HOW HOT OR COOL IS IT TO SPEAK TWO LANGUAGES:

EXECUTIVE FUNCTION ADVANTAGES IN BILINGUAL CHILDREN

A Dissertation

by

RACHEL CHRISTIANE WEBER

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2011

Major Subject: School Psychology

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ABSTRACT

How Hot or Cool Is It to Speak Two Languages:

Executive Function Advantages in Bilingual Children.

(August 2011)

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Chair of Advisory Committee: Dr. Cynthia A. Riccio

According to the 2009 U.S. Census Bureau, approximately 57 million individuals, ages five and older, living in the United States spoke a language other than English at home. There is a clear and growing number of bilingual individuals and English Language Learners (ELL) in the United States. With these growing numbers, especially within the school-aged population, it is crucial that a clear understanding exist regarding the development of children who are bilingual or learning English as their second language.

There is evidence that bilingual children differ from their monolingual peers in the development of executive function (EF), and specifically demonstrate some advantages on EF tasks. This research has not been expanded to include the new conceptualization of EF as hot and cool. This study seeks to examine bilingual EF advantages in EF in light of this recent conceptualization. A second goal of this study is to identify other psychosocial variables that predict EF in children and, thus, might impact its development. The variables of interest include socioeconomic status (SES), economic stress, parenting practices (e.g., disciplinary practices and relational frustration), and cultural beliefs (e.g., individualism/collectivism).

A sample of 67 bilingual and monolingual English speaking children and their parents/guardians participated in this study. Children completed 4 EF tasks and parents completed a battery which included measures of the psychosocial variables and the BRIEF Parent Form. A MANCOVA model was utilized to examine bilingual differences in EF. Multiple regression models were also used to test for significant predictors of hot and cool EF and general EF (as measured by the BRIEF GEC) among the psychosocial variables.

No significant group differences were found in multivariate analyses. Significant predictors of specific EF measures and hot and cool total scores were identified, including economic stress, age, relational frustration, vertical individualism, and vertical collectivism. These are discussed in light of current literature and clinical applications.

DEDICATION

I dedicate this to my loving and supportive husband, Bryan, and to my parents, Bob and Cindy. Without their encouragement and acceptance, this would not have been possible. My relationships with each of them are some of my most prized possessions.

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NOMENCLATURE

EF	Executive Function
PFC	Prefrontal Cortex
OF-PFC	Orbitofrontal Prefrontal Cortex
DL-PFC	Dorsolateral Prefrontal Cortex
SES	Socioeconomic Status

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CHAPTER I

INTRODUCTION

In 2009, approximately 57 million individuals, ages five and older, living in the United States spoke a language other than English at home (U.S. Census Bureau, 2009). Of these individuals, 62% reported speaking Spanish; of those who reported speaking Spanish, 46% reported speaking English less than "very well." Many terms exist to label students who enter school speaking a language other than English: limited English proficient (LEP), culturally and linguistically diverse (CLD), second-language learner, English-language learner (ELL), and possibly bilingual, if appropriate (Ochoa, 2005). The native language of over 75% of LEP students is Spanish (Hopstock & Stephenson, 2003). These data indicate that a large number of school-aged children in the United States grow up learning two languages, most likely English and Spanish, or are exposed to a second language upon entering school. With this growing population of ELL and bilingual children, it is even more important for educational and mental health professionals to understand the development of Spanish-speaking and bilingual children and those variables which significantly impact their development.

Executive Function

The development of executive function (EF) skills is of interest in the fields of education and psychology, given its broad relations to outcomes in children (Anderson, 2002; Blair & Razza, 2007). EF skills have been shown to relate to academic,

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This dissertation follows the style of *Archives of Clinical Neuropsychology*.

behavioral, and emotional outcomes. EF is a broad term used to describe those functions responsible for planning and organizing behavior and regulating one's behavior, emotions, and thoughts (Gioia, Isquith, Kenworthy, & Barton, 2002).

EF skills were first identified after impairments were recognized among individuals who experienced injuries or illness that affected an area of the cerebral cortex known as the prefrontal cortex (PFC). One such landmark case was that of Phineas Gage. In the mid nineteenth century, Phineas Gage was involved in an accident on the railroad that sent a spike through his skull, below and through the left orbit. After this accident, Phineas Gage demonstrated markedly different behaviors, including "inordinate profanity, vacillation, capriciousness, poor planning, and uncontrolled impulsivity" (Fuster, 2008, p. 172). Damage to the PFC has been observed to impact one's ability to flexibly solve problems, plan one's behavior in future and goal-oriented terms, and regulate one's responses (Welsh, Pennington, & Groisser, 1991).

Miller and Cohen (2001) have developed a theory regarding how the PFC operates. It is vastly interconnected with other cortical and subcortical areas, including sensory association cortices, motor regions, and the limbic system (Fuster, 2008). In their Guided Activation Theory, Miller and Cohen (2001) propose that the PFC guides the flow of activity in the brain by sending bias signals, which activate the pathways between neural systems that are necessary to process sensory information, determine internal states, and initiate (and maintain) behavioral output. The purpose of these bias signals is to activate pathways that will lead to the achievement of a goal.

While the PFC is considered to be a cortical region that is extremely important for EF, the construct of EF is typically defined in behavioral terms. Fuster (2008) includes several components in his explanation of EF, such as attention, memory, working memory, planning, temporal integration, decision-making, monitoring, and inhibitory control.

Hot and Cool Executive Function

Recently, a distinction has been made in the understanding of EF as being hot or cool in regards to the context in which it is occurring (Zelazo & Müller, 2002). This distinction has also been applied to the different EF roles associated with different regions of the PFC. The dorsolateral (DL) PFC is typically activated during tasks that involve attention, working memory, planning, and inhibitory control (e.g., Hedden & Gabrieli, 2010; Heyder et al., 2004; McNab et al., 2008). The orbitofrontal (OF) PFC, in contrast, is observed to be activated in the presence of a reward or desired stimuli and associated with emotional and social decision making (Bechara, Damasio, Damasio & Anderson, 1994). This is possible, in part, because of the unique connections of the OF-PFC with structures of the limbic system, such as the amygdala (Barbas et al., in press). For these reasons, the DL-PFC is considered to be involved in "cooler" EF, while the OF-PFC is associated with "hot" EF. This neuroanatomical distinction informs their definitions as well.

Cool EF. Cool EF is defined as being "purely cognitive" and "elicited by abstract, decontextualized problems" (Hongwanishkul, Happaney, Lee & Zelazo, 2005, p. 618). The Wisconsin Card Sort and the Self-Ordered Pointing task are examples of cool EF tasks. These aspects are typically emphasized in developmental theories and addressed by most measurements of EF (Zelazo & Müller, 2002).

Hot EF. Hot EF is observed in contexts when problems require or involve emotion and motivational regulation (Hongwanishkul et al., 2005). “Hot EF, as opposed to cool EF is invoked when people care about the problems they are attempting to solve” (Zelazo, Qu, & Müller, 2005, p. 74). Examples of hot EF tasks include the Iowa Gambling Task and Delay of Gratification tasks, although further research is needed to establish the validity of hot EF tasks (Hongwanishkul et al., 2005).

Interaction within EF system. Hot and cool EF are part of one system involving multiple cortical and subcortical regions, including but not limited to the DL- and OF-PFC (Zelazo, Qu, & Kesek, 2010). While the OF-PFC is initially involved in the processing of emotional responses and simple rules that will lead to a desired outcome, the DL-PFC, among other areas, becomes increasingly more involved as more hierarchical processing of “if-then” representations is necessary. The OF- and DL-PFC also interact as one EF system in situations in an individual’s adaptation to the processing demands of a situation. There is evidence that some situations may be best navigated through a shift of attention or representation away from the emotional aspects of stimuli or potential rewards, while additional evidence suggests that emotion, specifically positive mood, can boost EF facilities in other situations.

Influences on EF Development

As mentioned earlier, the development and utilization of EF is crucial for every child. Neuroimaging and neuropsychological research has made it possible to understand the typical timeline for EF and PFC development in children. The PFC develops slowly until about 8 years of age, at which time it begins to grow rapidly until 14, not being fully complete until the age of 18 (Kanemura et al., 2003). This is in contrast to the development of the frontal lobe in general, which increases in volume steadily until age 10.

Language

There is evidence to suggest that the developmental course of EF among bilingual and second-language learning children may be somewhat different than what is typically expected. This evidence lies in research that has identified higher performances in bilingual and partially bilingual children on EF tasks when they are compared to their monolingual peers (Bialystok, 2005). These differences have been observed in samples of preschool and early school-aged children. Evidence suggests that bilingual children develop control over EF earlier and that this control also declines later in older adults (Bialystok, 2007). The bilingual advantage on these tasks seems to be in the area of inhibition, as bilingual children seem to have developed "the ability to control attention and ignore misleading information earlier than monolinguals" (p. 215). Bialystok and Martin (2004) identified a more specific bilingual advantage in "conceptual inhibition" using the Developmental Change Card Sort Task (DCCS), involving inhibiting the attention paid to a mental representation in order to construct a new representation (p. 337). Green (1998) proposed that a bilingual individual suppresses the language that is not relevant to a particular situation using the same executive functions that he or she utilizes to inhibit his/her behavior and control his/her attention.

The bilingual advantage in children has been observed almost exclusively in tasks emphasizing cool EF (Bialystok & Codd, 1997; Bialystok, 1999; Bialystok & Martin, 2004; Bialystok & Shapero, 2005). Carlson and Meltzoff (2008) included a delay of gratification task in their battery, which, as mentioned earlier, is thought to measure hot EF; a bilingual advantage was not observed for this measure, however. With a paucity of research using both hot and cool measures of EF, it is unclear whether the bilingual advantages observed in decontextualized tasks might also exist when there is motivation or an emotional component involved in EF tasks.

In generalizing the results of research comparing the EF bilingual and monolingual children, it is important to note that the linguistic backgrounds previously studied have not matched that of the bilingual or ELL population in the United States. Only one study to date, conducted by Carlson and Meltzoff (2008), has included a sample that exclusively examined the EF of bilingual English-Spanish speaking children. This limits the generalizability of the bilingual EF literature to the American population, given that the majority of bilingual and English language learners in the United States speak Spanish, as mentioned earlier (U.S. Census Bureau, 2009). Additionally, the bilingual EF data should not be interpreted without considering potential cultural and ethnic differences in the development of general executive function as well (Carlson & Meltzoff, 2008). Sabbagh, Xu, Carlson, Moses and Lee (2006) demonstrated that Chinese preschoolers performed significantly better on tasks of EF than age-matched preschoolers from the United States. These results may be explained, at least in part, by the Chinese cultural emphasis on self-regulation in children (Carlson & Meltzoff, 2008).

It is unclear, then, whether the EF advantage demonstrated in Mandarin- and Cantonese-English children over English-only speaking children (Bialystok, 1999; Bialystok & Martin, 2004) results from bilingualism alone or from their caregivers' and other adults' emphasis on self-regulation throughout their development. To date, only Carlson and Meltzoff (2008) have examined the potential influence of parental expectations (e.g. emphasis on self-regulation) on EF and bilingual-monolingual differences in EF. They did find, though, that while their bilingual parents rated self-control as more important than their monolingual parents, when this was included as a covariate in their analyses, bilingual advantages still existed.

Culture

The extent to which Latino parents emphasize the need for self-regulation in their children has not been studied in current published research. Existing data on the common parenting practice of Latino parents may, however, provide the basis for drawing some conclusions about the importance of child self-regulation within this culture. This data is most prevalent in comparisons of the parental practices of members of individualistic and collectivistic cultures (Feldman, Masalha & Alony, 2006). Latinos are considered to come from a more collectivistic cultural background while the mainstream culture in the United States, or American culture, is considered to be more individualistic in nature (Feng, Harwood, Leyendecker & Miller, 2001). Individualistic societies tend to focus on promoting "self-reliance, independence, and creativity" in their children, while collectivistic societies tend to focus on promoting "obedience, reliability, and proper behavior" (Triandis, 1989, p. 510). Several differences have been noted regarding the parental practices of these two groups, including differences in expectations for such developmental tasks as self-feeding and sleeping alone (Feng, Harwood, Leyendecker & Miller, 2001; Schulze, Harwood & Schoelmerich, 2001). It is unclear, however, whether these differences in parental practices and promoted behaviors would lead to differences in self-regulation.

Poverty

Development in impoverished or low-income environments has been shown to negatively impact the development of EF in children (Lipina & Colombo, 2009). Many studies show that SES predicts or explains a significant proportion of variance in EF (Hughes & Ensor, 2005; Hughes & Ensor, 2006). These effects have mostly been examined regarding cool EF. When hot EF has been included in research, it seems that it may not be as heavily impacted by SES disparities (Farah et al., 2006).

Previous research examining bilingual advantages in the United States has indicated that American bilingual and English language learning children may come from a lower socioeconomic background when compared to monolingual children (Carlson & Meltzoff, 2008). Due to these differences, and the known impact that poverty has on EF development, it is important that SES always be examined in bilingual-monolingual comparisons of American children.

Parenting. The effects of poverty can also be examined in light of parental economic stress, which can increase the likelihood of negative parent-child interactions. Conger and Elder (1994) developed a family stress model which illustrates how this occurs. Evidence already abounds to link parent-child interactions with both positive and negative developmental outcomes in children (e.g. LeCuyer-Maus & Houck, 2002; Houck & LeCuyer-Maus, 2004; Jennings et al., 2008). In the family stress model (Conger & Elder, 1994), poverty's impact is mediated by economic stress and parenting. Economic stress, as experienced by parents, has been found to relate to parental depression, which is in turn related to hostile parenting (Parke et al., 2004). Hostile parenting has been linked to child adjustment problems, as well as other poor social and emotional outcomes in children (Elder, Conger, Foster & Ardelt, 1991; Conger, Ge, Elder, Lorenz & Simons, 1994; Mistry, Vandewater, Huston & McLoyd, 2002; Dennis, Parke, Coltrane, Blacher & Borthwick-Duffy, 2003; Parke et al., 2004; Robila & Krishnakumar, 2006).

