and suggest visual-spatial memory success is significantly correlated with across both tasks.

Discussion

Experiment 1 examined whether bilingual children demonstrate an advantage in visual-spatial memory. In both tasks measuring visual-spatial memory, bilinguals outperformed monolinguals. Bilinguals produced fewer card-flip errors than both monolingual groups on games of Concentration, and were more accurate recalling correct shapes, colors, and locations on the Colorforms games.

These results demonstrate that balanced bilingual children as young as four display an advantage over monolinguals on visual-spatial memory tasks. In addition to extending the current research of bilingual cognitive advantages among specific-age population (e.g. four year olds), this cognitive advantage is present despite the low-SES status of the population I sampled. Future research may want to investigate whether bilingualism is a cognitive reserve for young children and if this cognitive reserve would reduce the negative effects caused by low SES (e.g. lower achievement scores, overall academic achievement, etc). These findings support that bilinguals encode information differently than monolinguals, and suggests a link between imagery and bilingualism (Ransdell and Fischler, 1991). For example, bilinguals rely more heavily on visual or spatial strategies, preferring such non-verbal representations, which are considered less ambiguous than verbal strategies. This may be an explanation of the bilinguals' success on visual-spatial memory tasks.

Experiment 2: Day/Night Task and Car Bike Inhibitory Control Task

Experiment 1 showed that bilinguals have an advantage in visual-spatial memory. In the next experiment, I utilize visual-spatial memory to explore the mechanism described in the introduction. Does this advantage in visual-spatial memory arise via inhibitory control? If so, is there a significant relationship between these two mechanisms? To address this theories, I tested children in both inhibitory control tasks and a visual-spatial memory task that drew directly on inhibitory control. If inhibitory control supports advantages in VSM, then there should be a correlation between IC and VSM.

Day/Night Task. Participants completed an inhibitory-control task called the Day-Night task. Previous studies have utilized overlapping measures to test for different components of executive functioning, making it difficult to identify what component is actually being measured. For these reasons, the Day-Night task was selected. This task is one of the few tasks not used by other researchers to measure more than one type of executive functioning. This task is a Stroop-like task in which children are required to inhibit salient visual stimuli and answer with an opposing label (Gerstadt et al., 1994). In this task, children were familiarized with two types of cards, one clearly depicting a day scene with a yellow sun (day card) and one a night scene with moon and stars (night card). Children were instructed to say "day" when shown a night card, and to say "night" when shown a day card. Children were given four practice cards; if a child answered incorrectly, the experimenter repeated both rules and repeated the practice trial again. Children then completed the task with 16 cards in a fixed random order. All trials were video recorded and coded to identify whether children had inhibited the verbal response to the target card and answered correctly. All experimenters were bilingual Spanish-English speakers. If the child was part of the monolingual speaker conditions (e.g. English or Spanish), they received instruction in their respective languages. If the child was bilingual (e.g. Spanish-English) the child was asked what language they would prefer. All bilingual participants chose English.

Car/Bike Task, Executive Functioning- Inhibitory Control and Visual-Spatial Memory Task. The task was created to measure both inhibitory control and visual-spatial memory. In this task, children watched a video of street traffic with two types of vehicles: (1) cars (2) bicycles. Children were asked to count one type of vehicle (target) while ignoring the other vehicle (non-target). After the video, children were asked to recall the number of those vehicles (target) they saw during the video and in some trials, they were asked to also recalled the other vehicle they were asked to ignore (non-target). The prediction here would be that bilinguals would be less accurate at recalling the correct number of vehicles they were asked to inhibit (non-target vehicles) but still be better at overall recall for visual-spatial memory for the vehicles they were prompted to remember (target-vehicles). This prediction is based on evidence that shows bilinguals are better at inhibition when required to do so. Monolinguals however, should display a higher score on inhibited items because they are worse than bilinguals at inhibition tasks.

Method

Participants. All children's parents completed a demographics questionnaire and children participated in vocabulary assessments prior to completing Experiment

2. For bilinguals, the scores on the PPVT English and the PPVT Spanish were correlated $r(58) = .68$, $p < .05$. Please refer to Table 6 for the responses participant demographics and vocabulary scores.

Materials and Procedure. For both tasks children were placed opposite of the experimenter across a table. All children's trials were videotaped in the same way as the experiments 1-2 and the PPVT sessions (camera placed diagonally from the left side) so that responses could be coded at a later time.

Day/Night Task. Children were given four practice cards after instruction to ensure they had been shown one of each type of card and had the opportunity to practice their answers. If the child answered incorrectly to a card during the practice session, the experimenter repeated both rules and repeated the practice session if necessary. If a child was unable to answer correctly or did not understand the instruction during the practice session, the child was given the instructions again and participated in a second practice session. However, all children were able to complete the initial practice session without complication. Children were presented with two types of cards, black card displaying a moon and stars (day card), and a white card displaying a yellow sun (night card). Children were tested with 4 practice cards (2-day cards, 2 night cards), and a total of 16 cards (8 of each type) in a fixed random order: D, N, D, D, N, D, N, N, D, N, D, D, N, D, N, N.

Car Bike Task-Inhibitory Control. Children were placed opposite the experimenter across a table. To the right of the child was a laptop that displayed a PowerPoint animation of street traffic. For each video, the experimenter played a different animation of two types of vehicles (cars and bicycles) moving across the screen. After each video the child was presented with three forced-choice options of how many vehicles they saw. Children were presented with a total of six-counted videos in addition to one practice video. The session was videotaped in the same way as experiments 1-4 and the PPVT sessions (i.e. camera placed diagonally from the left side) so that responses could be coded at a later time. Each video elapsed the same amount of time this was done by utilized the same number of animation PowerPoint slides for each of the videos. In addition, every video displayed the same two types of vehicles during each play.

Before watching the video, children completed a familiarizing trial so the experimenters could ensure that they understood different types of vehicles they might see in the video and that they understood negation. Negation was important for children to understand so that children understood the word NOT in the instruction prompt given before each video. The vehicles included either cars or bicycles and were counterbalanced as both target or non-target vehicles. Once children completed this familiarization session they were given one practice video and instructed with the following prompt: *"Today I'm going to show you a video of some street traffic. I want you to remember how many cars there are, NOT bicycles. After the video, I'm going to ask you how many cars there are, ok?"* Afterwards, children were presented with six videos in a specific order (see Table 3 for the presentation of the vehicles per trial). The target vehicles children were instruction to remember and were told to not remember the non-target vehicle.

After each video, children were asked to recall the number of cars (or bicycles, depending on the target for the video), they saw from three forced-choice pictures (e.g. (a) three cars, (b), two cars, (c) one car). In addition to a correct picture, there were two force-choice incorrect pictures. After videos 1, 3, 5 children were asked about the target vehicle (cars). After videos 2, 4, and 6, children were asked about both the target vehicle (bicycles) and the non-target vehicles (cars).

Table 3

Car Bike Inhibitory Control VSM task order of videos, presentation of vehicles and possible corresponding answer cards over each of the six trials.

Test Trial Video	Vehicles Present		Force-Choice Answer Cards	
	Cars	Bicycles	First (Target)	Second (Non-Target)
1	4	1	Cars 3; 2; 4	-
2	3	2	Bicycles 3; 2; 1	Cars 2; 3; 1
3	2	3	Cars 1; 2; 3	-
4	1	4	Bicycles 4; 1; 3;	Cars 4; 1; 2
5	3	2	Cars 1; 4; 3	-
6	2	3	Bicycles 3; 1; 2	Cars 2; 3; 4

Note: Bolded Forced-Choice Answer cards are the correct answers.

In the first trial children were asked to remember cars; there were four cars and one bicycle, and the child was only asked about cars. In the second trial there are 3 cars and 2 bicycles and children were asked about the target-vehicle (bikes) and also asked about the non-target vehicle (cars). In the third trial children were asked to remember Cars and were only asked about cars. For the fourth trial, children were asked to focus on bicycles and were asked about both bicycles and cars. In the fifth trial children were asked about cars, and only asked about cars. In the six trial children were asked to remember bicycles and then asked about both bikes and cars.

Forced-choices consisted of three force-choice cards displaying pictures of the vehicles. One choice was the correct number of the target vehicle, one card that displayed the correct number of the opposite target vehicle, and one was a random number.

Analyses. The children's responses for Experiment 2 were coded from the video recorded session. All correctly inhibited responses for the Day/Night task were coded. In addition, children's completion times were also measured by beginning the timer when the first target card was presented to when the last card was presented. All trials were video-recorded, coded, and analyzed for the number of correct choices including overall visual-spatial memory (target and non-target vehicle choices), inhibitory control choices (non-target vehicles). Specifically, in every trial there was a target vehicle that children were asked to remember, that was coded as correct or incorrect. In trials 2, 4, 6, children were also asked about the additional non-target vehicle that they were initially not asked to remember, this will be referred to as the non-target (inhibited) vehicle.

Results

Day/Night Task. Two analyses were done for this particular task. First, in previous studies that used only to identify the total number of correctly inhibited cards reported in the initial twenty seconds. In previous studies that used the Day/Night task with this particular age group, experimenters conducted analyses for the number of inhibited correct cards within the first twenty seconds. An ANOVA was conducted on the number of inhibited correct cards within the first twenty seconds as a dependent variable and language group as a between-subject factor. This ANOVA revealed a significant effect of language group $F(2,57) = 15.274$, $p < .05$, $\eta^2 = .35$. Tukey's post hoc procedures indicated bilinguals (M=4.10, SD=1.37) correctly labeled significantly more cards than monolingual English speakers (M=1.95, SD=1.57) and monolingual Spanish speakers (M=2.15, SD=1.09) within the initial 20 seconds of the task. There was not a significant difference in the number of correctly inhibited cards between monolingual English and monolingual Spanish speakers. This analysis was to identify if there was a significant difference among groups in regard to their overall performance. This particular analysis was not done previously among bilingual studies.

A one-way ANOVA was conducted on the total number of correct inhibited cards as a dependent variable and language group as a between-subject factor. This ANOVA revealed a significant effect of language group, $F(2,57) = 7.778$, $p < .05$, $\eta^2 = .21$. Bilinguals (M=11.20, SD=2.46) labeled significantly more cards than both Monolingual English speakers (M=7.40, SD=4.57) and Monolingual Spanish speakers (M=6.95, SD=3.89). Additional independent-samples t-tests revealed Bilinguals significantly differed, $t(38)=3.274$, $p < .05$ from Monolingual English. Bilinguals also significantly differed, $t(38)=4.131$, $p < .05$, from Monolingual Spanish, correctly labeling more cards. There were no significant differences in correctly labeling cards between the Monolingual English group, $t(38)=.335$, $p = .739$, and the Monolingual Spanish group. The means of the number of correctly inhibited cards in the first 20 seconds and the overall score for each language group are reported in Figure 3.

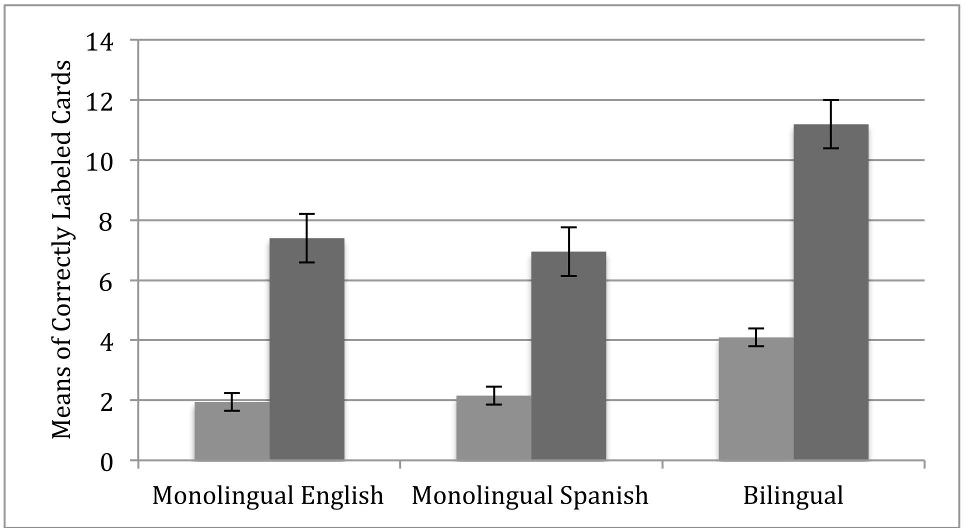


Figure 3. Means counts for correctly labeled cards in the Day/Night Task of Experiment 2, separately by language group. Means of the first 20 seconds (left column) and Overall Score (right column).

In addition to this analysis, I included an analysis for the child's overall completion time, (beginning when the child ends their practice trial to when the child utters their final response). An additional ANOVA for overall time completion as a dependent variable and language group as a between-subject factor revealed significant differences between language groups, $F(2,57) = .494$, $p = .613$, $\eta^2 = .02$ for overall time completion (in seconds) among the different language groups displaying a faster overall competition time for Monolingual Spanish (M=49.40, SD = 15.32) than both Monolingual English (M=52.95, SD = 11.92), Bilingual (M=54.65, SD = 22.26) groups.

Car/Bike Task Inhibitory Control Visual-Spatial Memory Task. An ANOVA was conducted on the total number of correct vehicles recalled during non-target vehicle trials trials as a dependent variable and language group as a between-subjects factor. This ANOVA revealed a significant effect of language group,

$F(2,57) = 7.912$, $p < .05$, $\eta^2 = .22$. During these specific trials, groups were asked about both target and non-target vehicles (See Figure 4); bilinguals were less accurate recalling the non-target (or inhibited) vehicle (M=.55, SD=.89) than both monolingual English speakers (M=1.20, SD=.62) and monolingual Spanish speakers (M=1.45, SD=.69). An additional ANOVA was conducted to identify if there was an effect of trial, and if children did not change strategies over the course of the task. The total number of correct vehicles recalled during the non-target vehicle trials was used as a within-subject factor and language group as a between-subjects factor revealing no significant difference among language groups, Wilks' Lambda = .911, $F(2,57) = 2.733$, $p = 0.074$, $\eta^2 = .09$.

For the trials containing the total number of correctly identified target vehicles (dependent variable) among language groups (between-subject variable), an ANOVA revealed a significant effect of language group, $F(2,57) = 4.276$, $p < .05$, $\eta^2 = .13$, bilinguals (M=4.40, SD=1.14) recalled significantly more target vehicles, than both monolingual English speakers (M=3.20, SD=1.58) and monolingual Spanish speakers (M=3.30, SD=1.56). Additional independent-samples t-tests revealed Bilinguals significantly differed, $t(38)=2.757$, $p < .05$ from Monolingual English, with bilinguals identifying more target vehicles. Bilinguals also significantly differed, $t(38)=2.545$, $p < .05$, from the Monolingual Spanish group. There were no significant differences in correctly identifying more target vehicles between the Monolingual English group, $t(38)=.202$, $p = .841$, and the Monolingual Spanish group. These results suggest that bilinguals are utilizing inhibitory control to remember successfully the target vehicle and inhibit the non-target vehicle (see Figure 5).

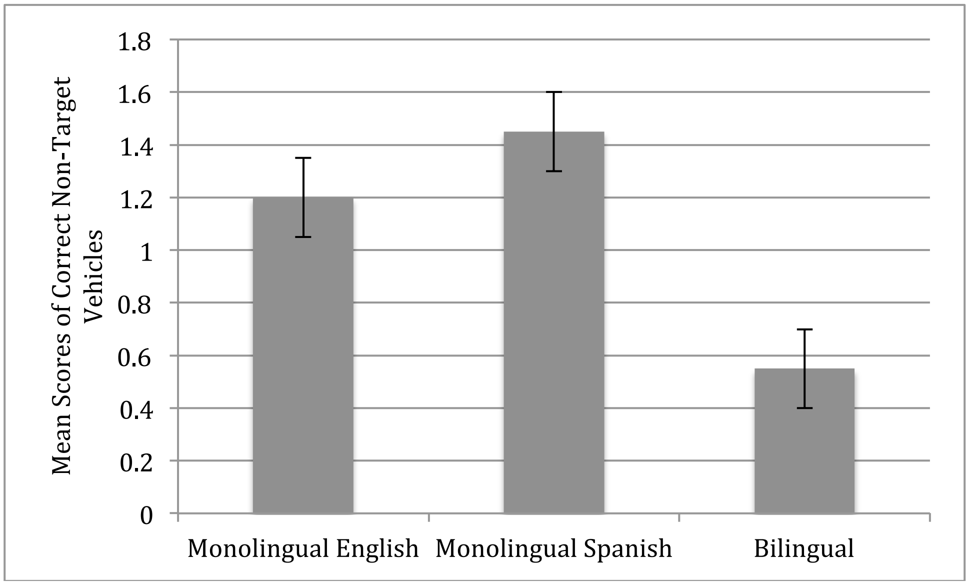


Figure 4. Mean count scores of correctly identified non-target vehicles in the Car Bike Inhibitory Control Task of Experiment 2, separately by language group.

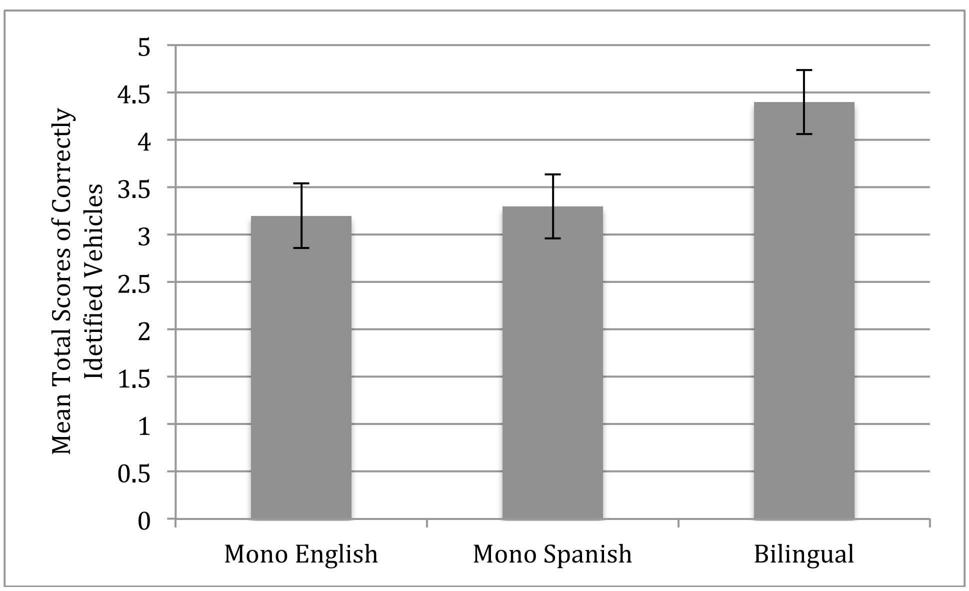


Figure 5. Mean counted scores of the total correctly identified target vehicles in the Car Bike Inhibitory Control Task of Experiment 2, separately by language group.

An additional analysis was completed to identify if bilinguals and monolinguals chose the corresponding non-target card that was the same number of vehicles as the target vehicle (e.g. the participant chose the non-target vehicle corresponding choice of three cars when target vehicle was three bicycles). An ANOVA was conducted on the total number of non-target answer cards that were chosen and also corresponded with the number of target vehicles as a dependent variable and language group as a between-subject factor. This ANOVA revealed no significant differences between the language groups $F(2,57) = 1.248$, $p = .295$, $\eta^2 = .04$. Of the three groups, bilinguals ($M = .90$, $SD = .72$) did show a higher mean than both monolingual Spanish ($M = .60$, $SD = .68$) and monolingual English ($M = .60$, $SD = .68$) and did not significantly recall the corresponding number from the non-target vehicle, as the number of target vehicle.

A series of ANOVAs was conducted on the time completion (in seconds) for each of the six trials and then averaged as a dependent variable and language group as a between-subject factor. Finally, there was not a significant difference in the total time completion in seconds between Bilinguals, monolingual English and monolingual Spanish speakers, $F(2,57) = .202$, $p = .818$, $\eta^2 = .01$. (See Table 4 for time completion for language groups in seconds for each of the six trials).

Table 4

Time completion means (in seconds) for the Car/Bike Inhibitory Control task of Experiment 2, by language group.

		Language Group			
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Time (Seconds)					
Trial 1 M (SD)	7.95 (4.75)	8.35 (6.05)	5.65 (2.49)	1.965	0.06
Trial 2	10.65 (2.11)	10.00 (4.58)	12.30 (4.03)	2.027	0.07
Trial 3	4.55 (1.88)	4.10 (1.94)	3.95 (1.88)	0.540	0.02
Trial 4	9.80 (1.61)	11.25 (4.18)	9.50 (2.76)	1.898	0.06
Trial 5*	6.05 (2.96)	4.45 (1.14)	4.15 (1.66)	4.866	0.15
Trial 6	9.10 (3.35)	9.75 (3.68)	8.65 (4.70)	0.391	0.01

Comparison Between Tasks. Experiment 2 predicted that (1) bilinguals would exhibit better inhibition (e.g. Day/Night Task) and (2) use this inhibition to suppress the non-target vehicles in the Car/Bike Task, resulting in poorer performance on the non-target vehicles than the monolinguals. A significant negative relationship between the total correctly identified cards in the first task, day/night task and the correct number of non-target vehicle trials from this current task, $r(58) = -.31$, $p < .05$. There is no correlation between the day/night task and the target vehicles, $r(58) = .079$, $p = .548$, or between target vehicles and non-target vehicles,

$r(58) = .010$, $p = .942$. These comparisons suggest bilinguals are utilizing inhibitory control to suppress non-target vehicles in the Car/Bike Task.

Discussion

In this last experiment, executive functioning-inhibitory control was isolated and measured across all three language groups. A cognitive advantage was found among bilingual participants, and no significant differences were found among monolingual groups. This finding is consistent with previous literature when conducted with pre-school aged students (Bialystok & Senman, 2004; Carlson & Metlzoff, 2008). In addition to this contribution and consistent finding to the existing literature, this finding shows that, like the previous experiment, a bilingual advantage is still present despite economic disparities and slightly lower receptive vocabulary scores.

The theoretical implication is that the patterns of findings also suggest a possible link between visual-spatial memory, inhibitory control, and bilingualism. In the first experiment, a visual-spatial memory advantage was present in similar populations as this current experiment, suggesting that children as young as four may possess increased abilities in inhibition of a mental representation (in order to succeed on visual-spatial tasks) by inhibiting irrelevant information to focus on relevant information to succeed a on a task (Bialystok, 1991). Similarly, correlations found between both advanced visual-spatial memory and inhibitory control (e.g. performance on target and non-target trials) suggests a relationship between these areas of cognition for early bilingual populations. However, this does not rule out the possibility that bilingual advantages arise via both inhibitory and attentional control (i.e. mechanism 3). Experiment 3 examines this possibility.

Experiment 3: Embedded Figures and Car Bike Attentional Control Task

In the previous study, one type of executive functioning (inhibitory control) was examined and a bilingual advantage was found for both tasks. Experiment 3 aimed to explore (1) whether these young bilinguals have an advantage in attentional control and (2) whether this plays a role in their advantages on VSM.

Embedded Figures. An embedded figures task requires the participant to identify hidden figures from a distracting or confusing background. In this particular task, children had to identify more than one of a particular embedded shape (ex. triangle) within a picture of overlapping distracting shapes (ex. squares, rectangles, squares, etc.). These trials test the child's ability to control attention and focus on the positive (embedded stimulus target-shapes) rather than negative objects (surrounding distracting non-target shapes). In other words, children would need to select relevant from irrelevant stimuli by focusing and refocusing their attention. Children completed a practice trial and six counted trials. Each trial had four embedded target-shapes, however the exact number of target-shapes was not disclosed to participants. Participants were measured on their overall discovery times (when they would point to the correct target-shape) and the total number of discovered target-shapes.

Car/Bike Task Executive Functioning- Attentional Control and Visual-Spatial Memory Task. The task was created to measure both attentional control and visual-spatial memory in a similar procedure as the Car Bike Inhibitory Control task from Experiment 2. Unlike in Experiments 2, children were not explicitly told to ignore any subset of the vehicles; rather they were encouraged to watch for only one type of vehicle. After viewing the video, children were asked to recall the number of cars and bicycles they viewed by choosing from three force-choice cards (one correct, two distraction) displaying different numbers of cars or bicycles (depending on the vehicle in question). There were the same numbers of time/slides each video.

Every video included the two possible target vehicles (car or bicycle) and two of the six videos that contained an additional vehicle (bus). The video and target-vehicle changed for each trial. For example, in the first trial children were asked to remember cars (target-vehicle), there were four cars and one bicycle, and the child was only asked about cars. In the second video children were asked to remember bicycles but asked about both bicycles and cars and so on. Trials asked for both vehicles and were counterbalanced to eliminate possible practice effects (e.g. switching the target vehicle to either cars or bicycles). Finally, the forced-choice answers consisted of three options: one correct answer, one that matched the number of the target vehicles and one distracting. For the two videos that contained a bus, children were presented with two cards to answer if they saw a bus in the video, one displaying a happy face (yes), and one displaying a sad face (no). Choosing the happy face indicates that the child saw the bus (distractor) even though the bus was not a potential target or non-target vehicle. This suggests children were unable to use attentional control to focus only on the target vehicle. Choosing a sad face (e.g. did not see the bus), suggests that the child exhibited greater attentional control by focusing more on the target vehicle, successfully ignoring the bus.

Method

Participants. All children's parents completed a demographics questionnaire and children participated in vocabulary assessments prior to completing Experiment 3. A Pearson Correlation analysis of the PPVT scores for bilinguals revealed a positive relationship between raw PPVT English and PPVT Spanish scores, $r(58) = .48$, $p < .05$. Please refer to Table 9 for the responses participant demographics and vocabulary scores.

Materials and Procedure. For both tasks children were placed opposite of the experimenter across a table. The child was presented with one picture card that was composed of embedded shapes. The card was placed on the table directly in front of the child, and then removed after the child indicated their response through pointing or touching their answers. Children were presented with a total of six-counted trials in addition to one practice trial. All sessions were video recorded in the same way as previous experiments and the PPVT sessions (i.e. camera placed diagonally from the left side) so that responses could be coded at a later time.

Embedded Figures. Prior to the test trials, children were presented with shapes (two at a time) to ensure that they knew the name of each shape. For example, children were presented with a rectangle and a square and asked to point to the rectangle. The shapes familiarization task was to ensure the child would be able to identify a target-shape when prompted during the experiment. Before the child was presented with the embedded picture, they were given a target shape to identify. Children were instructed to touch all the target-shapes they could find as fast as they could. Each trial contained four possible embedded target-shapes out of 9 shapes total. However, the exact total of possible correct target-shapes was not be disclosed to participants.

Car Bike Task-Attentional Control. Children were placed opposite of the experimenter across a table. To the right of the child was a laptop that displayed a PowerPoint animation of street traffic. For each video, the experimenter played a different animation. After each video the child was presented with three force choice options of how many vehicles they saw. Children were presented with a total of six-counted test videos, in addition to one practice video. All sessions were videotaped in the same way as experiments 1-4 and the PPVT sessions (e.g. camera placed diagonally from the left side) so that responses could be coded at a later time.

Before watching the video, children in this session completed a familiarization test so that experimenters could ensure that they understood the different types of vehicles they might see in the video. These vehicles included cars, bicycles, and a bus. The cars and bicycles were counterbalanced as both target and non-target vehicles, and the bus was the distractor vehicle. It was important to know that the child would be able to distinguish a car from a bus. Once children completed this familiarization session they were given one practice video and instructed with the following prompt: *"Today I'm going to show you a video of some street traffic. I want you to remember how many cars there are. After the video, I'm going to ask you how many cars there are, ok?"* After the prompt the child was shown a video. The prompt was provided before each video.

After viewing the video, children were asked to recall the number of cars (or bicycles, depending on the target for the video), they saw from three forced-choice pictures (e.g. (a) three cars, (b), two cars, (c) four cars). After videos 2 and 5, children were asked about both the target vehicle (bicycles) and the non-target vehicles (cars). After videos 3, 4, 6 children were asked about the target vehicle and whether or not they saw a bus; a bus was only present in videos 3 and 6. This was done to eliminate practice effects after children were initially asked about a bus in trial 3. Children were asked to point to a happy face if they saw a bus and sad face if they did not see a bus after they were asked about the target vehicle (see Table 5 for the presentation of vehicles per trial and the possible corresponding answer cards over each of the six trials).

Table 5

Car Bike Attentional Control VSM task order of videos, presentation of vehicles and possible corresponding answer cards over each of the six trials.

Test Trial Video	Vehicles Present			Force Choice Answer Cards Options	
	Cars	Bicycles	Bus	First (Target) #;#;#	Second (Non-Target or Distraction) #;#;#
1	4	1	-	Cars 2; 4; 1	-
2	3	2	-	Bicycles 4; 2; 3	Cars 4; 3; 2
3	2	3	1	Cars 2; 3; 4	Bus ☺ ☹
4	1	4	-	Cars 4; 1; 3	Bus ☺ ☹
5	3	2	-	Bicycles 3; 1; 2	Cars 1; 3; 2
6	2	3	1	Cars 2; 1; 3	Bus ☺ ☹

Analyses. All videos of experiment 3 were coded for performance. The embedded figures task were coded for (1) the number of correctly discovered target shapes, and (2) the overall discovery times. All videos of the car bike task were coded for (1) the total number of correct choices for both overall visual-spatial memory (target and non-target answers), (2) attentional-control trials (non-target answers), (3) overall completion time per trial (beginning with the time the video ended and finishing after children have selected an answer card), and any possible strategies displayed by participants.