Due to the earlier mentioned SES differences between American bilingual and monolingual children (Carlson & Meltzoff, 2008), it is important that the potential mediators of economic stress and parenting practices also be examined when comparing these populations, as they may also explain how EF develops in children from varying SES backgrounds.

Current Study

In sum, research has established that bilingual children tend to perform better than monolingual children on a limited number of cool EF tasks. Specifically, this advantage has been shown on tasks that require inhibition and mental representations of rules and targets. Differences between bilingual and monolingual children are not as clear on measures of hot EF, with only one study to date utilizing such measures. It is also unclear whether consistent differences exist across all linguistic groups, as only one study has compared Spanish-English speaking bilingual children to monolingual English speakers. Finally, there is a paucity of research that has examined whether the relationship between EF and bilingualism is consistent when covariates such as culture, poverty, economic stress, and parenting are taken into account.

The purpose of the current study is to examine and compare both hot and cool EF in bilingual Spanish-English speaking children and their monolingual peers. This study will involve three research questions. The first is regarding whether Spanish-English bilingual children will demonstrate both hot and cool EF advantages when compared to their monolingual peers. It is hypothesized that bilingual advantages will be observed on cool EF tasks that require inhibition, consistent with previous findings. Even though this was not found by Carlson and Meltzoff (2008), it is hypothesized that bilingual advantages will also be observed on hot EF tasks, given the demonstrated bilingual ability to cognitively inhibit non-salient aspects of stimuli when completing EF tasks. This may translate into a bilingual advantage in the processing of emotional aspects of stimuli as well, enabling bilingual children to mentally "decontextualize," or cool down, on the hot EF tasks. The second research question asks what role psychosocial variables, such as SES, economic stress, parenting practices (e.g., disciplinary practices and relational frustration) and culture play in predicting EF. It is hypothesized that each of these variables will account for a significant portion of the variance when predicting EF in this sample. If bilingual advantages are found, as hypothesized, a third research question follows, which asks whether these advantages continue to exist when significant psychosocial predictors of EF are included in the multivariate analysis as covariates. It was hypothesized that these advantages would still be observed.

Implications

As mentioned earlier, a substantial number of American children currently speak a language other than English (Hopstock & Stephenson, 2003), creating an environment of linguistic and cultural diversity in American schools. Students who are not yet bilingual in their native language and English, those of Limited English Proficiency (LEP), are at risk for being incorrectly identified for special education assessments and services due to their lack of English language skills (Ochoa, 2005). In fact, approximately nine percent of all LEP students in U.S. public schools are currently receiving special education services (Zehler et al., 2003). For those children who enter school in the United States speaking Spanish, the research on bilingual children indicates that the acquisition of proficiency in English at an early age will not only promote academic success, but potentially additional resilience in social and emotional areas as well. This is especially important as Latino children are at a heightened risk for poor outcomes and negative life experiences (Garcia-Preto, 2005). Because previous research indicates that EF is associated with a host of academic, behavioral, and emotional outcomes, it seems that the EF advantages associated with early bilingualism could serve as a protective factor against the accumulated risks experienced by Latino students.

Definitions

Limited English Proficient (LEP) – This term will be used to refer to an individual who does not currently possess proficiency in the English language.

English Language Learner (ELL) – This term will also be used to refer to an individual who does not possess proficiency in English and is currently learning to communicate in English.

Culturally and Linguistically Diverse (CLD) – This term will be used to refer to an individual who comes from a cultural and linguistic background that is different from that of the mainstream American culture and English language background.

Latino – This term will be used to refer to an individual whose family origin derives from a Spanish-speaking country or to any individual who self-identifies themselves or their family as Latino.

Bilingual – This term will be used to refer to an individual who possess proficiency in two languages.

Cool Executive Function – This term will be used to refer to executive function that elicits cognitive effort but less explicitly engages an individual's emotional or motivational drives.

Hot Executive Function – This term will be used to refer to executive functions that explicitly involve motivational or emotional drives.

Self-regulation – This term will be used to refer to the processes by which an individual attempts to control his or her emotions, motivation, and attention as a means to achieve a goal.

Collectivism – This term will be used to refer to the set of cultural values that emphasizes concern over how one's own actions or decisions will impact others, sharing of both material and nonmaterial resources, acceptance of the views or opinions of others, concern over the "loss of face," the "correspondence" of one's own outcomes with others' outcomes, and involvement in the lives of others (Hui & Triandis, 1986, p. 225).

Economic Stress – This term will be used to refer to the negative experience of parents or caregivers due to economic hardship (Conger & Elder, 1994).

CHAPTER II

LITERATURE REVIEW

Prefrontal Cortex

Fuster (2008) defines the prefrontal cortex (PFC) as the area of the cerebral cortex that “receives projections from the mediodorsal nucleus of the thalamus” (p. 1-2). The PFC is a large neuroanatomical area, taking up more than 30% of the total cortical mass (Miller & Cohen, 2001). It is, like the entire frontal cortex, considered action cortex, which means it is devoted to some form of movement, or is the “doer” cortex, as Fuster (2008, p. 2) calls it. It is crucial in “top-down” processing, which differs from “bottom-up” processing in that it is guided by intentions, while “bottom-up” processes are determined by the qualities of sensory stimuli and “well-established neural pathways” (Miller & Cohen, 2001, p. 168). In their Guided Activation Theory, Miller and Cohen suggest that goal-oriented behavior requires the “representation of goals and rules in the form of patterns of activity in the PFC, which configure processing in other parts of the brain in accordance with current task demands” (p. 170). This theory is based on the idea that cognitive processing is competitive in nature, in that neural pathways compete for behavioral expression. In order to guide the flow of neural activity, the PFC sends bias signals throughout the cerebral cortex to activate necessary pathways between the systems responsible for processing sensory information, determining internal states (including memory and emotions), and behavioral output, all in efforts to achieve a particular goal.

Damage to the PFC has been observed to impact future- and goal-oriented behavior, in that individuals are impaired in their abilities to plan, think flexibly, and self-regulate (Welsh, Pennington & Groisser, 1991). One of the earliest records of this exists in the work of Bianchi (1922, as cited in Duncan, 1986). In his work, monkeys with frontal lesions demonstrated “disorganized and fragmentary behavior, with sequences of action left incomplete, and apparently purposeless actions introduced” (p. 271). Additional early evidence of the impacts of PFC insult exists in the case of Phineas Gage, who experienced an injury on a railroad site in the mid-nineteenth century (Damasio et al., 1994). An iron bar penetrated his skull, traveling from below and through the left orbit, causing damage to his PFC. Gage experienced vast changes in personality after his injury and recovery, including “inordinate profanity, vacillation, capriciousness, poor planning, and uncontrolled impulsivity” (Fuster, 2008, p. 172). PFC damage experienced early development can greatly impact lifelong social, emotional, and behavioral functioning, as evidenced by case studies (Anderson, Damasio, Tranel, & Damasio, 2000). Finally, PFC damage hinders one’s ability to learn rules, or associations, between stimuli (Petrides, 1985, 1990; Halsband & Passingham, 1985). As Fuster (2008), writes,

> there is now considerable agreement on the essential symptomatology of prefrontal dysfunctions in the human. Depending to some extent on the location of the lesion, its manifestations may be found predominately in the behavioral sphere, the cognitive sphere, or the affective sphere. Nevertheless, any prefrontal syndrome usually consists of a mixture of symptoms in all three (p. 173).

To serve the purpose outlined by Miller and Cohen (2001), the PFC must have access to the cortical systems that involve the processing of sensory information, motor output, and memory and affect. Indeed, the PFC possesses connections throughout the cerebral cortex, in addition to subcortical areas. As mentioned earlier, the PFC receives most of its afferent information from the mediosorsal nucleus, which is part of the thalamus (Barbas, Haswell Henion, & Dermon, 1991; Fuster, 2008; Goldman-Rakic & Porrino, 1985; McLardy, 1950; Meyer, Beck, & McLardy, 1947). The thalamus is known as a relay center for the cortex, meaning sensory and internal state information are communicated to other regions of the brain, in this case, the PFC, by way of its nuclei (Blumenfeld, 2002). All input to the PFC is not relayed through the thalamus, however (Fuster, 2008). The hypothalamus, subthalamus, mesencephalon (Goldman & Nauta, 1976), limbic system (Goldman-Rakic, Selemon, & Schwartz, 1984; Jacobson & Trojanowski, 1975; Porrino, Crane, & Goldman-Rakic, 1981) and cerebellum each project afferent information directly to the PFC. It is yet unknown exactly what these inputs entail, but the functions of these structures allow some speculation as to their nature. For instance, the input from the hippocampus most likely involves information related to motor learning and memory, while the substantia nigra and lower brain structures would provide input regarding the actual execution of movement (Fuster, 2008). The mesencephalon, hypothalamus, and amygdala would provide input related to internal states and motives. Finally, the cerebellar input would involve motor coordination. It is important to note, here, that the PFC does not contain any direct connections to primary sensory cortices, but instead to association, or secondary, cortices (Barbas, 2000).

The PFC is subdivided by regions, including the orbital, medial, lateral, and mid-dorsal regions (Miller & Cohen, 2001). These regions are labeled by their location in the PFC: orbital refers to the region that is directly above the orbital ridges of the eye, while lateral describes the sides of the PFC. Medial means middle, while dorsal refers to the superior areas. In general, the PFC encompasses Brodmann's areas 8-12, 24, 32, and 44-47 (Brodmann, 1909; Fuster, 2008). The lateral area of the PFC comprises part or all of Brodmann's areas 8-10 and 44-47. The orbital area is mainly referring to areas 10, 11, 13, and 47. Finally, the medial area encompasses parts of areas 8-10 and areas 12, 24, and 32. The area referred to as the anterior cingulate cortex is located in areas 24 and 32.

The PFC sends efferent signals to almost every structure from which it receives input (Fuster, 2008). For instance, the mediodorsal nucleus, which is a primary source of information for the PFC, is also a prime recipient of PFC projections (Fuster, 2008). The PFC projects to the ventral and intralaminar thalamic nuclei as well (Chow & Hutt, 1953; Ilinsky, Jouandet, & Goldman-Rakic, 1985). In addition, there are structures that only receive projections from the PFC, such as the intercalated masses (IM) of the amygdala, which receives signals from the posterior orbitofrontal cortex (pOFC; Barbas, Zikopoulos, & Timbie, in press). This is in contrast to the amygdala's basal nuclei, which both send and project to the pOFC (Porrino, Crane, & Goldman-Rakic, 1981; Barbas & De Olmos, 1990; Ghashghaei & Barbas, 2001; Ghashghaei, Hilgetag, & Barbas, 2007).

There are also many PFC connections that are considered local, in that the different areas of the PFC are interconnected, likely “to support an intermixing of disparate information” (Miller & Cohen, 2001, p. 174). For instance, the dorsolateral PFC is interconnected with the anterior cingulate cortex (ACC; Medulla & Barbas, 2010), which is located in the medial PFC. The PFC is also interconnected with other parts of the frontal lobe, such as the premotor areas (Lu, Preston, & Strick, 1994), which gives it access to the primary motor cortex and “central control of movement” (p. 375).

The neural pathways to and from the PFC are not evenly distributed (Fuster, 2008), but most areas of the PFC receive input from at least two sensory association cortices (Chavis & Pandya, 1976; Jones & Powell, 1970). The lateral PFC receives visual, auditory, and somatic input, while the orbitofrontal PFC (OF-PFC) receives more global sensory input (Barbas, 1993; Cavada et al., 2000; Barbas et al., 2002; Barbas et al., in press). This is mainly due to the fact that the inputs to the OF-PFC are received from higher order sensory association cortices, as compared to those sensory association cortices that project to the lateral PFC. This is also evidenced by the areas of the thalamus that project to the lateral versus OF-PFC, as the majority of neurons that project to the PFC are located in the mediodorsal thalamic nucleus, while those that project to the OF-PFC include not only mediodorsal, but also nuclei from the midline and anterior (Barbas et al., 1991; Barbas et al., 2002). The medial areas of the PFC seem to receive only auditory sensory information. There are two distinct circuits by which the PFC receives input from the basal ganglia (Alexander, DeLong, and Strick, 1986), one involving the dorsolateral area and the other the lateral orbitofrontal region. The dorsolateral PFC (DL-PFC) is heavily connected with the hippocampal formation, both directly and indirectly (Goldman-Rakic, Selemon, & Schwartz, 1984), and the premotor cortex (Lu, Preston, & Strick, 1994). The orbital and medial PFC are connected extensively with the limbic structures (Amaral & Price, 1984; Carmichael & Price, 1995). The OF-PFC also has exclusive connections to the nuclei of the amygdala, as mentioned earlier (Porrino, Crane, & Goldman-Rakic, 1981; Barbas et al., in press).