Results

Embedded Figures Task. An ANOVA was conducted on the mean performance (identifying the correct number of embedded figures task) as a dependent variable and language group as a between-subjects factor. This ANOVA revealed a significant effect of language group, $F(2,57) = 9.228$, $p < 0 .05$, $\eta^2 = .24$. Bilinguals (M=19.25, SD=3.46) identified significantly more target shapes in the embedded figures task than both monolingual English speakers (M=14.65, SD=6.44) and monolingual Spanish speakers (M=12.65, SD=4.58). Additional independent-samples t-tests revealed a significant effect for language in which Bilinguals significantly differed, $t(38)=2.813$, $p < .05$ from Monolingual English correctly identifying more target shapes. Bilinguals also significantly differed, $t(38)=5.141$, $p < .05$, from Monolingual Spanish, correctly identifying more target shapes. There were no significant differences in the total number of identified target shapes between the Monolingual English group, $t(38)=1.132$, $p = .265$, and the Monolingual

Spanish group. The mean performance for each language group is reported in Figure 6.

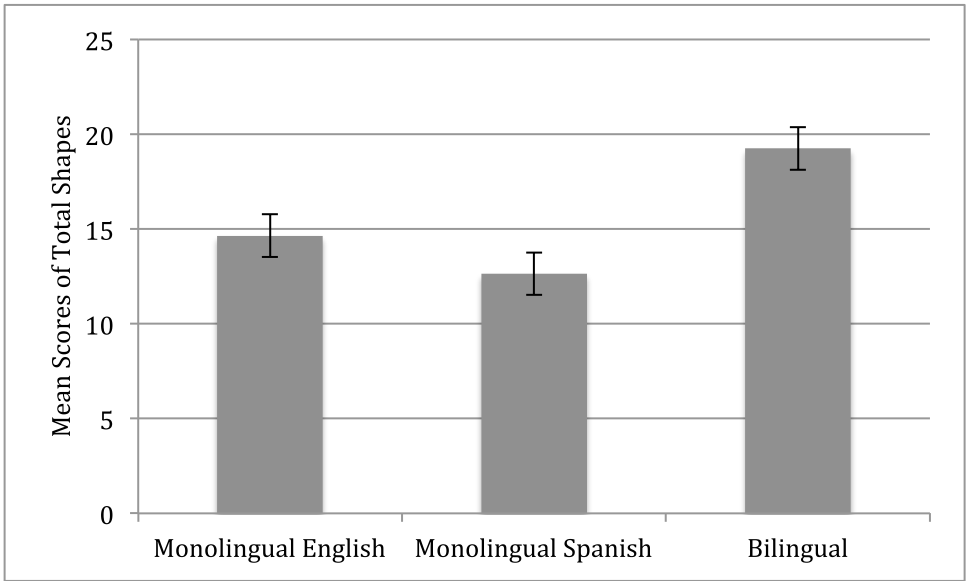


Figure 6. Mean count scores of total shapes discovered in the Embedded Figures task of Experiment 3, separately by language group.

Car Bike Attentional Control. An ANOVA was conducted on the total number of correctly recalled vehicles (target and non-target) with trial as a dependent variable and language group as a between-subject factor. This ANOVA revealed a significant effect of language group, $F(2,57) = 8.562$, $p < .05$, $\eta^2 = .23$. Bilinguals ($M=4.80$, $SD=1.15$) recalled significantly more vehicles than both monolingual English speakers ($M=3.45$, $SD=1.15$) and monolingual Spanish speakers ($M=3.80$, $SD=.89$). Total means of correctly identified target vehicles for each language group is reported in Figure 7.

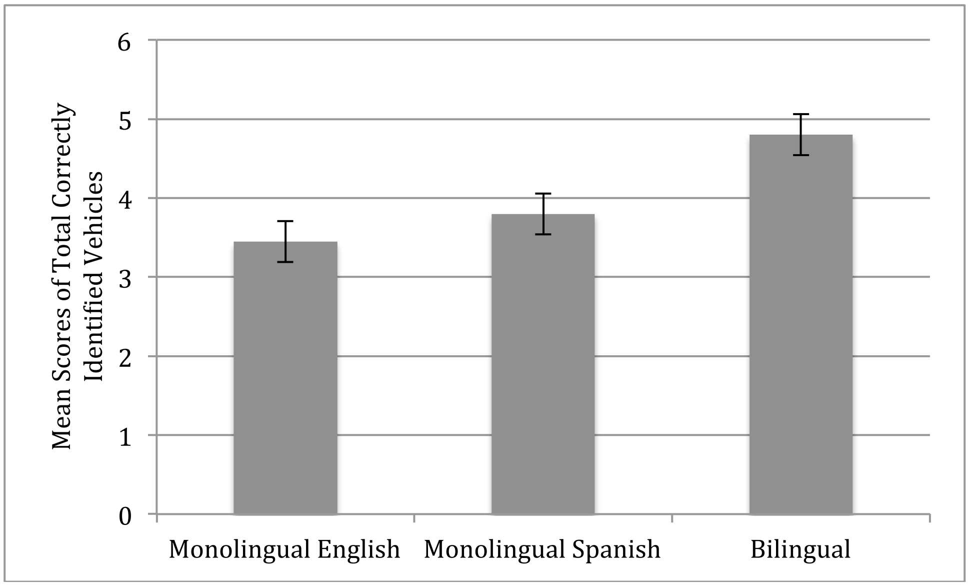


Figure 7. Mean Scores of the total correctly identified target and non-target vehicles in the Car Bike Attentional Control Task of Experiment 3, separately by language group. Scores are summed across the six trials for each child.

During trials 3,4, and 6, children were asked about the presence of a bus. However a bus was only present during trials 3 and 6. The purpose of trial 4 identified if children were simply saying yes to all questions regarding the presence of a bus.

An ANOVA was conducted on the total number of correctly recalled presence of the bus with trial as a dependent variable and language group as a between-subject factor, revealing a significant effect across language groups $F(2,57) = 5.264$, $p < 0.05$, $\eta^2 = .16$. Bilinguals (M=2.20, SD=0.77) correctly recalled the presence of the bus, more than both monolingual English speakers (M=1.45, SD=0.99) and monolingual Spanish speakers (M=1.30, SD=1.03) (see Figure 8).

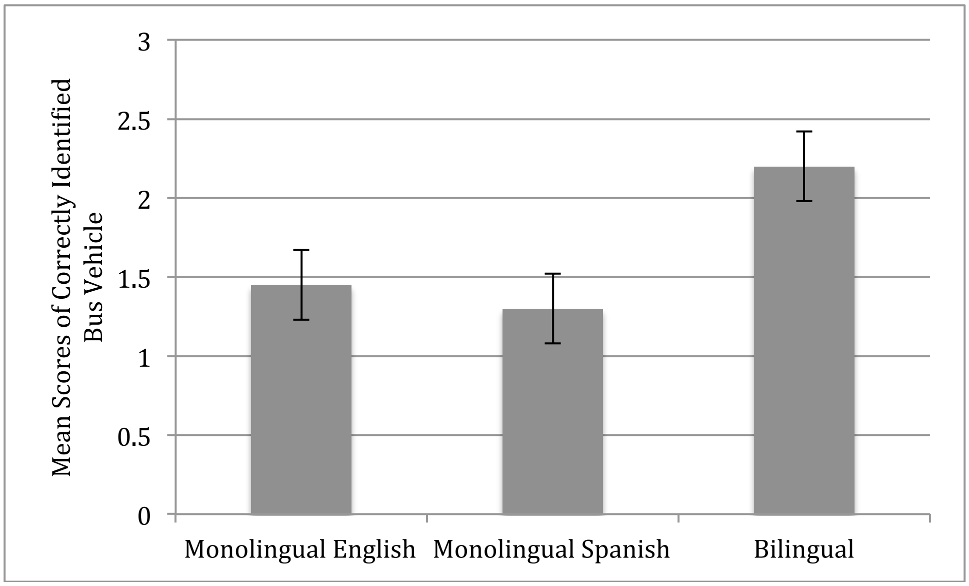


Figure 8. Mean Scores of the total correctly identified the bus (distractor) vehicle in the Car Bike Attentional Control Task of Experiment 3, separately by language group. Scores are summed across the three bus trials for each child.

An ANOVA utilizing performance on non-target trials as a dependent variable and language group as a between-subjects factor revealed no significant difference among language groups during non-target trails, $F(2,57) = .864$, $p = .427$, $\eta^2 = .13$. Bilinguals (M=.55, SD=.69) recalled fewer non-target vehicles than both monolingual English speakers (M=.70, SD=.73) and monolingual Spanish speakers (M=.85, SD=.75) (See Figure 9).

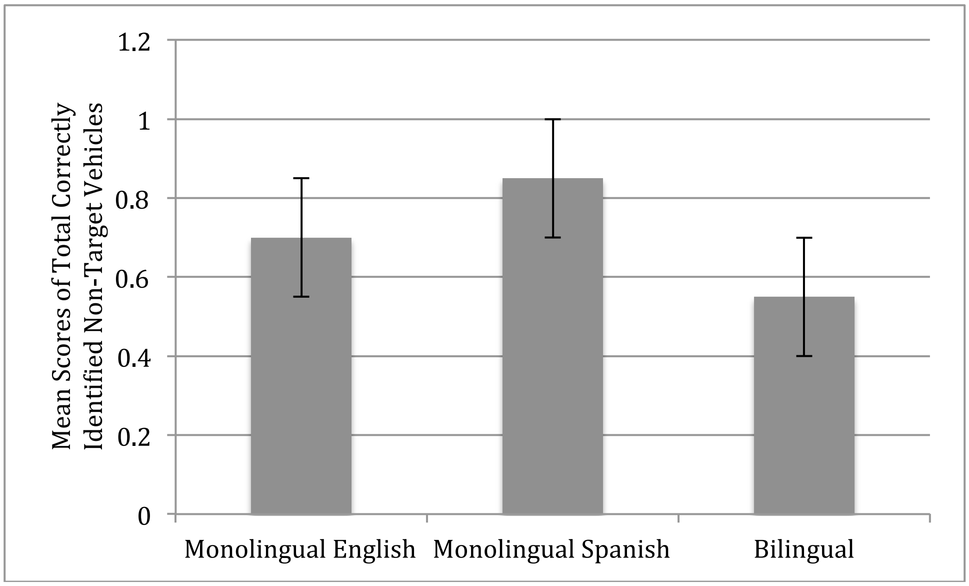


Figure 9. Mean Scores of the total correctly identified non-target vehicles in the Car Bike Attentional Control Task of Experiment 3, separately by language group. Errors are summed across the two trials for each child.

A series of ANOVAs was conducted on the time completion (in seconds) for each of the six trials and then averaged as a dependent variable and language group as a between-subjects factor. This ANOVA revealed no significant differences between the language groups, $F(2,57) = 2.550$, $p = .087$, $\eta^2 = .08$. Finally, there was not a significant difference in total time completion in seconds between Bilinguals, monolingual English and monolingual Spanish speakers. (See Table 6 for time completion for language groups in seconds).

Table 6

Time completion means (seconds) for the Car/Bike Attentional Control task of Experiment 3, by language group.

	Language Group				
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Time (seconds)					
Trial 1* M (SD)	13.75 (7.12)	6.80 (4.21)	9.05 (4.14)	8.818	0.24
Trial 2*	15.70 (6.59)	10.95 (2.62)	11.95 (3.07)	6.292	0.18
Trial 3	13.80 (4.94)	12.65 (3.00)	13.80 (5.59)	0.410	0.01
Trial 4	12.40 (5.05)	10.60 (4.31)	11.80 (3.69)	0.873	0.03
Trial 5	11.45 (4.07)	10.80 (2.59)	10.10 (2.92)	0.860	0.03
Trial 6	11.25 (3.11)	9.60 (2.66)	11.83 (3.72)	2.317	0.08

Comparison Between Tasks. Experiment 3 examined whether (1) bilinguals have better attentional control (Embedded Figures) and (2) whether attentional control relates to their performance on the car-bike task. If the bilinguals were primarily using attentional control to selectively focus on the target vehicles, then bilinguals recall of the target vehicles would be positively correlated with their performance on the embedded figures task. Despite a significant advantage for bilinguals on the Embedded Figures Task there was not a significant relationship between performance on Embedded Figures Task and recall of target vehicles in the CarBike Task, $r(58) = .108$, $p = .51$, suggesting attentional control may not be the primary mechanism for success in that task. Instead, it may be that inhibition plays a bigger role.

These results suggest no significant relationship between embedded figures and non-target vehicles, $r(58) = -.004$, $p = .98$, there was not a significant relationship between performance on target vehicles and the bus $r(58) = .062$, $p = .636$ and no significant relationship between non-target vehicles and the bus, $r(58) = -.131$, $p = .32$. Since bilinguals were better able to remember target vehicles and buses, and less able to remember non-target vehicles these results suggest that inhibition plays a bigger role.

Discussion

In this last experiment, executive functioning-attentional control was the second type of executive functioning that was measured independently and with a visual-spatial memory task. The embedded figures measure had not been previously utilized to measure other types of executive functioning (e.g. inhibitory control). A cognitive advantage was found among bilinguals in this initial task and this finding is congruent with previous studies that display an advantage for bilinguals on executive functioning-attentional control (Bialystok, 2001; Emmorey, Luk, Pyers, Bialystok, 2008). And like examination of executive-inhibitory control in Experiment 2, this current experiment found another executive functioning advantage among low SES populations.

In the Car Bike Task, bilinguals did significantly differ from monolinguals on both target trials and on bus trials and did not perform significantly worse on non-target trials. This finding suggests that perhaps when solving visual spatial memory tasks, bilingual may be utilizing inhibitory control, instead of attentional control. In the Car Bike Task, bilinguals significantly recalled seeing the bus than the correct number of the other non-target vehicle, suggesting that bilinguals were inhibiting the other non-target vehicle because they had been previously asked to either pay attention to cars or bicycles, anticipating one or the other vehicle but not a bus. Therefore bilingual children were recalling the target vehicle and inhibiting the non-target vehicle, and accurately remembering the bus because it was never explicitly as a target video prior to a video. The theoretical implications of these findings may suggest that bilinguals, in the absence of specific instruction (e.g. this vehicle, NOT that vehicle), are still spontaneously inhibiting the sub group of non-target vehicles. This finding these studies have put forth new areas to explore in relation to the bilingual cognitive advantage and unexplored areas of meta-cognition among bilingual populations.

General Discussion

The present dissertation addressed previous methodological and developmental inconsistencies regarding bilingual cognition among early populations through three experiments. Each experiment utilized three language group comparisons and low-SES four-year olds and found cognitive advantages were present for bilinguals across all three experiments. These findings suggest having equal proficiency levels in two languages lead to success on tasks of visual-spatial memory, inhibitory control, and attentional control. Results of these experiments are presented in Figure 10, with the mean scores and time competitions of dependent variables, converted to z-scores, combining and averaging across language groups. Displaying success for bilinguals, with exception of time completion for the Car/Bike Attentional Control task. For tasks in which a lower score indicates success, the inverse z-score was reported.