In continuing with Miller and Cohen's (2001) Guided Activation Theory, in addition to interconnectivity with the cortical systems listed, the PFC must also piece together the information it receives to create associations, or representations, in the form of goals or rules. There is evidence that this occurs in lateral PFC neurons, specifically (Asaad, Rainer, & Miller, 1998). The PFC has also been found to acquire new sensitivity to stimuli features that become salient, given behavioral demands (Bichot, Schall, & Thompson, 1996). This was again noted specifically in the lateral PFC (Watanabe, 1990, 1992). PFC activity has been noted when subjects have had to engage in more complicated behaviors based on rules (Asaad et al., 2000; Barone & Joseph, 1989). Finally, as mentioned earlier, PFC damage has been shown to affect one's ability to learn/make these associations, or rules (Petrides, 1985, 1990; Halsband & Passingham, 1985). According to Miller and Cohen's (2001) theory, the PFC creates these rules or representations by sending the earlier mentioned bias signals throughout other parts of the brain, using the efferent pathways also mentioned earlier.

In order to adequately influence neural activity, the PFC must possess the ability to maintain activity as long as is necessary to perform the given task (Miller & Cohen, 2001). Evidence indicates that the PFC has this capacity, to sustain, and maintain, activity, especially in light of its competitive role within the Guided Activation Theory (Banich et al., 2000b; MacDonald et al., 2000). While the ability to sustain activity is not unique to the PFC, when compared to other cortical areas, its ability to do so in light of distractions, distinguishes it (Miller & Cohen, 2001).

The last capacity necessary for the PFC to operate according to Miller and Cohen's (2001) theory is that of learning across time. This is made possible, at least in part, by the dopaminergic systems of the brainstem. The neurons in these systems fire spontaneously at low levels, giving activity to events that are behaviorally salient, such as a reward (Mirenowicz & Schultz, 1994, 1996). As individuals learn, however, that this reward will be received, the dopamine (DA) neurons fire earlier, being activated by events that predict that reward (Schultz & Dickinson, 2000). The neurons are depressed if the reward does not appear when it was expected, coding a prediction error. Within the PFC, neurons seem to be activated in a very similar way (Miller & Cohen, 2001). Neurons in the lateral and ventromedial PFC communicate information about rewards, with their activity growing as the characteristics (e.g., size, desirability) of that reward change (London et al., 2000; O'Doherty et al., 2000; Tremblay & Schultz, 2000). The purpose of this activation system is not just to predict rewards, but also to learn which behaviors lead to them (Miller & Cohen, 2001). The neuronal activation that occurs when there is an "error" in reward prediction not only facilitates learning by strengthening the connections between neurons that provide sensory information about reward prediction, but also the connections between these neurons and their PFC representations that will help guide the behaviors necessary to the reward (Schultz et al., 1997). The latter has been observed in individuals with frontal lobe insult, in that they have difficulty learning and making decisions when evaluating rewards (Bechara et al., 1997; Rolls, 2000).

The Guided Activation Theory (Miller & Cohen, 2001) posits that "the role of the PFC is modulatory rather than transmissive" (p. 183). This means that the PFC guides the flow of activity along the pathways, through other cortical and subcortical areas, that are relevant to the task at hand. In doing this, the PFC's representations can take several forms, including rules or goals, as well as templates for attention to sensory stimuli and cues for memory retrieval. To successfully bias neural activity in this way, the PFC would require the sustained activity mentioned earlier, in differing amounts, depending on task demands. In other words, longer or greater PFC activation might be required for tasks that require control, such as novel tasks or those specifically designed to measure PFC activity. With rehearsal of these tasks, increased PFC activation, or strong PFC bias signals, would no longer be as necessary, because the pathways needed for completion of these tasks would be more established and, in some cases, automatic.

Executive Function

The activity described by Miller and Cohen (2001), performed by the PFC in light of its neuronal properties, has led to the development of the cognitive construct of executive function (EF; Miller, 1999). EF, as a construct, was developed due to the cluster of impairments observed in individuals who experienced PFC insult or injury discussed earlier. It is thought to encompass all of the functions involved in self-regulation, including the organization and direction of cognition, demonstrated emotions, and behaviors (Gioia, Isquith, Kenworthy & Barton, 2002). Fuster (2008) defines EF as “the ability to organize a sequence of actions toward a goal” (p. 178). As described in depth earlier, the PFC functions due to its extensive interconnections with other cortical and subcortical structures (Miller & Cohen, 2001). As such, the PFC alone is not responsible for executive function, but instead, the process by which it guides the flow of neural activity throughout these structures, including the activity within these structures themselves, makes up executive functioning. EF has been subdivided into multiple components, though there is no commonly accepted model which fully explains them. This paper will rely on those components outlined by Fuster (2008), which include attention, memory, working memory, planning, temporal integration, decision-making, monitoring, and inhibitory control. Damage to the PFC has been observed to negatively impact each of these components.

Attention

Fuster (2008) defined attention as “the capacity to concentrate neural resources on the processing of one given item of information to the exclusion of all others” (p. 179). He divided the abnormalities in attention demonstrated by those with frontal lobe damage into five categories: alertness, set, spatial attention, sustained attention, and interference control. In regards to alertness, there is evidence that individuals with PFC damage are, in general, less aware of their surroundings than the typical population (Luria, 1966, 1980, as cited in Fuster, 2008). This is especially prevalent in individuals with lateral PFC insult. Set is “the preparation of neural resources for expected sensory input or motor response in the course of executive performance" (p. 180). Set could also be considered one's ability to shift attention. This has also been shown to be difficult for individuals with PFC damage (Windman et al., 2006). The Wisconsin Card Sorting Test (WCST), developed by Grant and Berg (1948), demonstrates this difficulty, as it requires an examinee to shift his or her attention to a different sorting rule after 10 correct sorting choices (i.e., by color, number, or shape). Neuroimaging studies have shown WCST performance to involve activity in the lateral PFC and anterior cingulate cortex (ACC; Buchsbaum, Greer, Chang, & Berman, 2005). Evidence from performance on the Stroop task, however, has indicated that the DL-PFC alone, and not the ACC, may exhibit greater activation during incongruent trials, which require "imposing an attentional set" (Banich et al., 2000b, p. 7). Other tasks requiring shifting, such as global-local tasks, show activation in the parietal lobe regions and the left dorsolateral PFC (Hedden & Gabrieli, 2010).

The DL-PFC area 8 receives projections from visual association cortices (Barbas, 2000). Damage to this area has been specifically linked to difficulties with attention to sensory stimuli, specifically visual stimuli (Luria, 1966; Luria et al., 1966, as cited in Fuster, 2008). The individuals studied by Luria and colleagues were unable to utilize logical order in their analyses of details in visual images. Area 8, and the DL-PFC in general, are thus associated with spatial attention (Barbas, 2000). Additional evidence has arisen, which demonstrates general PFC lesion impacts on spatial attention, causing spatial neglect, or a "subject's lack of full awareness of one side of the body and the stimuli impinging on it," specifically in unilateral lesions, or lesions to only one side of the PFC (Fuster, 2008, p. 182; Guariglia et al., 1993; Peers et al., 2005). These lesions would affect spatial attention to the opposite, or contralateral, side of the body. Other spatial deficits have been reported in PFC patients, including their ability to perceive the relationship between themselves and the environment (Butxters et al., 1972) and guide their actions using spatial data (McFie & Thompson, 1972). Also, in Aubert tasks (Teuber 1964, 1966), which require individuals to adjust a rod's positioning according to instructions and other cues, individuals with PFC damage overcompensate, causing Teuber to develop the corollary-discharge theory. In this theory, the PFC prepares the sensory cortices for changes in stimuli that will result from movement. This allows for accurate sensory perception despite the change in the position of sensory receptors.

Sustained attention involves the maintenance of concentration on a specific action or thought sequence (Fuster, 2008). It is most difficult for individuals with PFC damage to sustain attention to internal representations (Jetter et al., 1986; Wilkins et al., 1987; Chao & Knight, 1995). Finally interference control involves control over stimuli, internal or external, that might interfere with the current set or action. The PFC patient cannot ignore this interference (Chao & Knight, 1995). Miller and Cohen (2001) offered an explanation of this interference control, or selective attention, in that one most choose to attend to the relevant task or thought instead of the competing stimuli attempting to interfere, in light of their Guided Activation theory. This was inspired by the earlier biased competition model of Desimone and Duncan (1995). In order to sustain attention, the PFC sends biasing signals "in favor of task-relevant information" (p. 186). The DL PFC is implicated, as well as the precuneus, which is located in the parietal lobe, in tasks of selective attention, such as the Stroop task (Banich et al., 2000a). Vendrell et al. (1995) found that individuals with right lateral PFC damage performed consistently poor on the Stroop task. This was in contrast to those with left lobectomies, who did not demonstrate an impaired performance.

Memory

Individuals with PFC damage are capable of utilizing long-term memory in creating and retrieving perceptual information (Fuster, 2008). They have difficulty, however, with free recall and recognition tasks (Gershberg & Shimamura, 1995). These difficulties seem related to the "organization and monitoring mnemonic material" (Fuster, 2008, p. 184; Mangels et al., 1996; Siegert & Warrington, 1996). Additional deficits have been observed in the memory of "serial tasks" (Gómez-Beldarrain et al., 1999) and stories (Zalla et al., 2001; Gilboa et al., 2006), and verbal material (Floel et al., 2004). The OF-PFC has strong connections with the cortical areas that are implicated in long-term memory (Barbas, 2000; Barbas et al., 2002; Rosene & van Hosen, 1977). It is hypothesized to be involved with the parahippocampal region in the encoding of new information (Petrides & Pandya, 2002). Damage or functional interference in the OF-PFC has been associated with deficits in visual memory (Bachevalier & Mishkin, 1986; Watanabe, 1981). The medial region of the PFC also receives robust hippocampal projections, indicating it also plays a role in memory (Barbas, 1997).

Working Memory

Fuster (2008) defines working memory as "the ability to retain an item of information for the prospective execution of an action that is dependent on that information" (p. 185). He claims the reason that working memory deficits are consistently found in PFC patients because this kind of memory is "necessary for prospective action, whether the action is a motor act, a mental operation, or a piece of spoken language" (p. 185). Fuster also refers to this EF component as "sustained attention to an internal representation" (p. 185). Deficits in working memory have been shown on digit span tests (Stuss, 1991), which require an individual to repeat a string of numbers in forwards and backwards order. Difficulties with working memory seem related to lateral PFC damage (Fuster, 2008). Neuroimaging and electrophysiological results have further confirmed this, finding that the areas involved during spatial and verbal working memory tasks include those located in the dorsolateral region (McNab et al., 2008; Miller, Erickson, & Desimone, 1996).

The term working memory was first used by Miller, Galanter and Pribram (1960; as cited in Baddeley, 2003). Baddeley and Hitch (1974) then utilized it when developing their model, which was comprised of three components. This model was developed to replace other existing models of short-term memory. Such models held that sensory information traveled directly into the short-term memory, and short-term memory would then send that information in and out of long-term memory (Baddeley, 2003). Baddeley and Hitch (1974) proposed their three component model based on observations of subjects with damage to the short-term memory system. These three components are the *phonological loop*, the *visuospatial sketchpad*, and the *central executive* (Baddeley & Hitch, 1974). Recently, a fourth component has been proposed—the *episodic buffer* (Baddeley, 2002). The phonological loop refers to what is also called verbal working memory, the visuospatial sketchpad refers to nonverbal working memory, and the central executive is an attentional control system (Baddeley & Hitch, 1994). Finally, the episodic buffer is a storage system that integrates information from various sources (Baddeley, 2000). The central executive retrieves information from this storage through the use of "conscious awareness" (Baddeley, 2002). This means that the central executive reflects on the information, "manipulating and modifying it" when necessary (Baddeley, 2000, p. 421).

Miller and Cohen (2001) offered an integration of the Baddeley & Hitch (1974) working memory model, as specifically how the central executive functions, with their Guided Activation theory of PFC functioning. As mentioned earlier, within the Baddeley and Hitch model, the episodic buffer maintains the information "online," and the central executive manipulates that information (Miller & Cohen, 2001, p. 185). Neuroanatomically, the episodic buffer role has been assigned elsewhere in the cerebral cortex, while the central executive has been assumed to be a role for the PFC. As discussed earlier, however, there is evidence that the PFC has the capacity to maintain or sustain activity in light of task control demands (Banich et al., 2000b; MacDonald et al., 2000). Miller and Cohen (2001) suggest that the PFC actively maintains, as a function of working memory, its representations of the behavioral goal or the rules involved in a task, in addition to any manipulation that is necessary.

Planning

The inability to plan has been reported consistently as a symptom of PFC damage (Fuster, 2008). It was first recognized in Phineas Gage's case (Harlow, 1848; as cited in

Fuster, 2008). Plan execution requires a plan concept, preparation for each of the steps of the plan, and anticipation of the plan's consequences. In this way, planning necessitates insight into the future. Poor planning has been observed in PFC patients on tasks like the Tower of London (Shallice, 1982), which requires individuals to make a series of moves, one at a time, of three wooden rings on three wooden pegs to match a picture (Owen et al., 1990). It is also evident on maze tasks (citation). These deficits are particularly prevalent in those with damage to the left hemisphere of the PFC (Shallice, 1982; Fuster, 2008). Lesions in DL-PFC are also associated with planning deficits (Heyder, Suchan, & Daum, 2004).

Temporal Integration

Temporal integration, "the ability to carry out new, temporally extended and goal-directed behavior, speech, or reasoning," requires working memory and planning (Fuster, 2008, p. 189). All damage to PFC involves a deficit in this EF component. The difficulty lies in the fact that these patterns of behavior are novel, such that no previously established, well-rehearsed behaviors can be utilized, and that they require the integration of behavioral contingencies, or if-then statements, across time. Temporal integration requires the interconnection of the PFC with the cortical and subcortical structures discussed earlier. Individuals with PFC damage experience a "concreteness" of thought about their own behavior, specifically as it relates to time. This means that these patients act only in light of their present-time needs and current stimuli, without consideration of past contingencies of those behaviors or in light of what might occur in the future (Ackerly, 1964). Fuster (2008) refers to this as temporal concreteness. This not only fosters more spontaneous behavior, but it also affects the individual's ability to sequence behaviors over time in efforts to reach a goal. Many of the tasks that indicate difficulties with attention, planning, and memory also indicate difficulties with temporal integration.

Monitoring

"Monitoring is reality testing, whether the reality is external (that is, defined in spatial-temporal coordinates and accessible to the senses) or internal (defined in memory)" (Fuster, 2008, p. 192). Monitoring assesses the impacts our actions have in light of behavioral goals. It also has an effect on the actions taken in the future, in that an individual might change his or her behavioral course depending on the contingencies established by previous actions. Monitoring is the process of obtaining feedback about one's behavior. The PFC is involved in monitoring by way of its interconnections with the limbic system and sensory association cortices, completing the "perception-action cycle" (p. 192). Difficulties with monitoring are typically seen in conjunction with deficits in most other EF components. There is no one PFC region associated with monitoring though lesion studies, but neuroimaging research has suggested that the anterior cingulate and orbital region may be involved (Swick & Turken, 2002).

Inhibitory Control

The concept of inhibition involves some of the processes discussed within attention—interference control, sustained attention, and selective attention. It is also the role of the episodic buffer in the Baddeley and Hitch (1974) working memory model. Selective attention and inhibitory control occur simultaneously; as Miller and Cohen

(2001) put it, “attention is the effect of biasing competition in favor of task-relevant information, and inhibition is the consequence that this has for the irrelevant information” (p. 186). In the same way, Fuster (2008) discusses the inclusive and exclusionary functions of attention. The first was discussed under the EF component of attention, in that the PFC sends biasing signals throughout the cortex and subcortical areas to focus attention to specific stimuli. The second involves suppressing those stimuli that are not relevant. PFC activity has been confirmed using fMRI during the Go/No-Go task, an established task requiring inhibition (Mesaluam, 1985; Casey et al., 1997; Chikazoe, 2010). The ventrolateral, specifically in the right hemisphere, and dorsolateral PFC are implicated in such tasks, in addition to the parietal lobes and basal ganglia (e.g., Chambers et al., 2006; Chambers, Garavan, & Bellgrove, 2009; Chikazoe, 2010; Hedden & Gabrieli, 2010; McNab et al., 2008; Nakata et al., 2008).

Decision-Making

Decision-making requires the other EF components discussed previously, including attention, working memory, planning, and temporal integration. Differences in decision-making have been identified in regards to their emotional salience and in terms of the regions of the PFC that are activated in the decision-making process (Fuster, 2008). While Damasio (1994) pointed out that there really is no such thing as a purely rational decision, there is evidence that particular areas, namely the OF-PFC, are more highly activated when a reward or motivational aspect is involved in deciding how to act or behave. This is related to the earlier mentioned unique connections that the OF-PFC has with the limbic system. With these differences in PFC activation during tasks that possess varying degrees of emotional or motivational salience, a new conceptualization of EF has also been developed. Recently, EF has been described as hot or cool, depending on the emotional or reward-driven nature of a task or situation (Zelazo et al., 2005). While hot and cool EF can be separated theoretically, it is also important, however, to still consider EF as one functional system, made up of the components described earlier (Hongwanishkul, Happaney, Lee & Zelazo, 2005). This interaction between hot and cool EF, and the utilization of both DL- and OF-PFC even in decisions that are emotionally-laden, will be discussed in the next section.

Hot and Cool EF

Hot EF is “invoked when people care about the problems they are attempting to solve,” while cool EF is involved in “relatively abstract, decontextualized problems” (Zelazo et al., 2005, p. 74). The distinction between hot and cool EF is based, in part, on the growing understanding of differential connections and activations of the orbitofrontal and dorsolateral (OF and DL, respectively; PFC; Miller & Cohen, 2001). The OF-PFC is associated with hot EF, while the DL-PFC is associated with cool EF. In order to effectively solve a problem or reach a goal, the OF-PFC and DL-PFC work as one EF system, as mentioned earlier. Additionally, the hot and cool distinction should be considered as more of a continuum, as opposed to a dichotomy.

The DL-PFC is connected to those brain areas that enable it to “play an important role in the integration of sensory and mnemonic information and the regulation of intellectual function and action” (Zelazo & Müller, 2002, p. 452). This region of the PFC receives sensory information from the association cortices involving visual, auditory, and somatosensory information (Barbas, 1993; Barbas et al., 2002; Barbas et al., in press; Cavada et al., 2000). As mentioned earlier, the DL-PFC receives its projections from the mediodorsal (MD) thalamic nucleus (Barbas et al., 1991; Barbas et al., 2002). It also has a unique circuit with the basal ganglia; the DL-PFC projects to the lateral globus pallidus and receives projections back from this area via the MD thalamic nucleus (Heyder et al., 2004). Finally, it is interconnected with the hippocampus, making it potentially involved in memory (Goldman-Rakic et al., 1984) and the premotor cortex, involving motor planning (Lu et al., 1994). Research has provided evidence of activation or involvement of the DL-PFC in such EF components as attention (Bachsbaum et al., 2005; Banich et al., 2000a; Banich et al., 2000b; Barbas, 2000; Hedden & Gabrieli, 2010; Vendrell et al., 1995), working memory (McNab et al., 2008; Miller et al., 1996), planning (Heyder et al., 2004), and inhibition (Chambers et al., 2006; Chambers et al., 2009; Chickazoe, 2010; Hedden & Gabrieli, 2010; McNab et al., 2008; Nakata et al., 2008). The majority of tasks utilized in research and clinical practice that are purported to measure EF would be considered measures of cool EF, in that they do not have a built-in motivational or reward component. These tasks include many of those mentioned earlier, such as the WCST, the Stroop task, and the Tower of London.

The first evidence of the role of the OF-PFC arose from the earlier mentioned case of Phineas Gage (Zelazo & Müller, 2002). After his injury, Gage regained most basic functions, with the exception of vision in his left eye, but drastic changes were noticed in his social and emotional functioning (Damasio, 1994). His behavior was markedly different from that before his injury. Unilateral lesions to the OF-PFC-amygdala circuit have been shown to negatively impact affective processing in rhesus monkeys (Izquierdo & Murray, 2004). Lesions in the OF-PFC have been associated with difficulties in planning, emotional expression, and decision-making (Shallice & Burgess, 1991; Bechara, Damasio, Damasio & Anderson, 1994).

The OF-PFC is uniquely connected with the amygdala and other structures of the limbic system (Amaral & Price, 1984; Barbas et al., in press; Carmichael & Price, 1995; Porrino et al., 1981). There is also evidence that it may be involved in memory, with its connections with the parahippocampus (Bachevalier & Mishkin, 1986; Barbas, 2000; Barbas et al., 2002; Rosene & van Hosen, 1977). The specific link between the medial temporal region, which is part of the limbic system, and the caudal OF-PFC is involved in the processing of emotionally-laden stimuli (Frey, Kostopoulos & Petrides, 2000). These connections enable the OF-PFC to be involved in sending signals to the autonomic nervous system as well to “promote chemical responses associated with emotion, out of the hypothalamus and brain stem” (Damasio, 1994, p. 183).

Damasio (1994) developed the Somatic Marker Hypothesis, which describes the role of the ventromedial PFC, which is part of the OF-PFC, in triggering “gut feelings” about the potential consequences, negative or positive, of certain choices. He labeled these triggered sensations somatic markers and they can include “visceral and nonvisceral sensation” (p. 173). These somatic markers are caused by mental representations, established by previously learned contingencies (if-then statements), and they boost working memory and attention as an individual evaluates his/her goals in light of his/her choices in a situation. This means that somatic markers, which are associated with the ventromedial PFC, influence the processing that occurs in the DL-PFC, including attention, working memory, and the other components of EF mentioned earlier. Rolls (2004) hypothesized that the OF-PFC is involved in the altering of behavior in response to changes in reinforcement, especially in an individual's response to social reinforcers. In support of this hypothesis, Hornak, Rolls and Wade (1996) found that damage to the OF-PFC indicated difficulty identifying such social reinforcers as the facial and vocal expressions of others.

Measures that emphasize hot EF that have recently been developed include the gambling task (GT) paradigm (Bechara, Tranel & Damasio, 2000), decision-making task (Rogers et al., 1999), and the guessing task (Elliott, Frith & Dolan, 1997). Specifically for children, measures such as the Children's Gambling Task (Kerr & Zelazo, 2004), Less is More (Carlson, Davis & Leach, 2005), and the Delay of Gratification task (Prencipe & Zelazo, 2005) were developed.

Hongwanishkul et al. (2005) examined the development of hot and cool EF in preschoolers, as well as their relations with general intellectual functioning and temperament. While hot and cool EF were observed to both improve with age, cool EF was strongly related to general intellectual function and hot EF was not. A similar pattern was also noted for temperament. Finally, Hongwanishkul et al.'s finding that performance on the Delay of Gratification task (Prencipe & Zelazo, 2005) and the Children's Gambling Task (Kerr & Zelazo, 2004), both considered hot EF tasks, were negatively correlated is surprising, and suggests that further research is needed in order to define and establish valid measures of hot EF. One hypothesis, raised by

Hongwanishkul et al. (2005), is that the Children's Gambling Task (Kerr & Zelazo, 2004) requires the utilization of working memory in addition to the assessment of emotionally-charged stimuli, perhaps making it less of a "pure" hot EF measure.

Interaction of Hot and Cool EF. Zelazo, Qu, and Kesek (2010) traced the course of EF, which begins with the relay stimuli information to the thalamus, which projects to the amygdala. The amygdala produces an initial emotional response and this is sent to the OF-PFC. The OF-PFC generates rule representations involving simple responses (i.e., approach or avoid the stimuli). The OF-PFC would also be involved if these rules needed to be reversed. These rules are sufficient for many stimuli and situations, but in others higher-level processing of rules is required. The ACC, monitors for potential errors in performance and signals that higher-level processing is necessary to create more hierarchical rules for responses to the stimuli, involving more lateral regions of the PFC. As processing progresses, the planned reactions to the stimuli become more and more elaborate, requiring a more complex PFC network. "These multiple regions then operate simultaneously and in parallel, with higher levels in the hierarchy supplementing and influencing lower levels (both directly and indirectly) but not replacing them" (p. 99). This process of evaluating one's response to stimuli is based in the Iterative-Reprocessing (IR) Model first proposed by Cunningham and Zelazo (2007). The simple rules mentioned earlier, that involve the OF-PFC, would require relatively few iterations, and would be considered more automatic, while the more elaborate reaction described would require multiple iterations and a complex evaluation process.

Research has indicated that EF in children can be negatively impacted by the emotional context of a situation (Zelazo et al., 2010). There is evidence that children can perform better on hot EF tasks when the desired reward or goal is made more abstract; in other words, when they are decontextualized, EF performance is improved. Carlson, Davis and Leach (2005) did this using their Less Is More task, in which children had to select a smaller pile of candy in order to receive the larger one. When the candy was in front of them, three-year-olds had difficulty maintaining this rule and inhibiting the prepotent response to point the pile they actually desired. When Carlson et al. replaced the piles with symbols the children were able to perform in their own best interest. The use of symbols as representations, internally or externally, may be an effective strategy to "cool" down the context of a task, enabling more effective EF. Metcalfe and Mischel (1999) refer to this strategy as "reconstruing the meaning of the hot stimulus" (p. 12).

There are also situations in which the emotional valence of stimuli may promote EF (Zelazo et al., 2010). In situations where there is no conflict between the rules for approach or avoidance generated by the OF-PFC and the higher-order processing necessary to obtain a goal, the mood and dopamine level increases associated with positive stimuli may contribute to processing (Ashby, Isen, & Turken, 1999; Zelazo et al., 2010). Rader and Hughes (2005) followed stories with happy, sad, or neutral endings with a block design task to determine the influence of these affective states on their performance. The children who received a happy story outperformed the neutral and negative conditions. Qu and Zelazo (2007) also demonstrated this by using two different versions of the Dimensional Change Card Sort (DCCS) (Müller, Frye, & Marcovitch, 2003), one of the standard version with pictures of red and blue boats and rabbits, and one with male and female black-and-white happy and sad facial expressions (Qu & Zelazo, 2007). The children performed significantly better on the Emotional Faces version of this task. Qu and Zelazo offered several explanations for why this may have occurred, including that the positive stimuli may have produced positive affect and that the inclusion of emotional content increased motivation in general.

Influences on PFC and EF Development

Developmental Course

In typical brain development, the frontal lobes are observed to develop last (Dempster, 1992). A recent three-dimensional magnetic resonance volumetric indicated that the volume of the frontal lobe increases steadily until approximately age 10, continuing to grow more slowly thereafter (Kanemura et al., 2003). The PFC, in contrast, increases slowly until the age of 8 years, with rapid growth between ages 8 and 14, and completion at approximately 18 years of age. Giedd et al. (1999) conducted a longitudinal MRI study of healthy children and young adults between the ages of 4 and 21. Gray matter in the frontal lobes increased during pre-adolescence, with a maximum size occurring around 11-12 years, then declining during post-adolescence. An additional MRI study by Sowell and colleagues (1999) found gray matter reduction to occur between adolescence and adulthood. They hypothesized that this most likely reflects “increased myelination in peripheral regions of the cortex that may improve cognitive processing in adulthood” (p. 860).