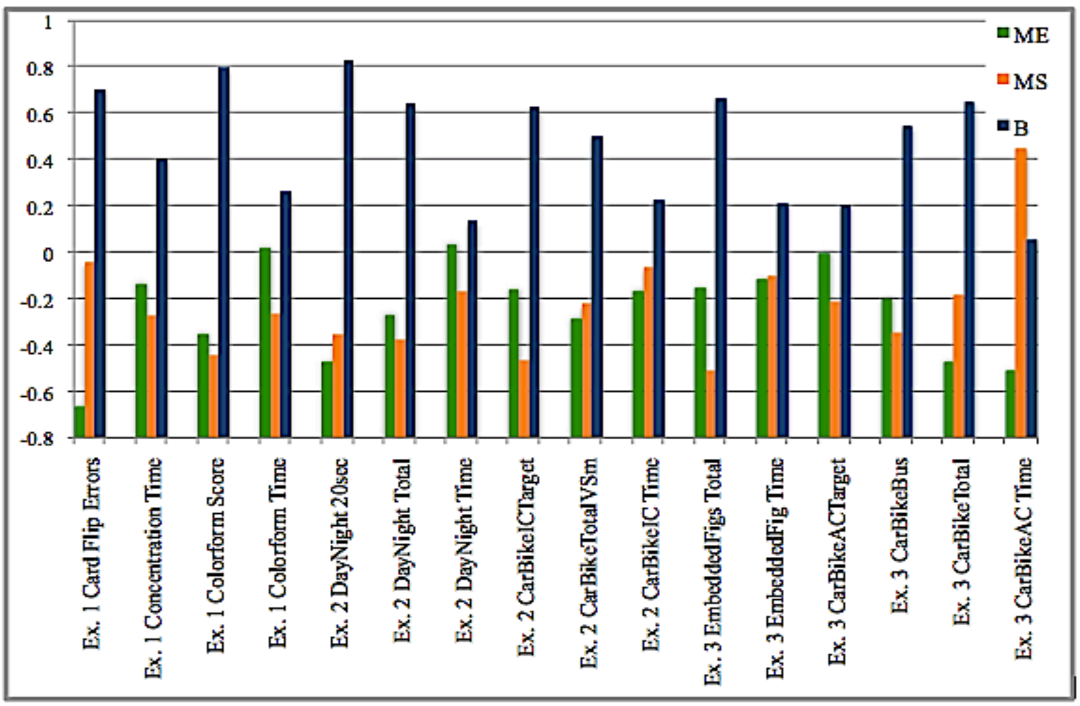


Figure 10. Means converted to Z-scores of each dependent variable for each experiment. Z-score inverses were computed for dependent variables where lower scores were better, higher Z-scores represent success on task.

In Experiment 1, language groups were measured on two types of visual-spatial memory tasks. Before such time, visual-spatial recognition (McLeay, 2003) and memory (Kormi-Nouri, Moniri, & Nilsson, 2003) had been assessed separately with older bilingual populations. Experiment 1 addressed these limitations and revealed an advantage for bilinguals over monolinguals in the Concentration task with fewer card-flip errors and recalling more colors, shapes, and locations of target items in the Colorforms task. These results speak to previous work, suggesting bilinguals tend to rely more on imagery then monolinguals when coding information on spatial manipulation tasks (Bialstok & Senmen, 2004) expanding on the present work of advanced bilingual abilities in a new area of cognition.

In Experiment 2, this dissertation addressed previous inconsistencies related to the executive functioning mechanism of inhibitory control and incorporated a measure to test a inhibitory control with visual-spatial memory. Previous studies had utilized overlapping measures for different types of executive functioning. The first task addressed this issue and used a task (Day/Night) that had only been used to measure inhibitory control. Bilinguals successfully labeling significantly more cards than monolinguals. These results are consistent with previous studies that utilize this task (Bialstok & Senmen, 2004). In the second task of inhibitory control and visual-spatial memory, bilinguals were less accurate when identifying the non-target vehicles than monolinguals and were more accurate identifying target vehicles. These results suggest bilinguals were better able to inhibit the non-target vehicle than monolinguals. An additional significant negative correlation between the day/night task and recall of non-target vehicles supports a relationship between executive functioning-inhibitory control tasks and visual-spatial memory.

Experiment 3 expanded results of experiment 2 by isolating an additional measure of executive functioning (attentional control) with visual-spatial memory. To further address issues related to the overlapping measures discussed previously, Experiment 3 utilized a measure (embedded figures) that had not previously been used to measure other components of executive functioning, to independently measure attentional control. Bilinguals outperformed monolinguals, identifying significantly more embedded target-shapes across six games of embedded figures tasks. In the second task of Experiment 3, no language group difference were found for non-target vehicles (either cars or bicycles); however, bilinguals identified more target vehicles than monolinguals and were more accurate recalling the presence of a bus (distractor). When comparing the success on embedded figures with better recall of target-vehicles, there was no significant correlation. These results suggest success on the car/bike task may involve another type of executive functioning (inhibitory control). Bilinguals may be spontaneously utilizing inhibitory control to inhibit or suppress the non-target vehicles, and therefore more accurate on the embedded figures task and better recalling the target vehicles and distractor vehicle. Bilinguals, in the absence of direct instruction, may be using meta-cognition to solve tasks.

The present work contributes to the existing literature in support of cognitive benefits of bilingualism and provides evidence of early advantages among young, low-SES Spanish-English bilinguals. Although the current studies do not suggest these bilingual benefits will continue to be significant over time, results provide evidence and support for future investigations of early bilingual populations.

Limitations. A possible criticism of the current dissertation pertains to issues of direction of causality (i.e. does balanced bilingualism enhance cognition or are these children just intellectually gifted and happen to become balanced bilinguals?). In this dissertation, children did not complete an IQ measure and therefore IQ was not controlled. One may argue that different IQ levels rather than bilingualism drove the observed differences for each experiment. However, it is not likely that there were large IQ discrepancies within or between the groups in light of the fact all participants for each experiment, were recruited from the same preschools and thus all had at least similar exposure to preschool material.

Another component that was not accounted for was frequency of adult-child interactions. One may argue that perhaps bilingual parents, through reinforcement of the native language at home, spend more time interacting with their children. These interactions could imply some social factors not previously considered that could increase cognitive abilities. For example, research suggests children who have more social interactions with parents possess an increased vocabulary of quantity and quality, even among low-SES populations (Dodici, Draper, & Peterson, 2003). One might also consider that bilingual children often possess the role of translator, sometimes referred to as “Child language brokering”, translating information back and forth between parents (e.g. using the native language) and another adult (e.g. second language) (McQuillian & Tse, 1995; Tse, 1996). Both of these types of early interactions with adults provide opportunities for bilingual children to practice their respective languages and with adult vocabulary. Another alternative explanation may be the level of proficiency of bilinguals.

The results of these experiments are limited to bilinguals with a particular degree of proficiency. The success of these tasks by bilinguals suggests advantages on cognitive tasks are only present when the bilingual obtains balanced proficiency in the first and second language, a consistent finding with current research (Carlson & Meltzoff, 2008; Martin-Rhee & Bialystok, 2008). Although earlier research (Peal & Lambert, 1967) established no cognitive determent to exposure to a second language, it may be useful to include additional populations of various levels of proficiency to observe any potential cognitive benefits. In addition, understanding the various degrees of proficiency may give insight into the cause and effect of early bilingualism on cognitive development.

Lastly the tasks used in Experiments 1, the embedded figures task, and the car bike tasks for Experiments 2 and 3 were not standardized tasks and were created for the current dissertation. Due to this factor, the validity of these findings and possible replication of these effects with future populations may be called into question. At present, there are few tasks that have not already been utilized for more than one type of mechanism and could be used to measure independent components of executive functioning. To provide a more sound comparison researchers should consider developing standardized tasks for younger populations, particularly for the executive functioning mechanisms.

Finally, although strategies were observed post hoc and were not analyzed in depth, future researchers may consider creating measures to test for specific types of strategy use. Specifically, how children use strategies to succeed on problem solving tasks, providing additional insight into the cognitive processes bilinguals and monolinguals exhibit when performing tasks. If specific strategies lead to success on cognitive tasks, future researchers may be interested in the application of these strategies in classroom settings.

Implications for Future Research. In order to examine a cause and effect of bilingualism, future research should pursue longitudinal studies to compare children who attend both bilingual dual-immersion schools (e.g. schools that focus on instruction of both the native- and second-language) and children who attend non-bilingual programs. In an early longitudinal study by Bank & Swain (1975), researchers evaluated IQ scores for children from regular and French-Canadian dual immersion programs and found that children who attended the dual immersion schools possessed significantly higher IQ scores throughout the testing points during the five year period. In an additional study by Diaz (1985) Spanish-English bilingual children (ages 5-7) who were enrolled in dual language immersion bilingual education programs were evaluated on cognitive tasks at two different time points (approximately six months apart). Results revealed increased proficiency in the second language (English) was a strong predictor of metalinguistic awareness and performance on nonverbal problem solving tasks. These results provide support for examining the potential cause and effect of increased bilingual proficiency.

These cognitive advantages may also combat education and achievement gaps for non-native English speakers. Recent studies have identified a positive relationship between SES and executive functioning suggesting advanced executive functioning may combat the academic deficits of low-SES environments (Lawsone, Hook, Hackman, & Farah; 2013). In this dissertation bilinguals succeeded on tasks of executive functioning despite possible confounding negative effects of low-SES, a finding that is consistent with recent research by Engel de Abreu, Cruz-Santos, Tourinho, Martin, and Bialystok (2012). In a recent study of low-SES bilingual children by Engel de Abreu et al., (2012), children (8-9 years old) were administered a series of executive functioning tasks and found a significant difference between bilinguals over monolinguals, suggesting bilingualism may, to some degree, be lessen the effects of low-SES environments.

In the past few years, education researchers have reported the majority of children who do not graduate high school are non-native English speakers and are often from low-SES Spanish-speaking populations. Many of these children, labeled as "Long-Term English Learners," attain conversational English skills but do not gain the academic English skills needed to complete high school (limited proficiency of academic English) (Menken & Kleyn, 2009; Olsen & Wan, 2010). Educational studies have cited reports of dual-immersion programs (teaching both the native and second language) as a possible method to closing the achievement gap for children (Menken & Kleyn, 2009; Olsen & Wan, 2010). Further suggesting children without support for native language proficiency will not gain the linguistic support needed to academic proficiency in English (Olsen & Wan, 2010). These recent discoveries of bilingual advantages among low-SES populations and increased academic achievement suggest a possible shift in support of bilingual education.

With respect to classroom application, this research is still in early stages of becoming an established field that can be used as a foundation for educators, researchers, and policy makers to make substantial changes to improve second language learning in the classroom. Until recently, the state of California has acknowledged and has recently attempted to promote foreign language instruction and bilingualism in public education. According to the Department of Education for California (2003), studying a foreign language completes and improves a student's education while providing a foundation for further cognitive development and overall scholastic achievement. Currently, the state of California only requires one-year of a foreign language as part of a high school graduation requirement. (CA Department of Education, 2003). Nevertheless, introducing a language in high school seems less than ideal and perhaps unattainable (due to limited time constraints) if students wish to gain cognitive and proficiency benefits associated with learning a second language.

While the educational goal for most settings in the United States focus only on the development and proficiency of English as a second language for students, the child's native language is sometimes discouraged or forbidden. Studies show that there is a direct correlation between the amount of time devoted to language study, and the language proficiency that students actually attain. In addition, children gain proficiency faster when they are encouraged to utilize the background knowledge of their native language (Curtain & Pesola, 1988; Cummins, 1989, Thomas & Collier, 1997). Children who begin foreign language study in elementary school, and continue such study for a number of years, have a better chance of developing a high level of foreign language proficiency (Cazabon et al., 1998l; Cummins, 1989, Evans, 1959), and with this level of balanced proficiency, an increase in cognitive abilities.

The results of the current dissertation have addressed several gaps in the current research of cognitive advantages but questions still remain: What are the causal mechanism(s) of bilingualism on different areas of cognition? What are the long-term benefits of bilingualism for low-SES bilinguals? How can educators and public policy makers utilize the current research to effectively implement native languages in the school environment? Current educators, who are committed to equitable education for limited English proficient students, will need to evolve present research to incorporate the role of bilingual cognition in second-language instruction at all levels of education, particularly early education, allowing bilinguals to utilize these cognitive advantages throughout formal education.

References

Baker, C. (1993). *Foundations of bilingual education and bilingualism*. Clevendon, Avon, England: Multilingual Matters.

Ben-Zeev, S. (1977). The influence of bilingualism on cognitive strategy and cognitive development. *Child Development, 48*(3), 1009-1018.

Bialystok, E. (1986). Children's concept of word. *Journal of Psycholinguistic Research, 15*, 13-32.

Bialystok, E. (1987). Influences of bilingualism on metalinguistic development. *Second Language Research, 3*, 154-166.

Bialystok, E. (1988). Levels of bilingualism and levels of linguistic awareness. *Developmental Psychology, 24*, 560–567.

Bialystok, E. (1991). *Language processing in bilingual children*. Cambridge: Cambridge University Press.

Bialystok, E. (1994). Analysis and control in the development of second language proficiency. *Studies in Second Language Acquisition 16*(2), 157–168.

Bialystok, E., & Codd, J. (1997). Cardinal limits: evidence from language awareness and bilingualism for developing concepts of number. *Cognitive Development, 12*, 85-106.

Bialystok, E., & Majumder, S. (1998). The relationship between bilingualism and the development of cognitive processes in problem-solving. *Applied Psycholinguistics, 19*, 69-85.

Bialystok, E. (2001). *Bilingualism in development: language, literacy, and cognition*. New York: Cambridge University Press.

Bialystok, E., & Martin, M.M. (2004). Attention and inhibition in bilingual children: evidence from the dimensional change card sort task. *Developmental Science, 7*, 325-339.

Bialystok, E., & Senman, L. (2004). Executive in appearance-reality tasks: the role of inhibition of attention and symbolic representation. *Child Development, 75*, 562-579.

Bialystok, E., Craik, F.I.M., Klein, R., & Viswanathan, M. (2004). Bilingualism, aging, and cognitive control: evidence from the simon task. *Psychology and Aging, 19*, 290-303.

Bialystok, E., Martin, M.M., & Viswanathan, M. (2005). Bilingualism across the lifespan: the rise and fall of inhibitory control. *International Journal of Bilingualism, 9*, 103-119.

Bialystok, E., & Shapero, D. (2005). Ambiguous benefits: the effect of bilingualism on reversing ambiguous figures. *Developmental Science, 8*, 595-604.

Bialystok, E. (2005). *Consequences of bilingualism for cognitive development*. In J.R. Kroll & A.de Groot (Eds.), *Handbook of Bilingualism: Psycholinguistic Approaches* (pp. 417-432). Oxford: Oxford University Press.

Bialystok, E., Craik, F.I.M., Grady, C., Chau, W., Ishii, R., Gunji, A., & Pantev, C. (2005). Effect of bilingualism on cognitive control in the simon task: evidence from MEG. *NeuroImage, 24*, 40-49.

Bialystok, E., Craik, F.I.M., & Ryan, J. (2006). Executive control in a modified anti saccade task: effects of aging and bilingualism. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*, 1341–1354.

Bialystok, E., Craik, F., Freedman, M. (2007). Bilingualism as a protection against the onset of symptoms of dementia. *Neuropsychologia, 45*, 459-64

Bialystok, E., Craik, F.I.M., & 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.

Bialystok, E., & DePape, A-M. (2009). Musical expertise, bilingualism, and executive functioning. *Journal of Experimental Psychology: Human Perception and Performance, 35*, 565-574.

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

Brooks-Gunn, J. & Duncan, G. (1997). The effects of poverty on children and youth. *The Future of Children, 7*, 55-71.

Bunge, S. A., Dudukovic. N. M., Thomason, M. E., Vaidya, C. J., & Gabrieli, J. D. E. (2002). Development of frontal lobe contributions to cognitive control in children: evidence from fMRI. *Neuron, 33*, 301-311.

Campbell, J.I.D. (2005). *Handbook of mathematical cognition*. Hove: Psychology Press

Carlson, S.M. (2003). Executive function in context: development, measurement, theory, and experience. *Monographs of the Society for Research in Child Development, 68*(274), 138–151.

Carlson, S.M. & Meltzoff, A.N. (2008). Bilingual experience and executive functioning in young children. *Developmental Science, 11*(2), 282-298.

Cummins, J. (1978). Bilingualism and the development of metalinguistic awareness. *Journal of Cross Cultural Psychology, 9*, 131–149.

Cazabon, M. T., Nicoladis, E., & Lambert, W. E. (1998). Becoming bilingual in the amigos two-way immersion program. *Center for Research on Education, Diversity & Excellence: University of California, Santa Cruz.*

Colzato, L. S., Bajo, M. T., van den Wildenberg, W., Paolieri, D., Nieuwenhuis, S. T., La Heij, W., & Hommel, B. (2008). How does bilingualism improve executive control? A Comparison of Active and Reactive Inhibition Mechanisms. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 34*, 302-312.

Costa, A., Miozzo, M., & Caramazza, A. (1998). Lexical selection in bilinguals: do words in the bilingual's two lexicons compete for selection? *Journal of Memory and Language, 41*(3), 365-397.

Craik, F.I.M., Bialystok, E., Freedman, M. (2010). Delaying the onset of Alzheimer disease: bilingualism as a form of cognitive reserve. *Neurology, 75*(19), 1726 1725.

Cromdal, J. (1999). Childhood bilingualism and metalinguistic skills: analysis and control in young Swedish-English bilinguals. *Applied Psycholinguistics, 20*(1), 1-20.

Cummins, J. & Gulutsan, M. (1974). Bilingual education and cognition. *The Alberta Journal of Educational Research, 20*, 259-269.

Cummins, J. (1977). Cognitive factors associated with the attainment of intermediate levels of bilingual skills. *The Modern Language Journal, 61*(1/2), 3-12.

Cummins, J. (1978). Bilingualism and the development of metalinguistic awareness. *Journal of Cross Cultural Psychology, 9*, l31-l49.

Cummins, J. (1979). Linguistic interdependence and the educational development of bilingual children. *Review of Educational Research, 49*, 222-25l.

Curtain, H. A. & Pesola, C. A. (1988). *Languages and children--Making the match*. Reading, MA: Addison-Wesley Publishing Company.

Diamond, A., Carlson, S.M., & Beck, D.M. (2005). Preschool children's performance in task switching on the dimensional change card sort task: Separating the Dimensions Aids the Ability to Switch. *Developmental Neuropsychology, 28*(2), 689-729.

Diaz, R. (1985). Bilingual cognitive development: addressing three gaps in current research. *Child Development, 56*(6), 1376-1388.

Emmorey, K., Luk, G., Pyers, J.E., & Bialystok, E. (2008). Research report: the source of enhanced cognitive control in bilinguals, evidence from bimodal bilinguals. *Association for Psychology Science, 19*(12), 1201-1206.

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science, 11*, 19–23.

Engel de Abreu, P.M.J., Cruz-Santos, A., Tourinho, C., Martin, R., Bialystok, E. (2012). Bilingualism enriches the poor: enhanced cognitive control in low income minority children. *Psychological Science, 23*(11), 1364-1371.

Feng, X., Diamond, A. & Bialystok, E. (2007). Manipulating information in working memory: an advantage *for* bilinguals. Poster presented at the *biennial meeting of the Society for Research in Child Development, Boston, MA*.

Flege, J. E. (1987). *“The production of ‘new’ and ‘similar’ phones in a foreign language: evidence from the effect of equivalence classification.”* Department of Biocommunication, University of Alabama in Birmingham, Birmingham, Alabama 35294, U.S.A.

Frye, D. Zelazo, P.D. and Palfai, T. (2005). Theory of mind and rule-based reasoning. *Cognitive Development, 10*, 483–527.

Galambos, S.J., & Hakuta, K. (1988). Subject-specific and task-specific characteristics of metalinguistic awareness in bilingual children. *Applied Psycholinguistics, 9*, 141-162.

Galambos, S. & Goldin-Meadow, S. (1990) The effects of learning two languages on levels of metalinguistic awareness. *Cognition, 34*, 1-56.

Green, D.W. (1998). Mental control of the bilingual lexicosemantic system. *Bilingualism: Language and Cognition, 1*, 67–81.

Hakuta, Kenji (1986). *Mirror of language: the debate on bilingualism*. New York: Basic Books.

Hakuta, K. & Diaz, R.M. (1985). *The relationship between degree of bilingualism and cognitive ability: a critical discussion and some new longitudinal data*. In K. E. Nelson (Ed.), Children's Language, 5, 319-344. Hillsdale, N. J.: Lawrence Erlbaum Associates.

Hakuta, K. (1986). *Mirror of language: the debate on bilingualism*. New York: Basic Books.

Hakuta, K., & Gould, L.J. (1987). Synthesis of research on bilingual education. *Educational Leadership, 44*(3), 38-44.

Hamers, J.F. & Blanc, M.H. (1989). *Bilingualism and bilinguality*. Cambridge: Cambridge University Press.

Helms, Don, and Sawtelle, Sara M. (2007). "A study of the effectiveness of cognitive skills therapy delivered in a video-game format". *Optom Visual Development, 38*(1), 19-26.

Haugen, E. (1956). *Bilingualism in the Americas: a bibliography and research guide*. Alabama: University of. Alabama Press.

Ivanova, I. & Costa, A. (2008). Does bilingualism hamper lexical access in highly-proficient bilinguals? *Acta Psychologica, 127*, 277-288.

Jacoby, L.L. (1991). A process dissociation framework: separating automatic from intentional uses of memory. *Journal of Memory and Language, 30*, 513 541.

Karmiloff-Smith, A. (1992). *Beyond modularity. a developmental perspective on cognitive science*. Cambridge, MA: MIT Press.

Kessler, C., & Quinn, M. E. (1980). *Positive effects of bilingualism of science problema solving abilities*. In J. E. Alatis (Ed.), 31st Annual Georgetown University Round Table on Languages and Linguistics. Washington, DC: Georgetown University Press.

Kormi-Nouri, R., Moniri, S., & Nilsson, L. (2003). Episodic and semantic memory in bilingual and monolingual children. *Scandinavian Journal of Psychology, 44*, 47-54.

Kroll, J. F., & De Groot, A. M .B. (1997*). Lexical and conceptual memory in the bilingual: mapping form to meaning in two languages*. In A. M. B. de Groot, & J.F. Kroll (Eds.), Tutorials in bilingualism: Psycholinguistic perspectives (pp. 169-199).

Lambert, W.E., Tucker, G.R., & d'Anglejan, A. (1973). Cognitive and attitudinal consequences of bilingual schooling. *Journal of Educational Psychology, 85*(2), 141-159.

Landry, R.G. (1974). A comparison of second language learners and monolinguals on divergent thinking tasks at the elementary school level. *Modern Language Journal, 58*(1-2), 10-15.

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.

MacKay, I. & Fledge, J. (2004). Effects of the age of second language (L2) learning on the duration of L1 and L2 sentences: the role of suppression. *Applied Psycholinguistics,25*, 373-396.

McLeay, H. (2003). The relationship between bilingualism and the performance of spatial tasks. *International Journal of Bilingual Education and Bilingualism*, *6*(6), 423-438.

McLoyd, V.C. (1998). Socioeconomic disadvantage and child development. *American Psychologist, 53*(2), 185-204.

McQuillian, J. & Tse, L. (1995). Child language brokering in linguistic minority communities: effects on cultural interaction, cognition, and literacy. *Language and Education, 9*(3), 195-215.

Menken, K. & Kleyn, T. (2009). The difficult road for long-term english learners. *Education Leadership, 66*(7).

Meuter, R.F.I. & Allport, A. (1999). Bilingual language switching in naming: asymmetrical costs of language selection. *Journal of Memory & Language, 40,* 25-40.

Miyake A, Freidman NP, Emerson MJ, Witzki AH, Howerter A, Wager TD. (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.

Norman, D.A. and Shallice, T. (1980/1986). *Attention to action: willed and automatic control of behaviour*. Centre for Human Information Processing (Technical Report #99). Reprinted in revised form in Davidson, R.J., Schwartz, G.E., and Shapiro, D. (Eds.) (1986), Consciousness and Self Regulation (Volume 4), New York: Plenum.

Olsen, L. and Wan, Y. (2010). *Reparable harm: fulfilling the unkept promise of educational opportunity for California's long term English learners.* Long Beach, CA: Californians Together Research & Policy Publication.

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

Ransdell, S. E. and Fischler, I. (1991), Imagery skill and preference in bilinguals. *Applied Cognitive Psychology, 5*, 97–112

Ricciardelli, L. (1992). Bilingualism and cognitive development in relation to threshold theory. *Journal of Psycholinguistic Research. 21*(4). 301-315.

Roberts, R, J., & Pennington, B. F. (1996). An interactive framework for examining prefrontal cognitive processes. *Developmental Neuropsychology, 12*, 105 126.

Rodríguez-Fornells A., de Diego Balaguer R., Münte T.F. (2006). Executive control in bilingual language processing. *Language Learning, 56*, 45-55.

Secada, W. G. (1991). Evaluating the Mathematics Education of Limited English Proficient Students in a Time of Educational Change. Paper presented at the

Second National Research Symposium on Limited English Proficient Student Issues, Washington, D.C.

Silverman, L. K. (2002). *Upside-down brilliance: the visual-spatial learner*. Denver: DeLeon Publishing.

Simon, J. R., and Wolf, J. D. (1963). Choice reaction times as a function of angular stimulus-response correspondence and age. *Ergonomics, 6*, 99-105.

Stern Y., Gurland, B., Tatemichi, TK., Tang, MX, Wilder, D., Mayeux, R. (1994). Influence of education and occupation on the incidence of Alzheimer's disease. *JAMA, 271*, 1004-1010.

Stern, Y. (2002). What is cognitive reserve? theory and research application of the reserve concept. *Journal of the International Neuropsychological Society, 8*, 448-460.

Thomas, W. & Collier, V. (1997). School effectiveness for language minority students *(NCBE Resource Collection Series No. 9)*. Washington, DC: National Clearinghouse for Bilingual Education.

Tse, L. (1996). Language brokering in linguistic minority communities: the case of chinese- and vietnamese-american students. *Bilingualism Research Journal, 20*(3), 485-498.

Winsler, A., Diaz, R,M., McCarthy, E.M., Atencio, D.J. & Chabay, A.L. (1999). Motherchild interaction, private speech, and task performance in preschool children with behavior problems. *Journal of Child Psychology & Psychiatry, 40*, 891-904.

Yang, H., Yang, S, Ceci, S., & Wang, Q. (2005). *Effects of bilinguals' controlled attention on working memory and recognition*. In Cohen, J., McAlister, K., Rolstad, K., & MacSwan, J. (Eds.), Proceedings of the 4th International Symposium on Bilingualism. Somerville, MA: Cascadilla Press.

Zelazo, P. D., Frye, D. & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development, 11*, 37-63.

Winsler, A., Diaz, R.M., Espinosa, L., & Rodriguez, J.L. (1999). When learning a second language does not mean losing the first: bilingual language development in low income, spanish-speaking children attending bilingual preschool. *Child Development, 70*, 349-362.

Appendix A
Demographic Information for Participants in Experiment 1

Table 7

Age and Vocabulary information for Participants in Experiment 1.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Age (Months)			
Mean (SD)	53.3 (3.14)	51.6 (2.78)	52.95 (3.33)
Range	48-59	48-59	48-59
Sex	10m, 10f	10m, 10f	10m, 10f
Verbal Ability (PPVT-English Raw Scores)	63.45, (15.64)	18.85, (6.64)	55.10, (12.46)
Verbal Ability (PPVT-Spanish Raw Scores)	10.65 (5.07)	47.00, (8.35)	51.00 (12.03)

Appendix A1

Demographic Information for Participants in Experiment 1

Table 8

Demographic information for Participants in Experiment 1.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Ethnicity	55% White 5% White (Non-Hispanic) 40% Hispanic	100% Hispanic	80% Hispanic 10% White 5% Asian-Pacific Islander 5% African-American
Education	20% Less than 12 years 40% At least 12 years or high school GED 25% Some College 10% 2-Year College Graduate (Associates Degree) 5% 4-Year College Graduate (Bachelor Degree)	20% Less than 12 years 45% At least 12 years or high school GED 25% Some College 10% 4-Year College Graduate (Bachelor Degree)	30% Less than 12 years 25% At least 12 years or high school GED 35% Some College 5% 2-Year College Graduate (Associates Degree) 5% 4-Year College Graduate (Bachelor Degree)
Income	55% Less than $20,000 45% $20,000-$39,999	80% Less than $20,000 20% $20,000-$39,999	60% Less than $20,000 40% $20,000-$39,999
Marital Status	65% Married 30% Never Married 5% Separated	55% Married 35% Never Married 10% Divorced	90% Married 5% Never Married 5% Divorced
Adults Per Household	55% 2 30% 1 10% 3 5% 1	75% 2 15% 3 10% 1	60% 2 20% 3 15% 4 5% 1
Children Per Household	55% 2 25% 1 20% 3	35% 4 30% 2 25% 3 10% 1	30% 2 30% 3 15% 1 15% 5 5% 4 5% 6

Appendix B

Demographic Information for Participants in Experiment 2

Table 9

Age and Vocabulary Information for Participants in Experiment 2.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Age (Year;Month)			
Mean (SD)	53.65 (3.50)	54.35 (3.31)	55.15 (2.94)
Range	48-59	48-59	48-59
Sex	10m, 10f	10m, 10f	10m, 10f
Verbal Ability (PPVT-English Raw Scores)	54.45, (10.63)	21.70, (6.92)	56.75, (23.26)
Verbal Ability (PPVT-Spanish Raw Scores)	9.75, (3.85)	60.60, (16.53)	57.50, (16.11)

Appendix B1

Demographic Information for Participants in Experiment 2

Table 10

Demographic Information for Participants in Experiment 2.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Ethnicity	65% Hispanic 10% White 10% African-American 10% Other (Hmong) 5% Asian-Pacific Islander	100% Hispanic	100% Hispanic
Education	15% Less than 12 years 50% At least 12 years or high school GED 15% Some College 15% 2-Year College Graduate (Associates Degree) 5% 4-Year College Graduate (Bachelor Degree)	55% Less than 12 years 40% At least 12 years or high school GED 5% Some College	35% Less than 12 years 45% At least 12 years or high school GED 15% Some College 5% 2-Year College Graduate (Associates Degree)
Income	65% Less than $20,000 35% $20,000-$39,999	75% Less than $20,000 25% $20,000-$39,999	70% Less than $20,000 30% $20,000-$39,999
Marital Status	65% Married 25% Never Married 5% Widowed 5% Divorced	75% Married 25% Never Married	65% Married 25% Never Married 10% Separated
Adults Per Household	50% 2 20% 4 15% 1 15% 3	80% 2 10% 3 5% 4 5% 6	65% 2 15% 1 10% 3 10% 4
Children Per Household	30% 1 25% 2 25% 3 10% 4 5% 5 5% 7	35% 2 35% 3 15% 1 15% 4	30% 2 25% 3 20% 4 15% 1 10% 2

Appendix C
Demographic Information for Participants in Experiment 3

Table 11

Age and Vocabulary Information for Participants in Experiment 3.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Age (Year;Month)			
Mean (SD) 4.35	53.2 (3.37)	52.2 (3.33)	53.7 (4.12)
Range	48-59	48-59	48-59
Sex	10m, 10f	10m, 10f	10m, 10f
Verbal Ability (PPVT-English Raw Scores)	57.05, (12.13)	17.10, (6.55)	54.95, (23.75)
Verbal Ability (PPVT-Spanish Raw Scores)	8.90 (4.06)	55.55, (12.15)	55.65, (15.54)

Appendix C1

Demographic Information for Participants in Experiment 3

Table 12

Demographic Information for Participants in Experiment 3.