Behavioral inhibition has been observed to rapidly improve between the ages of two and five (Diamond & Taylor, 1996). This is consistent with Piaget's developmental stages, as in the "concrete operations" stage 5-7 year-olds are able to inhibit strong impulses or responses and hold multiple ideas in mind (Diamond, Kirkham & Amso, 2002). In related research, adult-level performance, or a leveling-off of performance, on tasks measuring inhibition has been observed in children at age six (Welsh, Pennington & Groisser, 1991; Klenberg, Korkman & Lahti-Nuutila, 2001). Performance on measures of inhibition has also been observed to improve with age in children 24 to 41 months of age (Gerardi-Caulton, 2000; Backman Jones, Rothbart and Posner, 2003). During response inhibition tasks, children recruit similar PFC areas as adults (Bunge et al., 2002; Casey et al., 1997b). The volume of activation, however, has been shown to be much greater in children relative to adults, specifically within the DL-PFC. Additional differences were observed during the Stroop task between young adults (ages 18-22) and children (ages 7-11) in the activation in the anterior cingulate, left parietal, and parieto-occipital regions (Adelman et al., 2002).

Working memory has been observed in 6-month-old children, though it is not considered fully intact until middle childhood (Diamond, 1990; Tsujimoto et al., 2004). Geier, Garver, Terwilliger, and Luna (2009) found that, while basic working memory was intact in children (ages 8-12 years), there were also immaturies observed in those regions that support working memory in adults. Additional research has shown that children in these age ranges do not recruit the right DL-PFC and bilateral superior parietal cortex during working memory manipulation tasks, in contrast to adult and adolescent samples (Crone et al., 2006).

In regards to the development of hot EF, Garon and Moore (2004) utilized the children's version of the Iowa Gambling task in a sample of 3, 4, and 6 year old children. The 6-year-olds outperformed the two younger groups, indicating age-related progression in this area. In their research with the same task, Crone and van der Molen (2004, 2007) found that children between the ages of 8 and 10 and 12 and 14 perform similarly to patients who have experienced insult to the ventromedial PFC, in that they have difficulty anticipating the outcome of a decision before making it. This lead Crone and van der Molen to hypothesize whether children of these ages are able to recognize and utilize the somatic markers mentioned earlier in Damasio's (1994) hypothesis, or whether they are even available at these ages.

Language Exposure

The developmental course of EF and PFC development is hypothesized to be positively impacted by early exposure to a second language, and subsequent bilingual language development (Bialystok, 2005). Children with balanced bilingualism, meaning their abilities in each language are roughly equivalent, have demonstrated increased abilities in metalinguistic tasks, though the results have not always been consistent (Cummins, 1978; Rosenblum & Pinker, 1983; Bialystok, 1988; Galambos & Goldin-Meadow, 1990). While metalinguistic tasks can be classified as either requiring the analysis of representational structures or requiring control over one's processing, it is in the metalinguistic tasks that highly demand this processing control that bilingual children have demonstrated advantages (Bialystok, 1992). Specifically, these tasks are thought to have in common their requirement for control over attentional processing (Bialystok & Majumder, 1998). This refers to “the child’s ability to direct attention to specific aspects of either a stimulus field or a mental representation as problems are solved in real time” (Bialystok, 1992, p. 505). This definition seems to be very similar to that of selective attention, within Fuster’s (2008) EF component of attention.

Bialystok and Majumder (1998) sought to further test a potential bilingual advantage involving attention by comparing balanced French-English bilingual, monolingual English speaking and partially bilingual Bengali-English speaking children on both metalinguistic and nonverbal problem solving tasks. Of the nonverbal tasks, two were considered tests of control and one was considered a test of analysis. Significant and close-to-significant differences were observed in performance on Block Design from the WISC-R (Wechsler Intelligence Scale for Children-Revised; Wechsler, 1974) and the Water Level Task (Pascual-Leone, 1969), both considered tests of control. The balanced bilinguals outperformed both their partially bilingual and monolingual peers on these tasks. Bialystok (1999) administered the Moving Word task and the DCCS to a sample of monolingual English speakers and bilingual English-Chinese (Cantonese or Mandarin) speakers, ages three to six. On the DCCS, considered a “nonverbal sorting task,” there was a bilingual advantage. Bialystok and Martin (2004) further examined the bilingual advantage on the DCCS using three studies. First, they varied the representational demands of the task’s sorting rules and the stimuli using four conditions. The difference between the tasks was in “conceptual inhibition, namely, the type of information in the original representation that needed to be ignored when performing in the post-switch phase" (p. 328). Within the four conditions, the bilingual Cantonese-English speaking children demonstrated an advantage in two of the three conditions considered to tap into conceptual inhibition.

In a second study, Bialystok and Martin (2004) sought to examine these three conditions further to determine why the bilingual advantage was not found on each of them. This involved two conditions, each depending on two dimensions of the objects to be sorted—function and location, and color and shape. The bilingual French-English speaking children only outperformed the monolingual English-speaking children on the game using color and shape. It seems that these two tasks differed by the definition of the dimension along which the children were to sort the objects. One used perceptual or visual dimensions, and one used a "semantic property of the item" (p. 335). A final study was conducted, using two games along perceptual dimensions and two semantic dimension games. The bilingual Chinese-English (Mandarin or Cantonese) speaking children only outperformed the monolingual English speaking children on the perceptual conditions. Bialystok and Martin concluded that the difficulty of the DCCS is in the area of conceptual inhibition, in which the examinee must "inhibit attention to a mental representation and ignore misleading cues so that a new representation can be constructed" (p. 337). The bilingual advantage on the post-switch phase of the DCCS has also been shown to relate to bilingual children's ability to reverse ambiguous figures (Bialystok & Shapero, 2005).

Carlson and Meltzoff (2008) examined EF in a sample of bilingual English-Spanish speaking kindergartners, along with English-speaking kindergartners who had been in a language immersion program for six months (Spanish or Japanese) and English-speaking kindergartners in traditional programs. Approximately two-thirds of each of the monolingual groups was White/non-Hispanic. No group differences were found based on the raw scores on the EF tasks. When including age, verbal ability, and socioeconomic status (SES) as covariates, the bilingual kindergartners outperformed both of the monolingual groups. Specifically, group differences were found on Visually Cued Recall (Zelazo, Jacques, Burack & Frye, 2002), the Advanced DCCS, and the C-TONI (Comprehensive Test of Nonverbal Intelligence; Hammill, Pearson & Wiederholt, 1997). No linguistic differences were observed in tasks that required the kindergartners to suppress motor responses or delay gratification. Instead, advantages were "isolated to executive function measures that purportedly require memory and inhibition of attention to a prepotent/distracting response" (p. 294). Poulin-Dubois, Blaye, Coutya and Bialystok (2011) extended the findings of previous studies down to a 2-year-old sample, finding a native bilingual group advantage on the Stroop task. Similar advantages were not observed in delay tasks, including the Snack Delay and Gift delay tasks.

Those children who obtained more of a partial bilingualism have also demonstrated advantages on some tasks (Bialystok, 1988). Bialystok found that native English speakers who had been in a French immersion program for two years scored as high as bilingual French-English speakers on tasks requiring control of processing, but equivalently with monolingual English speakers on tasks that required analysis of knowledge.

From a comprehensive review of these and other studies on the cognitive abilities of bilingual children as compared to their monolingual peers, Bialystok (2001) concluded that bilingual children demonstrate more rapidly developing inhibitory control, particularly when they are required to control their attention when faced with problem features that are conflicting. Martin-Rhee and Bialystok (2008) further investigated the development of inhibitory control in bilingual children by examining it through tasks that required different levels and different types of control. The bilingual children demonstrated an advantage on the Simon task when the task was “based on a bivalent display in which two presented features potentially indicate different responses” (p. 90). This advantage was interpreted as “the initial ability to control attention to complex stimuli” (p. 90).

Green’s (1998) model of the regulation of the bilingual lexico-semantic system illustrates how inhibitory control might develop more rapidly in bilingual children. Green proposed an inhibitory control (IC) model by which the regulation of the bilingual lexico-semantic system operates. This inhibitory control model is necessary due to the current belief that bilinguals have “access to two competing linguistic systems” (Bialystok, 2007, p. 211). With these two language systems being active and competing, bilingual individuals are in need of a mechanism that controls which enables them to pay attention to the appropriate system and ignore the one that is not needed.

In Green's (1998) model, the performance of a language task first involves the expression of an intention to perform it, made possible by the supervisory attentional system (SAS). The SAS enables the activation of language task schemas. These schemas are "mental devices or networks that individuals may construct or adapt on the spot in order to achieve a specific task and not simply to structures in long-term memory" (Green, 1998, p. 69). Stimuli, either external or internal, trigger the activation of these schemas, which then compete to control the linguistic output. Several schemas can form coordinated "functional circuits," which control the tags of lemmas (p. 72). Lemmas specify the syntactic properties of individual lexical concepts (Levelt, Roelofs & Meyer, 1999). Lemmas have language tags (for either the primary language (L1) or the secondary language (L2)), which enables them to be specifically selected for word production.

The functional circuits of coordinated schemas both activate and inhibit these tags in order to facilitate the language-related goal. The activation of these tags is also determined by external or internal stimuli; in this case, external stimuli might involve hearing or reading certain words, and internal stimuli would involve the cognitive conceptual representation formed from long-term memory and motivated by the earlier mentioned language-related goal. IC comes into play as the functional control circuits inhibit those lemmas whose tags are incorrect, such as a potential situation in which an L2 lexical concept activates an L1 lemma due to the L2 concept being similar to another concept in the L1. This model suggests that bilingual individuals must utilize inhibitory processes on a frequent and regular basis. With a heightened demand for inhibitory control, it seems logical that bilingual individuals might develop these cognitive abilities at a quicker rate than their monolingual peers without this additional linguistic requirement for inhibition. Evidence for this mechanism exists in neuroimaging literature that has found DL-PFC activation during language switching (Hernandez, 2009; Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Hernandez, Martinez, & Kohnert, 2000).

Recent evidence seems to suggest that inhibitory control may not be the sole EF component that develops more quickly in bilingual children. Bialystok (2010) found bilingual advantages on global-local and the trail-making test in conditions with and without conflict. The advantages observed in this case were not necessarily in the area of inhibition, but were interpreted to be in the areas of working memory and shifting attention. This seems to suggest that a model completely based on inhibitory control may not fully explain the development of EF in bilingual individuals.

Neuroimaging research has suggested that bilingual individuals utilize different neural networks when performing EF tasks. Using magneto-encephalography (MEG) technology on the Simon task, Bialystok et al. (2005) found that, though monolingual and bilingual young adults both utilized left and medial PFC regions, the bilingual individuals showed greater activation mostly in the left hemisphere, in the superior and middle temporal, cingulate, and superior and inferior frontal regions. This activation was associated with faster reaction times. The monolingual group showed activation in the middle frontal regions when they were reacting faster. Garbin et al. (2010) found similar results during a non-verbal task-switching paradigm. The bilingual group activated the left inferior frontal cortex and left striatum in contrast to the areas activated in the monolingual participants, which were the right inferior frontal cortex and the anterior cingulate. Garbin and colleagues proposed that this greater involvement of the left inferior frontal cortex may indicate a higher ability in bilinguals “to establish the appropriate response set to each stimulus” (p. 1277).

There are important limitations to discuss regarding the current research on this topic. First, as Carlson and Meltzoff (2008) pointed out, the linguistic groups that have been represented in these studies is limited to those speaking Chinese, French, and English, with some studies included heterogeneous language groups. As cultural differences often times go hand-in-hand with linguistic differences, it is important that other languages be included in future research, especially considering how culture might impact parental or adult expectations for child behavior. For example, monolingual Chinese preschoolers have demonstrated higher EF compared to preschoolers from North America (Sabbagh, Xu, Carlson, Moses & Lee, 2006). Bialystok and Viswanathan (2009) attempted to examine how bilingual advantages may compare across cultures, examining bilingual and monolingual samples in Canada and India. The bilingual children from both countries outperformed their monolingual peers on tasks that required inhibitory control and cognitive flexibility. They also performed equivalently to each other.

Carlson and Meltzoff (2008) have conducted the only study examining the EF of Spanish speaking bilinguals, which represent the largest non-English language group in the United States (U.S. Census Bureau, 2006). Additionally, this study is the first to include more comprehensive analyses of demographic variables that might impact the development of EF in bilingual children, including SES and parental emphasis on self-control in children. Finally, there have been no studies that include analyses along the hot and cool distinction of EF. While, as mentioned earlier, it is impossible to have a purely hot or purely cool measure of EF, it would be possible to include measures in one's battery that emphasize one more so than the other.

Culture

As mentioned earlier, Carlson and Meltzoff (2008) alone have examined the potential influence of a more culturally derived demographic variable on the EF in bilingual children—parental emphasis on self-control, indicating a paucity of research in the effect of culture on the observed bilingual EF advantage. Existing data on cultural differences regarding parental expectations for self-regulation or self-control are most prevalent in comparisons of members of individualistic and collectivistic cultures (Feldman, Masalha & Alony, 2006). While the mainstream American culture is considered to be individualistic, many Latino and Asian cultures tend to come from a more collectivistic cultural background (Feng, Harwood, Leyendecker & Miller, 2001). In individualistic societies, the focus tends to be on building "self-reliance, independence, and creativity" in children, while in collectivistic societies, the focus is on promoting "obedience, reliability, and proper behavior" (Triandis, 1989, p. 510). Triandis (1995) further defines individualism and collectivism as having both vertical and horizontal components. The vertical dimension involves accepting oneself as different and acceptance of inequality, while the horizontal dimension "emphasizes that people should be similar on most attributes, especially status” (p. 44). In *horizontal individualism*, “people want to be distinct from groups…and are highly self-reliant,” while in *vertical individualism*, “people often want to become distinguished and acquire status” (Triandis & Gelfand, 1998, p. 119). *Horizontal collectivism* involves people emphasizing their commonalities with others, but not submitting to authority, while *vertical collectivism* includes making sacrifices of personal goals for the goals of the group. The latter would involve submission to authority for the sake of the group. Singelis, Triandis, Bhawuk, and Gelfand (1995) showed that this model, using factor analysis, is valid within an American sample.