	Language Group		
	Monolingual English	Monolingual Spanish	Bilingual
Ethnicity	85% Hispanic 5% Asian-Pacific Islander 5% African-American 5% Other (Hmong)	100% Hispanic	100% Hispanic
Education	35% Less than 12 years 15% At least 12 years or high school GED 25% Some College 10% 2-Year College Graduate (Associates Degree) 15% 4-Year College Graduate (Bachelor Degree)	45% Less than 12 years 25% At least 12 years or high school GED 5% Some College 25% 4-Year College Graduate (Bachelor Degree)	70% Less than 12 years 15% At least 12 years or high school GED 5% Some College 5% 2-Year College Graduate (Associates Degree) 5% 4-Year College Graduate (Bachelor Degree)
Income	75% Less than $20,000 25% $20,000-$39,999	85% Less than $20,000 15% $20,000-$39,999	95% Less $20,000 5% $20,000-$39,999
Marital Status	80% Married 5% Widowed 5% Divorced	85% Married 10% Never Married 5% Divorced	90% Married 5% Widowed 5% Never Married
Adults Per Household	65% 2 30% 1 5% 4	70% 2 10% 1 10% 5 5% 3 5% 4	70% 2 20% 4 5% 1 5% 3
Children Per Household	40% 1 30% 2 20% 3 5% 4 5% 5	50% 2 30% 1 15% 4 5% 3	30% 2 25% 1 20% 3 15% 4 10% 6

Appendix D
Strategy Definitions of Experiment 1 Concentration Task

Table 13

Strategies Observed during Experiment 1, Concentration Task.

Strategy	Definition
Touching Shapes	Child touches the shape or traces the shape once the card is turned over.
Naming Shapes	Child names the shape out loud after flipping over the card.
Touching Card Before Flipping	Child touches a card, but does not immediately flip the card.
Hovering	Child keeps their hands over a card (without touching it) and pause between 10 seconds and 50 seconds with their hand(s) over a card before deciding to either flip the card or choose another card.
Flipping Over The Same First Cards	Child flips over the same initial first card from the previous turn. Children were only coded as using this strategy if they turned over the same initial card from the previous turn. Instances where the children turned over the second card from the previous turn are not counted.

Appendix D1
Strategy Results of Experiment 1 Concentration Task

Table 14

Mean number of times a strategy was used in the Concentration task of Experiment 1, separately by language group. Strategies are summed for each type of strategy used, for each child.

		Language Group			
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Strategy					
Touching Shape	3.10 (3.08)	4.30 (6.05)	5.50 (6.42)	0.990	0.03
Naming Shape	0.75 (1.97)	0.25 (0.44)	1.65 (3.28)	2.034	0.07
Touch Before Flipping	13.45 (5.94)*	9.20 (9.15)	17.90 (8.14)**	6.129	0.18
Hovering	3.10 (3.08)*	4.30 (6.05)	5.50 (6.42)**	6.364	0.18
Flipping Over Same First Card	1.35 (2.37)	1.65 (1.85)	1.90 (2.51)	0.297	0.03

*significant < .05, **significant < .016

Appendix D2

Strategy Definitions of Experiment 1 Colorforms Task

Table 15

Strategies Observed during Experiment 1, Colorforms Task.

Strategy	Definition
Touching Shapes	Child names the shape(s) out loud during the presentation of pictures and during the force-choice answer session.
Naming Shapes	Consists of either touching one or more shapes presented on the picture.
Naming Colors	Names the color of the shape(s).
Touching Location of Missing Shape	Child touches the area or location of the missing shape as soon as the picture was presented and then chose a shape to place in that location.
Relating The Shape	Child comments on the shape as resembling something else, giving the shape a new context. For example, children would that the rectangle looked like red Lego block.

Appendix D3
Strategy Results of Experiment 1 Colorforms Task

Table 16

Means of when a strategy was used in the Concentration task of Experiment 1, separately by language group. Strategies are summed for each child and type of strategy.

		Language Group			
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Strategy M (SD)					
Touching Shape	14.25 (8.08)	12.90 (17.34)	20.45 (11.64)	1.939	0.06
Naming Shape	4.45 (6.98)	0.40 (1.14)	3.20 (3.96)**	3.926	0.12
Naming Colors	4.50 (8.32)	0.60 (1.39)	8.60 (10.96)	5.017	0.15
Touching Location of Missing Shape	1.05 (1.96)	0.60 (1.35)	2.75 (3.04)	5.171	0.15
Relating the Shape	0.30 (0.98)	0.00 (0.00)	0.25 (0.72)	1.054	0.04

Appendix E
Strategy Definitions of Experiment 2 Day/Night Task

Table 17

Strategies Observed during Experiment 2, Day/Night Task.

Strategy	Definition
Looking Away	Child looks away from the card presented to them when giving their answer to the task.
Utterance to Pause	Child stalls before answering (to either prevent from uttering impulsively the wrong term, or to give them a little time to remember what to say).
Repeats Instructions	Child repeats the researchers instructions out loud, immediately after the initial instructions of the task were given.

Appendix E1
Strategy Results of Experiment 2 Day/Night Task

Table 18

Means of when a strategy was used in the Day/Night task of Experiment 2, separately by language group. Strategies are summed for each type of strategy, for each child.

		Language Group			
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Strategy					
Looking Away	5.45 (4.59)	5.45 (4.59)	7.40 (5.59)	1.036	0.04
Utterance Before Answering	0.00 (0.00)	0.00 (0.00)	0.15 (0.37)	3.353	0.11
Repeats Instructions	0.00 (0.00)	1.30 (3.15)	1.30 (3.70)	1.432	0.05

Appendix E2

Strategy Definitions of Experiment 2 Car Bike Inhibitory Control VSM Task

Table 19

Strategies Observed during Experiment 2, Car Bike Inhibitory Control VSM Task.

Strategy	Definition
Points to Screen	Child points to the computer screen or follow the vehicles with their finger as the vehicles went across the screen.
Counts Aloud During Video	Child counts the number of the target vehicle as it passed on the screen.
Counts Vehicles when Choosing	Child counts the vehicles on the force-choice cards.
Color Reference Comments(s)	Child makes a comment regarding the color of the vehicles presented to them.
Refers or Looks at Screen When Choosing	Child looks back at the screen of the laptop, displaying empty street lanes to reference where they might have seen the vehicles during the video.
Hovering	Child hovers their hand or hands over a card they were considering as their answer.
Repeats Instructions	Child repeats parts of the instructions that are given to them from the experimenter.

Appendix E3

Strategy Results of Experiment 2 Car Bike Inhibitory Control VSM Task

Table 20

Means of when a strategy was used in the Car Bike Inhibitory Control VSM Task of Experiment 2, separately by language group. Strategies are summed for each type of strategy, for each child.

		Language Group			
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Strategy M (SD)					
Points To Screen	1.75 (2.43)	1.90 (2.34)	2.55 (2.63)	0.595	0.02
Counts During Video	1.40 (2.23)	0.90 (1.89)	2.45 (2.82)	2.275	0.07
Counts During Choosing	0.50 (1.15)	0.25 (0.72)	1.30 (1.63)	4.037	0.12
Refers to Screen When Choosing	0.30 (1.34)	0.00 (0.00)	0.00 (0.00	1.000	0.03
Color Reference	0.10 (0.31)	0.00 (0.00)	0.80 (1.54)	4.609	0.14
Hovers	0.30 (0.57)	0.15 (0.49)	1.20 (1.94)	4.486	0.14
Repeats Instructions	0.40 (0.82)	1.60 (1.88)	0.45 (0.89)	5.556	0.16

Appendix F

Strategy Definitions of Experiment 3 Embedded Figures Task

Table 21

Strategies Observed during Experiment 3, Embedded Figures Task.

Strategy	Definition
Names Shapes	Child searches for a particular shape and would sometimes name the shapes as they scanned and searched for the target shape.
Target Shape	Child repeats the target shape more than once, for example, if the target word was 'triangle', children would repeat to themselves out loud… "Triangle, find the triangles."
Counts Aloud	Child counts out loud each time he or she discovers a target shape.

Appendix F1
Strategy Results of Experiment 3 Embedded Figures Task

Table 22

Mean number of times a strategy was used in the Embedded Figures task of Experiment 3, separately by language group. Strategies are summed for each type of strategy, for each child.

Language Group					
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Strategy					
Names Shape M (SD)	0.35 (0.75)	0.00 (0.00)	1.05 (2.82)	2.018	0.07
Repeats Instructions	0.00 (0.00)	0.05 (0.22)	0.25 (0.91)	1.195	0.04
Counts Aloud	0.10 (0.45)	0.00 (0.00)	0.25 (0.91)	0.923	0.03

Appendix F2

Strategy Definitions of Experiment 3 Car Bike Attentional Control VSM Task

Table 23

Strategies Observed during Experiment 3, Car Bike Inhibitory Control VSM Task.

Strategy	Definition
Points to Screen	Child points to the computer screen or follow the vehicles with their finger as the vehicles went across the screen.
Counts Aloud During Video	Child counts the number of the target vehicle as it passed on the screen.
Counts Vehicles when Choosing	Child counts the vehicles on the force-choice cards. Many children counted out loud while choosing the number of vehicles they saw, many who counted out loud while watching the video did the same counting out loud during the force choice directly after viewing the video.
Color Reference Comments(s)	Child makes a comment regarding the color of the vehicles presented to them.
Refers or Looks at Screen When Choosing	Child looks back at the screen of the laptop, displaying empty street lanes to reference where they might have seen the vehicles during the video.
Hovering	Child hovers their hand or hands over a card they were considering as their answer.
Repeats Instructions	Child repeats parts of the instructions that are given to them from the experimenter.

Appendix F3

Strategy Results of Experiment 3 Car Bike Attentional Control VSM Task

Table 24

Means number of times a strategy was used in the Car Bike Attentional Control task of Experiment 3, separately by language group. Strategies are summed for each type of strategy, for each child.

		Language Group			
	Monolingual English	Monolingual Spanish	Bilingual	F	Effect Sizes
Strategy M (SD)					
Points To Screen	0.85 (1.57)	0.85 (1.57)	1.25 (1.55)	0.438	0.02
Counts During Video	1.40 (2.19)	0.80 (1.32)	2.10 (2.38)	2.082	0.07
Counts During Choosing	0.00 (0.00)	0.00 (0.00)	0.75 (1.25)	7.185	0.20
Refers to Screen When Choosing	0.05 (0.22)	0.00 (0.00)	0.50 (1.24)	2.886	0.03
Color Reference	0.10 (0.45)	0.00 (0.00)	0.15 (0.49)	0.796	0.03
Hovers	0.15 (0.37)	0.00 (0.00)	0.40 (0.88)	2.683	0.09
Repeats Instructions	2.60 (3.56)	2.05 (2.56)	5.30 (5.71)	3.499	0.11

Appendix G
PPVT English Scoring Sheet
(Not shown here due to copyright protection)

Appendix H

PPVT Spanish Scoring Sheet

(Not shown here due to copyright protection)

Appendix I
Demographic Survey- English

If you chose to participate in this study, please fill out the following survey. This should take approximately 10-15 minutes. Then, please return it to us in the provided envelope. Please note that we will photocopy both the letter and survey, and once photocopied, your identifying information on this sheet will be permanently separated from your answers on the other side of the sheet; in addition, the originals will be destroyed to ensure confidentiality.

Please respond to each of the following questions listed below as accurately as possible. Please do not leave any question unanswered.

---

1) What is your relationship to the child? (Circle one)

(a) Mother
(b) Father
(c) Grandmother
(d) Grandfather
(e) Other (Please write in):
____

2) Which of the following best describes your current marital status? (Circle one)

(a) Married
(b) Widowed
(c) Separated
(d) Divorced
(e) Never Married

3) Please indicate your ethnicity.

(a) White
(b) White (non-Hispanic)
(c) Hispanic
(d) Asian-Pacific Islander
(e) Native American
(f) African-American
(g) Other: __________

4) Please indicate the highest level of education you have completed.

(a) Less than 12 years
(b) At least 12 years or High School/GED
(c) Some college
(d) 2-Year College Graduate (Associates Degree)
(e) 4-Year College Graduate (Bachelor Degree)
(f) Masters Degree or Higher

5) How many people other than the child lives in the child's household?

Number of adults_____________
Number of children___________

6) Which of the following categories best describes your total household income before taxes last year? Please include income from all sources such as salaries and wages, Social Security, retirement income, investments, and other sources.

(a) Less than $20,000
(b) $20,000--$39,999
(c) $40,000--$59,999
(d) $60,000--$79,999
(e) $80,000 or more

Appendix J
Demographic Survey- Spanish

Si decide participar en este estudio, por favor conteste la siguiente encuesta. La encuesta durará aproximadamente 10 a 15 minutos en contestar. Por favor devuelva la encuesta en el sobre que le hemos proporcionado. Para mantener su información personal confidencial, queremos informarle que sacaremos fotocopia de la carta y la encuesta. Una vez hecho esto, los documentos originales serán destruidos.

Hacemos esto con el fin de que sus respuestas no sean conectadas con su información personal. Por favor conteste cada pregunta lo mejor que pueda. Por favor no deje ninguna pregunta sin contestar.

---

1) ¿Cuál es su parentesco con el niño/a? (Marque uno)

(a) Madre
(b) Padre
(c) Abuela
(d) Abuelo
(e) Otro (Por favor escriba): __________________________________

2) ¿Cuál es su estado civil? (Marque uno)

(a) Casado/a
(b) Viudo/a
(c) Separado/a
(d) Divorciado/a
(e) Soltero/a

3) Por favor indique su grupo étnico:

(a) Blanco
(b) Blanco (no-Hispano)
(c) Hispano
(d) Asiático
(e) Nativo Americano
(f) Africano Americano
(g) Otro: ____________

4) Por favor indique el nivel más alto de educación que haya terminado usted o cualquier otra persona en su familia.

(a) Menos de 12 años (primaria/secundaria)
(b) Por lo menos 12 años o High School/GED (preparatoria)
(c) Un poco de universidad
(d) Egresado del Colegio Comunitario – 2 años
(f) Egresado de una universidad de 4 años (Licenciatura)
(g) Maestría o nivel más alto

5) ¿Cuántas personas viven en el hogar del niño sin contar al niño?

Número de adultos_________
Número de niños___________

6) ¿Cuál de las siguientes categorías mejor describe su ingreso total antes de deducir los impuestos durante el año pasado? Por favor incluya las fuentes de ingreso tales como salarios, seguro social, retiro, inversiones y otras fuentes.

(a) Menos de $20,000
(b) $20,000--$39,999
(c) $40,000--$59,999
(d) $60,000--$79,999
(e) $80,000 o más

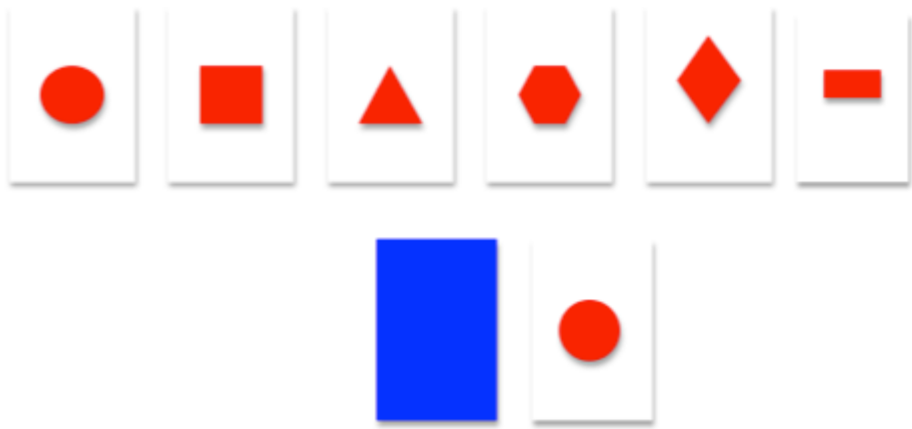
Appendix K
Reduced-Meal Eligibility

Reduced-Price Eligibility Scale
Meals and Snacks

Household Size	Annual	Monthly	Twice Per Month	Every Two Weeks	Weekly
1	$20,147	$1,679	$840	$775	$388
2	$27,214	$2,268	$1,134	$1,047	$524
3	$34,281	$2,857	$1,429	$1,319	$660
4	$41,348	$3,446	$1,723	$1,591	$796
5	$48,415	$4,035	$2,018	$1,863	$932
6	$55,482	$4,624	$2,312	$2,134	$1,067
7	$62,549	$5,213	$2,607	$2,406	$1,203
8	$69,616	$5,802	$2,901	$2,678	$1,339
For each additional family member, add:	+$7,067	+$589	+$295	+$272	+$136

- Household is synonymous with family and means a group of related or unrelated individuals who are not residents of an institution or boarding house, but who are living as one economic unit sharing housing and all significant income and expenses. This scale does not apply to households that receive CalFresh (formerly Food Stamps), Kinship Guardianship Assistance Payment (Kin-Gap), Food Distribution Program on Indian Reservations (FDPIR) benefits, or children who are recipients of California Work Opportunity and Responsibility to Kids Program (CalWORKs). Those children are automatically eligible for free meal benefits.
- In the Adult Care Component of the Child and Adult Care Food Program, a household includes the adult participant and, if residing with the participant, the spouse as well as any persons who are economically dependent on the adult participant. This scale does not apply to members of CalFresh (formerly Food Stamps) households, or recipients of Supplemental Security Income, Medicaid/Medi-Cal, or FDPIR benefits. Those participants are automatically eligible for free meals.

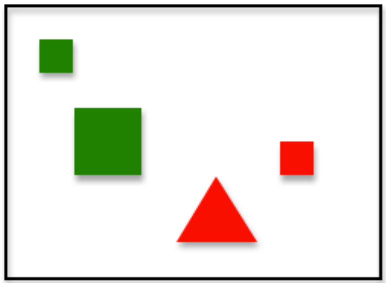
Appendix L
Concentration Task Card stimuli. All possible shape matches.



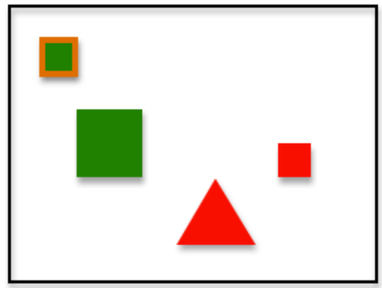
Appendix M

Colorforms Stimuli for each of the six games including the target-removed shape.

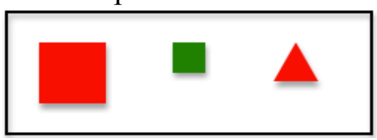
Game 1



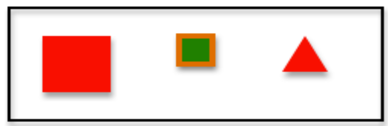
Picture presented to child



Picture with removed highlighted shape.

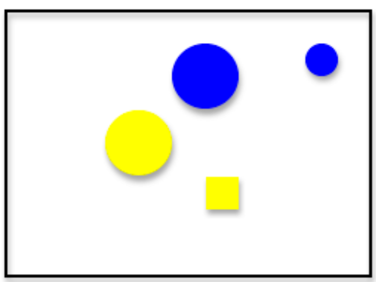


Possible Answers

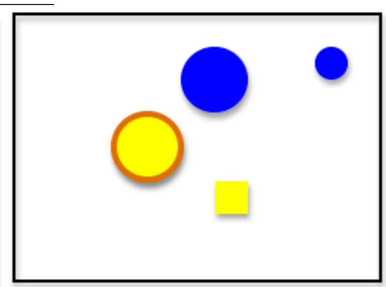


Highlighted Answer

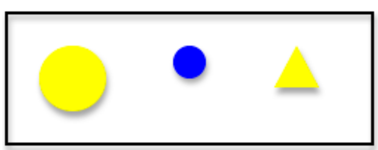
Game 2



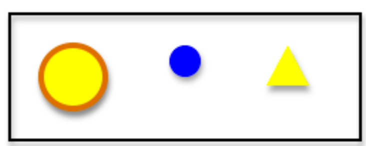
Picture presented to child



Picture with highlighted shape that is removed



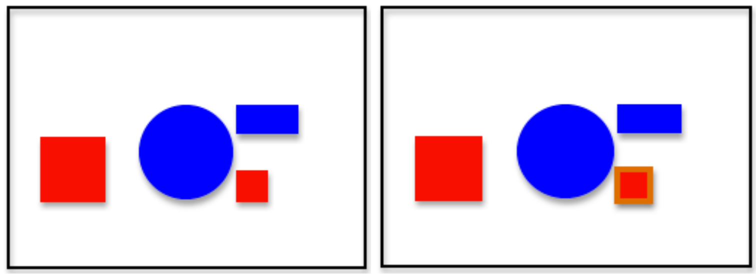
Possible Answers



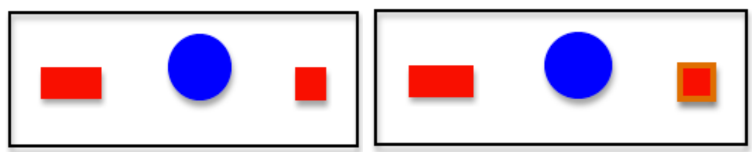
Highlighted Answer

Appendix M1
Colorforms Stimuli for each of the six games including the target-removed shape.

Game 3

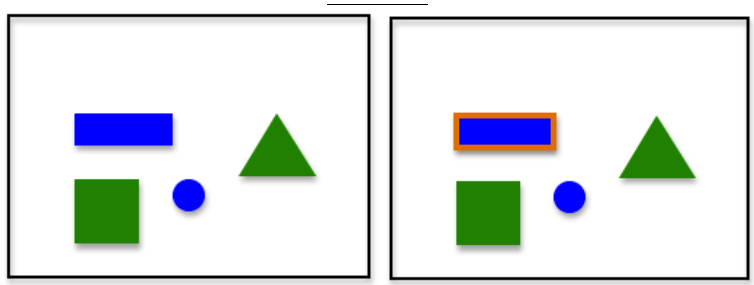


Picture presented to child   Picture with highlighted shape that is removed

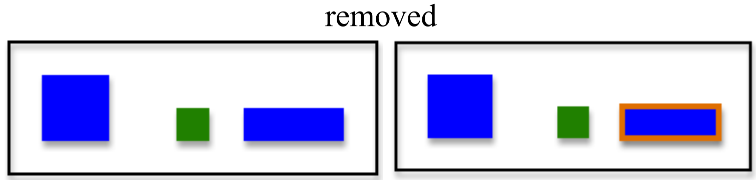


Possible Answers   Highlighted Answer

Game 4



Picture presented to child   Picture with highlighted shape that is removed

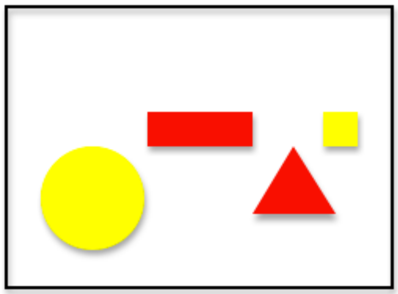
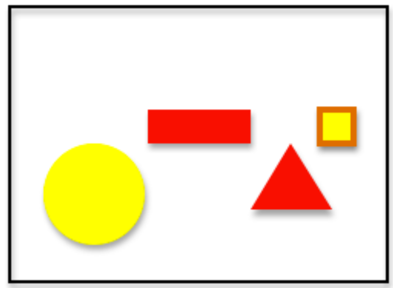


Possible Answers   Highlighted Answer

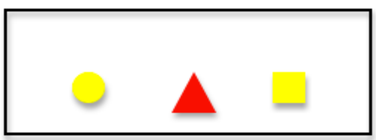
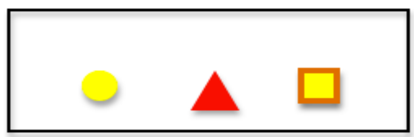
Appendix M2

Colorforms Stimuli for each of the six games including the target-removed shape.

<u>Game 5</u>

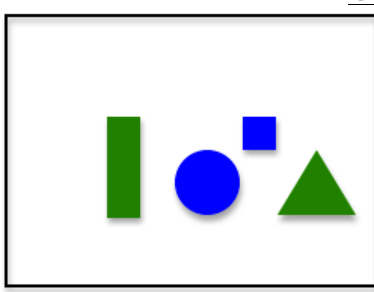
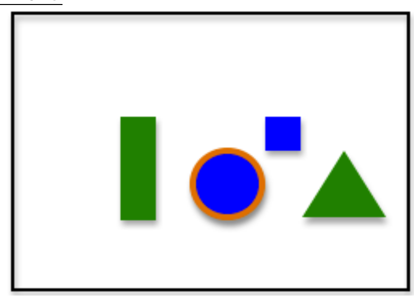



Picture presented to child   Picture with highlighted shape that is removed

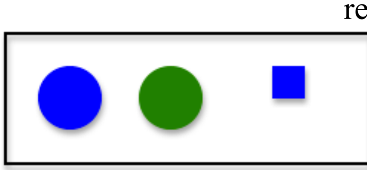
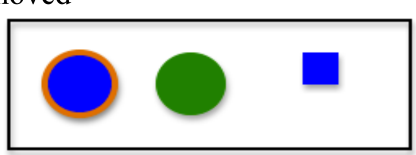