Differences have been noted in the parental practices of individuals from individualistic and collectivistic backgrounds. Caucasian parents were found to report that their infants spent significantly more time self-feeding and sleeping alone compared to Puerto Rican middle-class parents’ reports (Feng et al., 2001). The Puerto Rican parents reported that their infants spent much more time engaging in multiparty interactions compared to the Caucasian infants. This would reflect the different parental expectations of collectivistic cultures, specifically Latino here, for independent functioning in their child, as compared to Caucasian, or individualistic, cultural expectations. This difference in expectations for independent infant functioning was also observed by Schulze, Harwood and Schoelmerich (2001). In their study, Puerto Rican mothers reported that their infants began self-feeding at a significantly later age compared to Caucasian mothers. These mothers also reported emphasizing parental goals which fall in line with the earlier emphases of individualistic versus collectivistic cultures, with Puerto Rican mothers emphasizing proper demeanor and Caucasian mothers emphasizing self-maximization.

Harwood, Shoelmerich, Schulze and Gonzalez (1999) also inquired about parental strategies regarding their goals for the socialization of Puerto Rican and Caucasian children. The Puerto Rican mothers listed using “direct exercise of parental authority,” and strategies that “directly guide the child’s learning experiences, thus highlighting the child’s sense of interpersonal obligation” (p. 1013). The Caucasian mothers reported aiming to structure learning experiences indirectly in attempts to build their children’s autonomy and ability to choose independently. In a comparison of Cameroonian Nso farmers and Greek and Costa Rican middle-class farmers, the Costa Rican parents demonstrated aspects of both distal and proximal parenting styles, with their children performing between the other two cultural groups in terms of demonstrated self-regulation (Keller et al., 2004). This somewhat complicates the picture, as proximal parenting styles are associated with collectivistic societies, while distal parenting styles are typically demonstrated by parents from individualistic cultures, suggesting that the individualism-collectivism dimension may operate as a spectrum, on which the Cameroonian Nso sample in this study was more collectivistic than the Costa Rican families sampled, though the Greek families were more individualistic than both of these groups. Keller et al. reference “autonomous relatedness,” that occurs in educated, middle-class families from collectivistic societies, as “comprising autonomy and relatedness; the corresponding self is defined as autonomous with respect to agency and related with respect to interpersonal distance” (p.

1746). This may mean that education and SES may impact the relationship between culture and parenting practices.

Finally, in the earlier mentioned study by Carlson and Meltzoff (2008), parental value of their child's self-control, as assessed by the Rules Questionnaire (Smetana, Kochanska & Chuang, 2000), and the importance of self-control, as measured by the Children's Behavior Questionnaire (Rothbart, Ahadi, Hershey & Fischer, 2001), was higher in the parents of bilingual English-Spanish kindergartners than monolingual English-speaking children in traditional or language immersion kindergarten programs. While it seems that high parental expectations for self-regulation may exist within the Latino, collectivistic culture, it is unclear how these expectations might impact the performance of children on measures of EF.

Poverty

Socioeconomic status, or poverty, has been shown to impact the developmental course of EF (Lipina & Colombo, 2009). This is due to the multitude of risk factors associated with living in poverty, including physical, mental, and psychosocial environmental aspects (Farah et al., 2006). All of these factors, separately, and in accumulation, affect the developing brain and subsequent neural networks. It remains unclear, however, which specific PFC systems are most impacted by SES.

SES has predicted and/or explained the variance in EF performance in multiple studies. It predicted a significant proportion of variance in EF in two-year-olds and longitudinally from age two to three and from age two to four (Hughes & Ensor, 2005; Hughes & Ensor, 2006). Noble, Norman and Farah (2005) examined the impact of socioeconomic background on five domains of neurocognitive functioning in 60 kindergartners—the language system, the executive system, the spatial cognition system, the memory system and the visual cognition system. Across all five domains, a main effect of socioeconomic status (SES) was found, with children from lower SES backgrounds performing lower than their peers from middle SES backgrounds. An interaction effect was observed between SES and neurocognitive system for the language and executive systems, associated with the left perisylvian and prefrontal areas, respectively. Ardila, Rosselli, Matute & Guajardo (2005) found a significant correlation between parental education level and executive functions in a sample of Colombian and Mexican children. Mezzacappa (2004) compared socially advantaged and disadvantaged children in their performance on the ANT (Attention Network Test) (Berger, Jones, Rothbart, & Posner, 2000), with the socially advantaged children performing better in overall accuracy and response speed. Farah et al. (2006) examined three EF components, working memory, cognitive control, and reward processing, finding that only working memory and cognitive control were associated with SES disparities. This might suggest that hot EF performance is not as negatively impacted by SES factors, and could be at least partially explained by the faster maturation of the OF-PFC, making it less susceptible to the environmental effects of childhood poverty.

Parenting/Caregivers

Parenting practices may also influence the development of EF. One such way is as a mediator for the effects of poverty. This is illustrated by the family stress model (Conger & Elder, 1994). In this model, the impact poverty might have on outcomes in children is mediated by several variables. Though this model was originally developed in regards to families living in rural areas, Parke et al. (2004) used it to guide their study of an urban sample with diverse socioeconomic backgrounds. Using structural equation modeling (SEM), Parke and colleagues found that economic stress was related to parental reports of depression. This parental depression was linked to higher levels of hostile parenting in both parents, which, in turn, was linked to child adjustment problems (e.g. internalizing and externalizing behaviors). Several additional studies link economic stress, which is experienced by parents or caregivers, to poor social and emotional outcomes in children (Elder, Conger, Foster & Ardelt, 1991; Conger, Ge, Elder, Lorenz & Simons, 1994; Mistry, Vandewater, Huston & McLoyd, 2002; Dennis, Parke, Coltrane, Blacher & Borthwick-Duffy, 2003; Robila & Krishnakumar, 2006). It is important to note, though, that this relationship is often mediated by parental depression or distress. In contrast, evidence also exists to suggest that adequate parenting practices can serve as a protective factor against the myriad of other risk factors associated with living in poverty (Brody, Dorsey, Forehand, & Armistead, 2002).

Other caregiver-child interactions have been observed to impact the development of general self-regulatory skills. Self-regulation is demonstrated by infants, and can be influenced by the choices caregivers make as to where they sleep (Shonkoff & Phillips, 2000). Those infants who sleep alone in their cribs may establish self-settling patterns earlier than those in other sleeping arrangements. Bradley et al. (2001) conducted a large-scale study of the home environments of American children, finding that parental responsiveness was significantly related to social development, though this relationship was of a small magnitude. Maternal warmth has also been well-studied in its relationship with self-regulation in children (Jennings et al., 2008). Other maternal behaviors, such as their strategy for instructing their children, have been shown to relate to the demonstrated self-regulatory behaviors of three-year-old children (LeCuyer-Maus & Houck, 2002; Houck & LeCuyer-Maus, 2004. When research has specifically examined the relationship between EF and parent-child interactions, the results have not led to any clear conclusions. Additional research is needed to determine if such a relationship exists.

CHAPTER III

METHODS

The current study utilized quasi-experimental methods to examine the executive function (EF) skills of bilingual Spanish-English speaking children, as compared to their monolingual peers and to examine psychosocial predictors of EF in children. A MANCOVA design was used to compare two independent groups of children, ages 4-7 years, on five performance-based measures of EF, including two that emphasize hot EF and three that emphasize cool EF, and one observation-based measure of EF (the BRIEF Parent Ratings). Additional analyses examined the ability of psychosocial variables, including parenting practices and culture to predict EF, using a multiple regression model. The remainder of this chapter will describe the methodology that will be used in recruitment, data collection, as well as a description of the measures used and the statistical analyses.

Recruitment

Approval was obtained from the Institutional Review Board (IRB) prior to, and throughout, data collection. Families of children, ages 4-7, were recruited from public schools and community centers in Southwestern communities of the United States. These families were recruited through the distribution of recruitment materials, which included a recruitment letter, consent, and permission forms. Interested families returned these completed forms to their community center or school and were contacted by the researchers outside of these facilities. Families completed a brief phone interview in order to determine their eligibility for the current study. Families of children with identified disabilities or who were currently taking stimulant medication were excluded from the sample to limit potential confounds. Children who spoke a language other than Spanish or English were also excluded.

Procedure

As mentioned earlier, recruitment materials were sent home with children, ages 4-7, at participating schools and community centers. Interested parents returned signed informed permission and consent forms and were contacted by the researchers. A screening phone interview was then conducted to determine eligibility, gather demographic information, and to schedule a measurement session. These sessions were completed at families' homes or at a neutral community location, such as a reserved library meeting room. Sessions lasted from 1-2 hours, with the option for parents to come for one longer session or two shorter ones.

At the measurement session(s) parents completed the Behavior Inventory of Executive Function (BRIEF; Gioia et al., 2000), the Parenting Relationship Questionnaire (PRQ; Reynolds & Kamphaus, 2006), the Individualism/Collectivism Scale (Triandis, 1995), a race/ethnicity measurement, and a measurement of economic stress. The child participants completed measurements of height, weight, receptive oral language, utilizing the Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4; Dunn & Dunn, 2007) and five tasks measuring EF. Height, weight, and the fifth test of EF are not analyzed in the current study. Of the four tasks analyzed in this study, two emphasize cool EF and two emphasize hot EF. Each child participant was administered the PPVT-

4. Only those children whose parents reported that they were Spanish speaking were administered the TVIP. The PPVT-4 was administered first in every session, followed by the TVIP if appropriate. The order of the EF tasks was randomly assigned, with one of five potential orders.

Child language status was determined by a cutoff standard score of 70, by which bilingual children obtained a standard score of 70 on both the PPVT-4 and the TVIP. Children who had not been exposed to Spanish or whose parents reported they only spoke English were considered to be monolingual English speakers. Those children who had been exposed to Spanish but did not obtain a standard score of 70 or higher on the TVIP and PPVT-4 were coded into a third "partial bilingual" group. Children were administered the four EF tasks in the language in which they obtained the highest receptive oral language score (either English or Spanish).

The measures of EF included the Delay of Gratification task (Prencipe & Zelazo, 2005), the Children's Stroop task (Gerstadt, Hong, & Diamond, 1994), the Less is More task (Carlson, Davis, & Leach, 2005), and the Tower task from the NEPSY (Korkman, Kirk & Kemp, 1998).

After the families completed all of the measurements, they each received $20 cash and were entered into a drawing for a $150 Walmart gift card. Children received two small prizes for their participation, as well.

Sample

The sample includes 78 children, ages 4-7 years, and one parent or primary caregiver. Of these children, 19 were considered to be bilingual, 48 were considered to be monolingual English speakers, and 11 were considered partially bilingual. Of those considered partially bilingual, 6 children had only Spanish receptive vocabulary over the 70 standards score cutoff and 4 had only English receptive vocabulary above the cutoff. Partially bilingual children and their families were excluded from the analyses in this study, due to the small sample size; resulting in a sample size of 67. The mean age of the sample was 6.23 years (SD = .71). Most children were born in the United States (*n* = 60). A total of 23 children were reported to be of Latino or Hispanic descent. The majority of these children were reported to be of Mexican American or Mexican descent (*n* = 15). There were slightly more female child participants than males (*n* = 39 and 28, respectively). The majority of the children considered bilingual speak Spanish at home (61%) and both English and Spanish at school (67%). Their parents reported speaking mostly Spanish at home (72%). Additional demographic data can be found in Table 1.

Instruments

Demographic Questionnaire

A demographic questionnaire was administered via brief phone interview or on paper. It was developed for the purposes of this study, containing approximately 10 items. These items addressed background information about the child participant, including country of origin, languages spoken both at home and/or at school, number of years in the United States, parental education, parental occupation, and the economic stress experienced by the family. It was administered/provided either English or Spanish depending on parental preference. See Appendix B.

The demographic questionnaire included three items measuring economic stress. Two of these indicators were originally utilized by Parke et al. (2004). The first indicator uses two items addressing monthly income: the parents' ability to pay bills each month and the presence of any monetary surplus by the end of the month. In concordance with Parke et al., the parent's ability to pay their monthly bills were measured on a 5-point Likert scale, with 1 indicating no difficulty paying bills, and 5 indicating much difficulty. The second item was measured on a 4-point Likert scale, as in Parke et al.'s study, with a rating of 1 indicating that the family has plenty of money left over, and a rating of 4 indicating that there was not enough money to "make ends meet" (p. 1636). Parke et al. report correlations of these two items ranging from .66-.67 in Mexican American parents and from .80-.81 in European American parents.

The second indicator of economic stress measures the ability of parents' to meet the basic needs of their family, including shelter, food, clothing, household items, transportation, and medical care. Parke et al. report Cronbach's αs of .92 for European mothers, .90 for Mexican American mothers, .94 for European American fathers and .86 for Mexican American fathers for this indicator. This item was slightly modified from the item used in Parke et al., in that it included "transportation" as a basic need, instead of "car," and did not include "recreational activities," as this was not considered a basic need by the primary investigator. Due to this modification, internal consistency was re-evaluated, indicating sufficient reliability in English and Spanish (Cronbach's $\alpha = .87$ and .81, respectively).

The third indicator used by Parke et al. was not included in this study. The construct of economic stress was first developed by Conger and Elder (1994) to describe how the effects of economic hardship impact family life. Parents who experience high levels of economic stress due to economic hardships like those included as indicators in Parke et al. (2004), have demonstrated high levels of negative emotions (e.g. depression and distress) that have been associated with poor outcomes in their children (Elder, Conger, Foster & Ardelt, 1991; Conger, Ge, Elder, Lorenz & Simons, 1994; Mistry, Vandewater, Huston & McLoyd, 2002; Dennis, Parke, Coltrane, Blacher & Borthwick-Duffy, 2003; Robila & Krishnakumar, 2006).

For parental education and occupation, a Hollingshead index score was assigned using a simplified version of the Hollingshead Occupational Scale (1975). The occupation scores ranged from 0 to 9, which were then multiplied by a weight of 5. A score of 0 was given to individuals without employ or who reported being homemakers. Parental education was assessed in reported years, with scores ranging from 1 to 7, which were then multiplied by a weight of 3. Per Hollingshead, these scores could then be added together, however, internal consistency for this was low (Cronbach's $\alpha = .42$) and these were analyzed as separate indicators of socioeconomic status (SES).

Behavior Rating Inventory of Executive Function (BRIEF)

The BRIEF (Gioia et al., 2000) will be used as an observational measure of EF, completed by the participating child's parent(s). The BRIEF contains 86 items that are included in eight clinical scales, some of which overlap, and two validity scales. The eight scales include Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials and Monitor. Two broad indexes are created from these scales—Behavioral Regulation and Metacognition. An additional Global Executive Composite score is derived from all scales in the BRIEF. The BRIEF is available in both English and Spanish, and took approximately 10-15 minutes to complete.

The internal consistency of the BRIEF is high, ranging from .80 to .98 (Gioia et al., 2000). Over an average interval of two weeks, test-retest correlations across the clinical scales ranged from .76 to .85. In terms of content validity, the items that were selected came from clinical interviews with parents and teachers in order to "capture common descriptions and complaints that reflect behavioral expressions of executive functions" (p. 53). Construct validity was established through correlations with the ADHD-Rating Scale-IV, the Child Behavior Checklist, the Behavior Assessment System for Children and the Conners' Rating Scale. Additional exploratory factor analyses were conducted, with a two-factor solution accounting for 74% of the variance.

Parenting Relationship Questionnaire (PRQ)

The PRQ (Reynolds & Kamphaus, 2006) was used to measure two psychosocial variables of parenting practices. While the questionnaire includes seven scales, only two will be used in the current study: Discipline Practices, and Relational Frustration. The Discipline Practices scale measures parental responses to misbehavior and parent beliefs about rule adherence, and will be used to measure parental disciplinary practices. The Relational Frustration scale measures parental stress regarding their parent-child relationship, and will be used to measure parental stress. Each of these variables will be in the form of the T-score of the appropriate PRQ scale. The PRQ take approximately 10-15 minutes to complete and is available in both English and Spanish. Both forms of the PRQ—the Preschool (PRQ-P) and the Child and adolescent forms (PRQ-CA)—will be necessary, due to the potential that some kindergartners may be age 6.

The Discipline Practices scale on the PRQ-P has an internal consistency of .86 and an internal consistency of .82 on the PRQ-CA for 6-9-year-olds. The Relational Frustration scale has an internal consistency ranging from .76-.80 on the PRQ-P and an internal consistency ranging from .86-.87 in 6-9-year-olds on the PRQ-CA. On the PRQ-P, Discipline Practices has test-retest reliability of .89, while on the PRQ-CA, this scale has test-retest reliability of .72. On the PRQ-P, the Relational Frustration scale has test-retest reliability of .81-.82, while on the PRQ-CA, this scale has a test-retest reliability of .78-.82. The PRQ was compared to the Parent-Child Relationship Inventory, the Parenting Stress Index, Third Edition, the Stress Index for Parents of Adolescents, the Behavior Assessment System for Children (BASC), the BASC-2 Self-Report of Personality, the PSI, and the SIPA. These correlations were all in the expected directions and consistent with a priori expectations.

Individualism/Collectivism Scale

Instrument 1 from Triandis (1995) will be used to measure individualism and collectivism in the parents participating in this study. For the purposes of the study, it will be called the Individualism/Collectivism Scale. In following Cote and Bornstein (2003), only the first portion of this instrument was used. The scale consists of 32 items, each of which includes a statement and a 9-point Likert scale. On this scale, a rating of 1 indicates “Strongly Disagree,” and a rating of 9 indicates “Strongly Agree.” There are 8 items for each scale of horizontal and vertical individualism and collectivism. As such each parent obtained four scores from this measure. Triandis (1995) demonstrated sufficient construct validity of this measure and internal consistency of Cronbach’s α between .67 and .74 for each scale. A Spanish translation of this instrument was created for the purposes of this study. For this reason, internal consistency was recalculated for the English and Spanish versions. For the English version, the internal consistency was between .54 and .77 for each of the four scales. For the Spanish version, Cronbach’s α ranged from .50 to .71 for each scale.

Peabody Picture Vocabulary Test, Fourth Edition (PPVT-4)

The PPVT-4 (Dunn & Dunn, 2007) will be used to measure receptive oral language in English. Oral language has been measured in previous studies of bilingual EF in order to measure language proficiency (Bialystok, 1988; Bialystok, 1999; Goetz, 2003; Bialystok & Martin, 2004; Bialystok & Senman, 2004; Bialystok & Shapero, 2005). Specifically, these studies have used earlier versions of the PPVT (e.g. PPVT-R, PPVT-III) to measure English oral language. As mentioned earlier, this will be used to establish English language proficiency, so as to determine the most appropriate language group in which to include each participant.

The PPVT-4 was administered individually, with the examiner saying each word item, to which the child will respond by pointed to one of four pictures that best represents the meaning of that word (Dunn & Dunn, 2007). The internal consistency of the PPVT-4 on Form A ranges from .93 to .98. The test-retest correlations range from

.92 to .96. It has demonstrated sufficient convergent validity, correlating highly with other language measures (e.g. EVT-2, CASL, CELF-4, GRADE and PPVT-III). Content validity has also been established, as the stimulus words were chosen from reviews of other published reference works.

Test de Vocabulario en Imagenes Peabody (TVIP)

The TVIP (Dunn et al., 1986) was used to measure of Spanish receptive oral language. As mentioned regarding English oral language, oral language is an established measure of language proficiency. There is no established precedent within the bilingual EF literature for using the TVIP, in part because Spanish speakers have not been utilized with much frequency in such studies. There is, however, a precedent for measuring oral language in both languages spoken by the bilingual sample if possible, as in Bialystok (1988), in which an Italian translation of the PPVT was used in addition to the English version.

The TVIP was administered individually, with the examiner saying each word item, to which the child will respond by pointed to one of four pictures that best represents the meaning of that word (Dunn et al., 1986). The TVIP has an internal consistency ranging from .80 to .95. It has sufficient content validity, as the stimulus words were taken from the English PPVT-R, and concurrent validity, as the TVIP correlated significantly with the K-ABC and the Habilidad General Ability.

Delay of Gratification

The delay of gratification task (Prencipe & Zelazo (2005) was used as one of two measures emphasizing hot EF. Prencipe and Zelazo modified this task from that of

Thompson, Barresi and Moore's (1997) delay of gratification task. This task involves presenting a deck of cards to the examinee, with each card requiring a decision of whether to take an immediate reward or to save the reward until the end of the task (Prencipe & Zelazo, 2005). There are nine trials, varied by reward type (candy, stickers, and pennies) and choice type (one now vs. two later, one now vs. four later, and one now vs. six later). Each card specifies the reward and choice type with a picture. Internal consistency for this task, both in English and Spanish, was considered acceptable (Cronbach's $\alpha = .86$ and .63, respectively). Previous research has not established a bilingual advantage on this task (Carlson & Meltzoff, 2008), but to date only one study has conducted a bilingual-monolingual comparison on this measure, and this study did not include the delay of gratification task specifically as a measure of hot EF.

Less Is More

Less is More (Carlson et al., 2005) was the second of two measures emphasizing hot EF in the current study. It is described as a "reverse-reward contingency task," because the examinee receives a larger amount of a reward when he/she points to the smaller amount of that same reward. In this task, the examiner first gives the child a choice between two treats (e.g. jelly beans or chocolate chips), which are then used as the reward for the rest of the task. The examiner then presents a pile of five treats and a pile of two treats, asking the child which they prefer. After they select the larger pile, the experimenter introduces the child to a puppet, who is described as naughty because he wants all the treats for himself. The experimenter then places a cup in front of the puppet and the child to show how the treats are accumulating. The experimenter then explains that every time the child selects a pile of treats, they will go into the puppet's cup, and the other pile will go into his/her cup. After practicing this one time and checking for rule understanding, the child receives 16 test trials. Each trial involves sets of two and five treats, with the positions counterbalanced (left vs. right). A verbal remainder of the rule is given after 8 trials, with the puppet and the puppet's cup being moved to the other side of the child. The score used for this study will be the proportion of trials in which the child chose the smaller, optimal pile. Internal consistency for this task, both in English and Spanish, was considered acceptable (Cronbach's $\alpha = .89$ and .74, respectively). To date, the Less is More task has not been included in comparisons of monolingual and bilingual EF.

Day/Night Task

The Children's Stroop Task (Gerstadt et al., 1994) was used as one of two measures emphasizing cool EF. This task specifically measures inhibition. It was developed as a simplified version of the Stroop color-word task (Stroop, 1935). In this task, a deck of cards is used. Half of these cards have a white face with a picture of a sun, and half have a black face with pictures of the moon and stars. When the child is presented with the sun card, they are to say "night." When the child is presented with the moon card, they are to say "day." There are a total of 16 cards presented in this task, with the total number correct being used as the score in the current study. Internal consistency for this task, both in English and Spanish, was considered acceptable (Cronbach's $\alpha = .82$ and .94, respectively). Previous bilingual-monolingual comparisons have found a bilingual advantage on Stroop tasks (Poulin-Dubois et al., 2011). This task requires the inhibition of prepotent responses and is considered a measure of selective attention (Banich et al., 2000a) and inhibitory control, which occur simultaneously (Miller & Cohen, 2001).

Tower Task

The tower task from the NEPSY (Korkman, Kirk & Kemp, 1998) was used as the second of two measures emphasizing cool EF, due to the ages of the children in this sample. The tower is one of seven subtests measures the Attention-Executive Domain of the NEPSY. This task involves working memory, planning, inhibition, and mental flexibility (Bull, Epsy & Senn, 2004). The task was administered according to the published instructions in the NEPSY manual (Korman et al., 1998). In the tower task, children are shown three colored balls that can move from one peg to another. They are then told the rules, which involve only moving one ball at a time, that the balls must remain on the pegs when not being moved, and that each move is finished when they remove their hand from the ball. The stimulus book contains the target positions for each of 20 trials. If a child breaks the rule, the balls are put back in the original places and the task continues. There is a time and move limit per trial. The test is discontinued after 4 consecutive failures to meet these limits. The score used in the current study is the total trials passed. The NEPSY Core Domain Scores demonstrate sufficient internal consistency (.69-.91) and stability coefficients (.67-.76) (Miller, 2001). Content validity was established through a review of the items by an expert panel. The construct validity was established through correlational patterns among the subtests for each Domain. Convergent and divergent validity was established through correlational studies with measures of general cognitive ability, achievement, and neuropsychological functions. Internal consistency for this task, both in English and Spanish, was considered acceptable (Cronbach's $\alpha = .78$ and .87, respectively). The Tower task has not previously been utilized in bilingual-monolingual comparisons. It is considered to be a measure of planning (Shallice, 1982), but this version also requires inhibitory control in that the child must think about his/her move sequence before actually moving the balls to get the items correct.

Translations

For those instruments without Spanish translations, the items and instructions were translated into Spanish and reverse translated back into English in order to ensure that the meaning of those items is retained. Due to the lack of a Spanish-speaking normative sample for these translated measures, raw task scores were used in bilingual-monolingual comparisons instead of standard scores. Approximately 22% of parents completed Spanish translations of forms and 16% of the child participants were administered the EF tasks primarily in Spanish.

Data Analyses

Skewness and kurtosis were examined for each language group separately. To determine normality of distributions, the skewness and kurtosis statistics were divided by their standard error. Values above 3 were considered abnormal, in accordance with Kline (1998). For the EF measures, the Day/Night and Less is More task distributions were extremely negatively skewed and overly kurtotic among the monolingual English sample. The hot EF total score was also negatively skewed and overly kurtotic within this group. To correct for this, first a restricted range technique was implemented, in which all scores for these tasks were corrected to fall within two standard deviations of the mean. This was implemented on the monolingual English and bilingual samples, using each sample's respective mean and standard deviation. Any outlier scores for these measures were changed the respective value of two standard deviations above or below the mean. This technique reduced the skewness and kurtosis of all three distributions, with only Less is More still remaining extremely negative skewed and overly kurtotic. The entire sample's Less is More score were then reversed, changing the negative skew to positive, and a log transformation ($\log_{10}$) was applied. With this transformation, all skewness and kurtosis values were within the acceptable ranges.

There were 1-8 data points, depending on the variable, missing randomly from the data set due to parental errors in completing the surveys or researcher errors in the provision of appropriate translations of forms. These missing data points were unrelated to any participant characteristics. To address these missing data, multiple imputation was conducted, producing 10 different imputed data sets. The same skewness and kurtosis techniques were applied to each of these imputed data sets.

Data analyses were conducted in order to answer the research questions described in Chapter I. First, groups were compared across demographic variables to determine the appropriate covariates to be utilized. To further assist in this determination, correlations were observed between and among the independent variables and dependent variables. A MANCOVA model was utilized to examine group differences in hot and cool EF.