Possible Answers   Highlighted Answer

<u>Game 6</u>

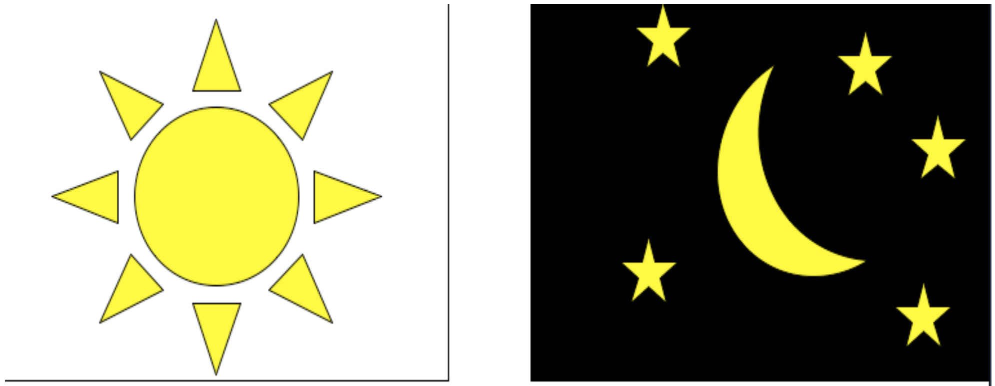



Picture presented to child   Picture with highlighted shape that is removed

Possible Answers   Highlighted Answer

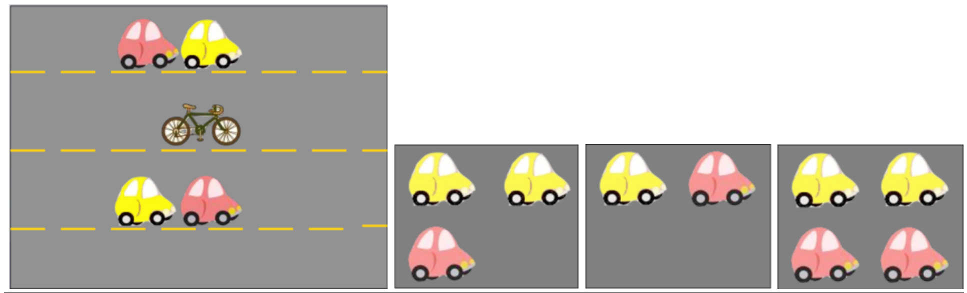
Appendix N
Day/Night Task Stimulus



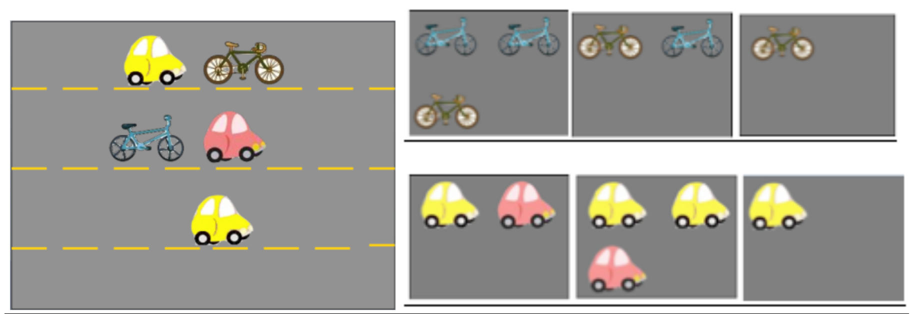
Appendix O

Car Bike Task IC Stimuli and Force-Choice Cards

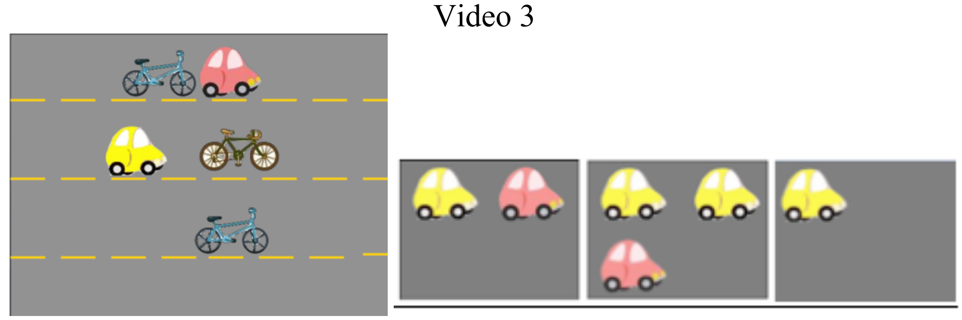
Video 1



Video 2

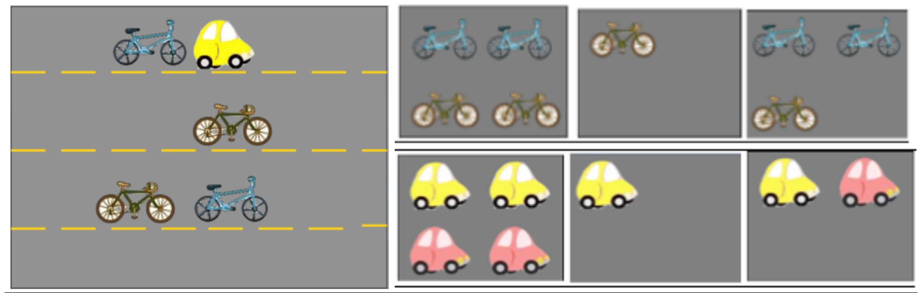


Video 3

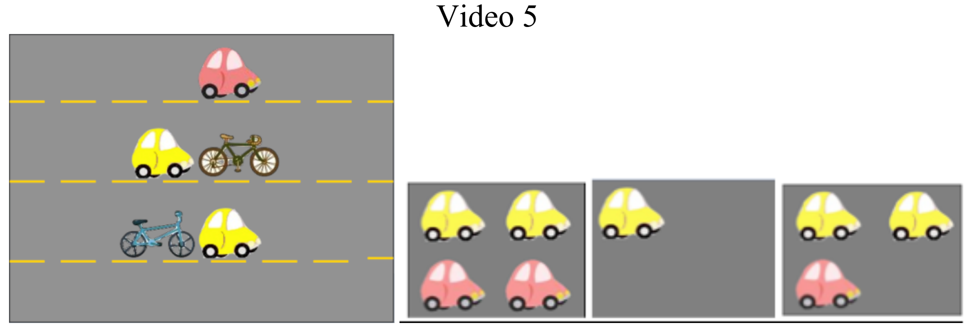


Appendix O1
Car Bike Task IC Stimuli and Force-Choice Cards

Video 4



Video 5

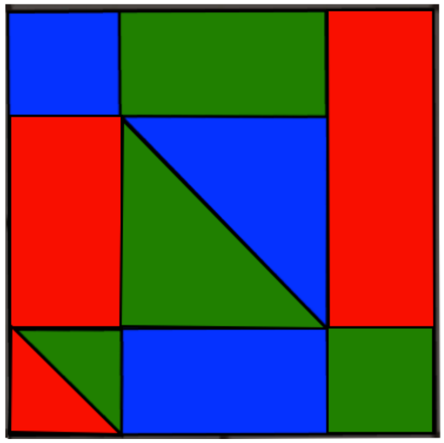


Video 6

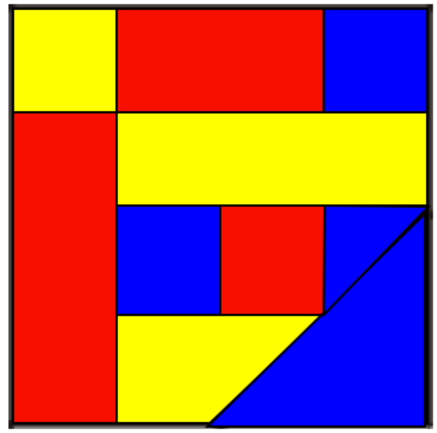
Appendix P

Embedded Figures Stimuli with Target Shape

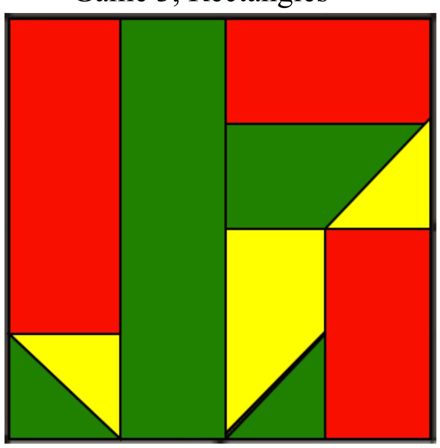
Game 1, Target: Triangle



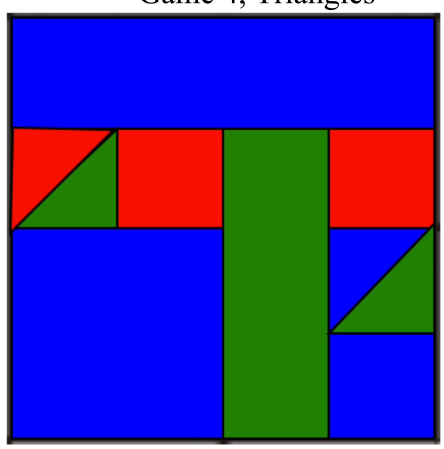
Game 2, Target: Squares



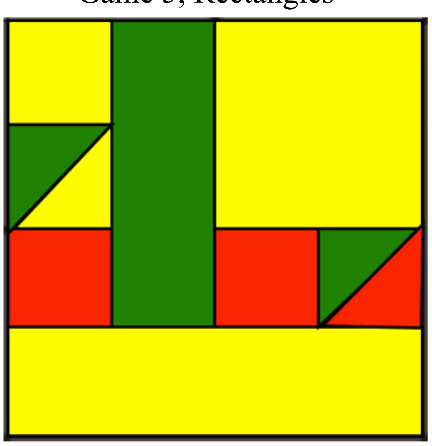
Game 3, Rectangles



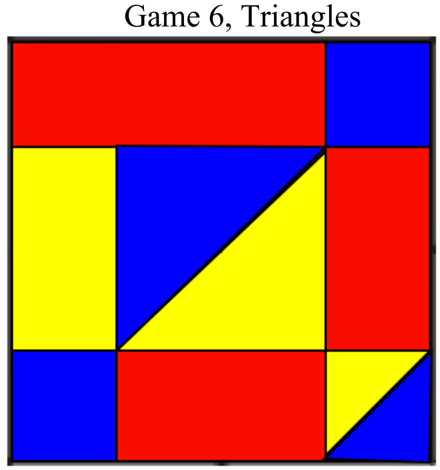
Game 4, Triangles



Game 5, Rectangles

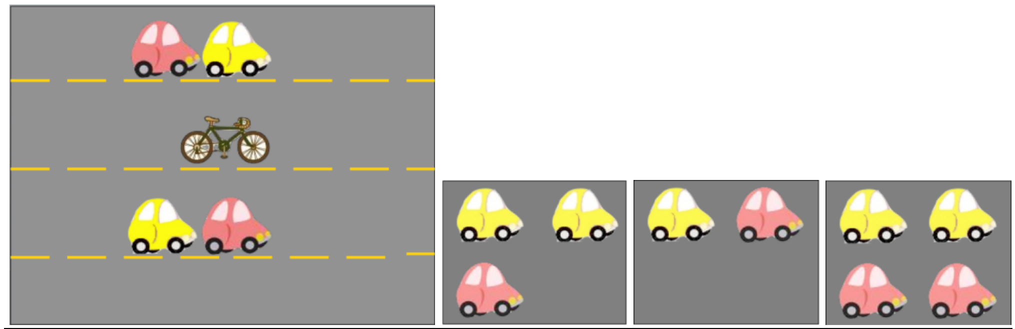


Game 6, Triangles

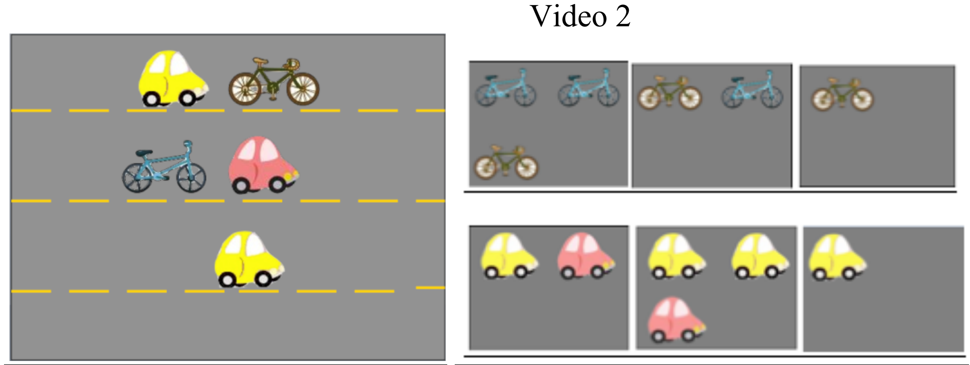


Appendix Q
Car Bike Task Attentional Control Stimuli

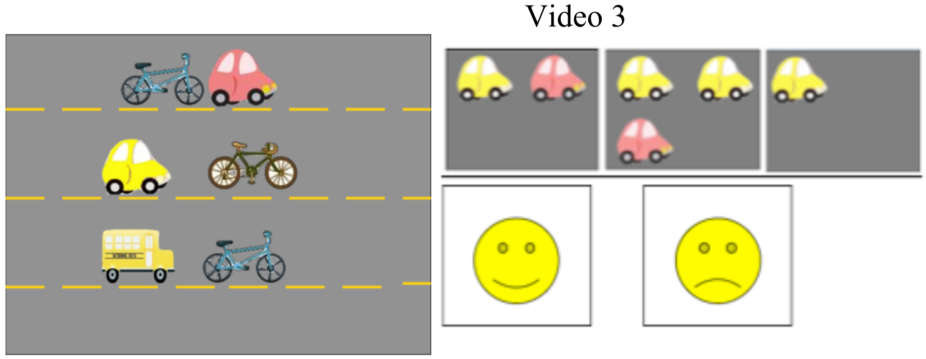
Video 1



Video 2



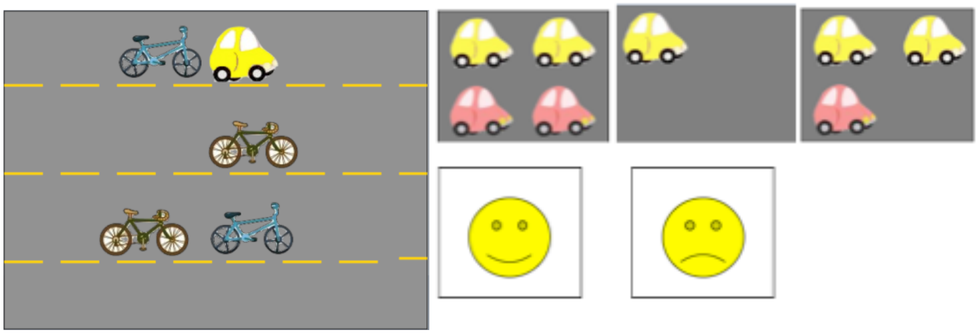
Video 3



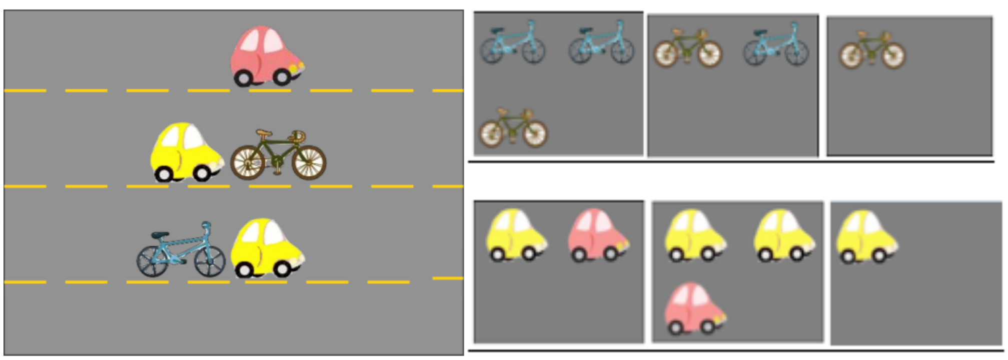
Appendix Q1

Car Bike Task Attentional Control Stimuli

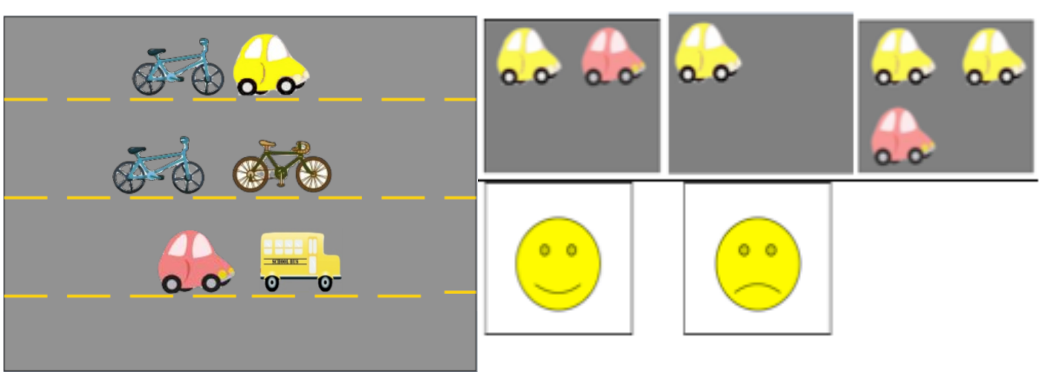
Video 4



Video 5



Video 6



Appendix R
Camera Set-up