The second research question was answered by three multiple regression equations. The cool EF equation utilized the cool EF total score, for which the Day/Night and Tower task scores were added together. Likewise, the hot EF total score was used for the hot EF equation, including the Less is More and Delay of Gratification scores. A final regression model was used to predict BRIEF GEC. These models included those covariates that were significant in the MANCOVA model as well as all four individualism and collectivism scales, disciplinary practices, and relational frustration.

Due to a lack of significant findings regarding the first research question, additional analyses were not conducted to answer the third research question.

CHAPTER IV

RESULTS

Preliminary Analyses

Demographic Characteristics

The monolingual and bilingual groups were compared across multiple variables, including age, parental education, parental occupation, economic stress, English receptive vocabulary, the four scales of the Individualism/Collectivism measure, disciplinary practices, and relational frustration.

The groups significantly differed in terms of economic stress (t (64) = -2.759, $p < .01$), both indicators of SES (parental education: t (60) = 6.908, $p < .001$; parental occupation: t (62) = 3.207, $p < .01$), age (t (65) = -2.299, $p < .05$), English receptive vocabulary (t (65) = 7.191, $p < .001$), and horizontal collectivism (t (61) = -3.087, $p < .01$). Group means and significant group differences are included in Table 1.

Correlations

One-tailed correlations among age, economic stress, SES indicators, English receptive vocabulary, the Individualism/Collectivism scales, disciplinary practices, relational frustration, and EF scores are presented in Table 2. One-tailed statistics were selected due to their being a specific directional hypothesis regarding the relationship between the selected variables. Of note, performance on the Tower task was significantly correlated with economic stress (r = -.235, $p < .05$), parental education (r = .223, $p < .05$), and age (r = .331, $p < .01$). Day/Night task performance was significantly correlated with parental education ($r = .337$ $p < .01$), English receptive vocabulary ($r = .341$, $p < .01$), and vertical individualism ($r = .213$, $p < .05$). Less is More was significantly related to parental education ($r = -.360$, $p < .01$) and English receptive vocabulary ($r = -.308$, $p < .01$). Delay of Gratification was significant correlated with vertical individualism ($r = -.296$, $p < .05$). Finally, the BRIEF GEC *T*-score was significantly correlated with parental education ($r = .241$, $p < .05$), relational frustration ($r = .706$, $p < .001$), and horizontal collectivism ($r = -.270$, $p < .05$).

Group Comparisons

Due to significant group differences in English receptive vocabulary, parental education, age, horizontal collectivism, and economic stress, as well as significant correlations of these variables with at least one EF task, they were included as covariates in group comparisons.

All EF measurements, including hot and cool EF tasks and the BRIEF GEC, were the dependent variables in the MANCOVA model analyzed. The five covariates listed earlier were included in the model, in addition to the group factor. The MANCOVA was first run using the original data set, before imputations, in order to obtain a multivariate effect for language status. Next, the MANCOVA was run with each of the 10 imputed data sets in order to obtain pooled parameter estimates.

The MANCOVA with the original data set yielded no significant multivariate effects for language group, $\lambda = .899$ (F (5, 45) = 1.009, $p > .05$). There were also no significant univariate effects indicated. The covariate economic stress was significantly related to GEC *T*-score (F (1, 49) = 6.703, $p < .05$, partial $\eta^2 = .12$), in that higher economic stress was related to higher GEC *T*-scores, which indicate more global parental EF concerns. Age was also significantly related to Tower performance (F (1, 49) = 8.061, $p < .01$, partial $\eta^2 = .14$), in that as age increased, tower performance improved. MANCOVA results are listed in Table 3.

Pooled parameter estimates for the MANCOVA model from the 10 imputed data sets can found in Table 4. Of note, the pooled parameter estimate for economic stress in predicting GEC was significant ($p < .05$), as was the parameter estimate for age in predicting Tower task performance ($p < .01$). Both of these parameters were positive.

Multiple Regression

Two EF total scores (hot and cool EF totals) were calculated to account for potentially different aspects of cool and hot EF being measured by each EF task. A separate regression was used to predict BRIEF GEC. The predictors were entered into the model in one step using forced entry. Based on the parameter estimates of the MANCOVA model, age was included in the cool EF regression model and economic stress was included in the GEC model. Additional predictors included disciplinary practices, relational frustration, and the four Individualism/Collectivism scales. A summary of these analyses can be viewed in Table 5.

For the hot EF tasks, the proposed model accounted for 27.6% of the variance in this total score. Follow-up ANOVA tests indicated good model fit (F (6, 44) = 2.798, $p < .05$). Vertical individualism was the sole parameter yielding a significant t statistic (t (44) = -2.923, $p < .05$). This parameter was negative, indicating that as parents' beliefs about the importance of competition and personal distinction increase, performance on hot EF tasks becomes poorer.

For the cool EF tasks, the proposed model accounted for 26.9% of the variance in this total score. Follow-up ANOVA tests indicated good model fit (F (7, 43) = 2.263, p < .05). Vertical collectivism was the sole parameter yielding a significant t statistic (t (43) = -3.059, p < .01). This parameter was negative, indicating that as parental cultural beliefs about the importance of duty and self-sacrifice for one's family or group increase, performance on cool EF tasks decreases, or becomes poorer.

Finally, the proposed model accounted for 65.1% of the variance in BRIEF GEC score. Follow-up ANOVA tests indicated good model fit (F (7, 42) = 11.18, p < .001). Economic stress (t (42) = 2.574, p < .05) and relational frustration (t (42) = 7.039, p < .001) contributed significantly to the model. These parameters were both positive, indicating that as parental economic stress and/or relational frustration (with their rated child) increases, so does parental report of global EF impairment.

CHAPTER V

CONCLUSIONS

The present study sought to examine three research questions. The first asked whether bilingual advantages in EF would be observed when comparing Spanish-English speaking children and their English-speaking monolingual peers, specifically in the areas of hot and cool EF. Previous studies have firmly established bilingual advantages on tasks that require inhibition (Bialystok, 2001; Poulin-Doubois et al., 2011) and suggest potential advantage on tasks that measure working memory and attentional shifting (Bialystok, 2010). These tasks could all be categorized as measures of cool EF. To date, only two studies making bilingual-monolingual comparisons have utilized hot EF measures, but neither differentiated them as distinctively hot (Carlson & Meltzoff, 2008; Poulin-Doubois et al., 2011). Both studies failed to find bilingual advantages on these measures, but there is still reason to hypothesize, based on Zelazo et al.'s (2010) work on the interaction of hot and cool EF, that bilingual children could outperform their monolingual peers on measures of hot EF. As such, the present study hypothesized that bilingual advantages would be observed on measures of hot and cool EF.

The second research question inquired into the prediction of EF by psychosocial variables such as SES, economic stress, culture, and parenting practices. Previous research has shown that SES explains significant amounts of variance in EF (e.g., Ardila et al., 2005; Hughes & Ensor, 2005, 2006; Mezzacappa, 2004). Economic stress, parenting practices, and parental individualism and collectivism have not been researched in relation to EF, but are theorized to have an impact on EF due to parent-child interactions and parental emphasis and expectations related to self-regulation. As such, it was hypothesized that each of these variables would account for a significant portion of the variance when predicting EF in this sample.

The third research question followed the previous two, asking whether any bilingual advantages identified persisted when significant psychosocial predictors of EF were included in the multivariate analysis as covariates. It was hypothesized that these advantages would still be observed.

Bilingual EF Advantages

In relation to the first and third research questions, this study failed to establish or confirm that a bilingual advantage exists in the measures of EF included. Advantages were not present in multivariate or univariate analyses. There are several reasons why the previous advantages observed in bilingual children may not have been present in this sample.

Bilingual advantages may not have been observed due to the way in which bilingualism was measured in the present study. Previous studies have relied on parental report of bilingualism, determined by the presence of at least one parent who is, his or herself, bilingual, and indicating exposure to both languages at home. In the present study, bilingualism was determined by receptive vocabulary of 70 or higher in both English and Spanish. The majority of the parents of these children reported only speaking Spanish at home, indicating they themselves were not bilingual. The bilingual children included in this sample were exposed to English at school, indicating this exposure may have started at a later developmental period than the bilingual samples included in previous studies. It may be that this later exposure may not boost EF development in the same way or to the same extent that earlier exposure does. Carlson and Meltzoff (2008) found that the language exposure of children who had experienced six months of second-language immersion for half of a school day was not sufficient to produce an EF advantage. Bialystok (1988) also examined EF in individuals who had been immersed in a second language for two years, finding that they did, in fact, score as high as bilingual individuals on a cognitive control measure. It may be that the present study contributes to these findings in that even children with demonstrated receptive linguistic skill in two languages may not have sufficient experiences in regularly utilizing those two languages to produce heightened EF skills when compared to monolingual children.

The majority of bilingual-monolingual EF comparisons have been conducted with samples outside of the United States. In fact, only one other study has ever been conducted with an American bilingual sample. It may be that the development of bilingualism among American children learning two languages has a slightly different course than that of the populations previously examined. As Carlson and Meltzoff (2008) point out, Spanish-English bilingual children in the United States are often not at a disadvantage in terms of verbal ability and SES when compared to their monolingual peers. As the impact of poverty on EF development has yet to be fully understood, it may be that environmental factors experienced by American bilingual children affect their developmental trajectory in such a way as to not match that of bilingual children living outside of the United States.

That being said, it is important to note that, while in the present study the monolingual children came from higher SES backgrounds and had parents who reported lower economic stress, no significant differences were observed between the monolingual and bilingual groups. With higher reported parental education, more "prestigious" reported parental occupations, and lower parental economic stress, one might expect the monolingual group to demonstrate higher overall EF in these analyses. Carlson and Meltzoff (2008) described the equivalence of bilingual and monolingual raw scores on EF tasks as evidence of American Spanish-English speaking bilingual children possibly "doing more with less," in that they are able to compensate, or demonstrate resiliency, despite not having equivalent resources when compared to their monolingual peers (p. 293). This study provides additional evidence that bilingualism, as measured by this study, and as measured in previous studies, may serve as a protective factor, or moderating variable, for the negative effects of poverty on EF.

A final reason that bilingual advantages may not have been observed in the present study may lie in the specific components of EF that were measured here. Previous research has shown these advantages to be most consistently present in measures of conceptual or conflict inhibition (Bialystok & Martin, 2004). Additional more recent findings have observed potential advantages in working memory and attention shifting (Bialystok, 2010; Carlson & Meltzoff, 2008). These limited areas of EF advantage might explain some of the lack of findings in the present study, specifically as they relate to the planning required for Tower task performance and the delaying of rewards in the Delay of Gratification task. However, one would expect the Day/Night task to have produced a bilingual advantage, given the previous findings by Poulin-Dubois et al. (2011). Additionally, given the great need to hold rules in mind in the Less is More task, one would expect a potential working memory advantage to have been demonstrated on this task by bilingual children as well. The lack of findings in the present study, even with measures that were previously shown to be sensitive to bilingual EF advantages, indicates the need for continued research in the specific areas fostered by the cognitive control required in bilingual children.

EF Prediction

In relation to the second research question, this study established four psychosocial variables that predicted EF in this sample, though they were not consistent across tasks or methods of EF measurement. Specifically, cultural variables were found to significantly predict both hot and cool EF in this sample. It is interesting to note that these were both related to vertical dimensions, which involve differentiating oneself from the group. Hot EF was significantly predicted by vertical individualism, which is suggested by Triandis (1995) to be the tendency of middle- and upper-class Americans. It is related to the desire to stand out in a crowd and be distinctive. This variable's coefficient was negative, however, which indicates that children perform worse on hot EF tasks as their parents' endorsement of vertical individualistic items increased. This may link to the requirement of these tasks to engage in the de-contextualizing or "cooling down" of emotionally salient stimuli, like candy and sticker (Zelazo et al., 2010). If one's cultural values reflect a strong desire to always be distinctive, this may impede one's ability to effectively decontextualize a situation and engage more of the lateral PFC in the higher-order iterations of decision making mentioned earlier (Cunningham & Zelazo, 2007). Parents who emphasize competition may find themselves more easily aroused by the motivational aspects of situations and may model this for their children. It may be that this heightened emotional state makes iterative processing more difficult, and this leads to decreased hot EF task performance. It may also be that parents who are more vertically individualistic do not also teach/model effective emotional regulation skills to their children that might aid in their development of hot EF.

Vertical collectivism, on the other hand, significantly contributed to the model predicting cool EF. This relationship was also negative. In contrast to vertical individualism, vertical collectivism includes "a sense of serving the ingroup and sacrificing for the benefit of the ingroup and doing one's duty" (Triandis, 1995, p. 44). Parental emphasis on duty and self-sacrifice for the group may not promote the problem-solving skills necessary to perform well on cool EF tasks. Cognitive flexibility, working memory, and planning skills may develop through a certain degree of independence and exploration in early life, which are more permitted and emphasized by individualistic parents. These results are interesting in light of previous findings such as those by Sabbagh et al. (2006), in which Chinese children outperformed North American children on cool EF tasks. While all individuals from collectivistic cultures may not ascribe to vertical collectivistic values, one would expect that parental emphasis on self-regulation, which would occur across collectivistic domains, would promote earlier or more robust development of EF, as evidenced in the study conducted by Sabbagh and colleagues. These findings are indicators of the impact that cultural beliefs, and subsequent parenting practices, could potentially have on the development of EF in children. It is also evidence that different aspects of parenting may influence hot and cool EF development, making this an important field of future study.

Finally, it is interesting to note that two of the variables measuring parental stress or frustration significantly contributed to the prediction of parental ratings of EF. These variables included relational frustration and economic stress. It is important to note that the coefficient for relational frustration was quite large ($\beta = .715$), indicating that the BRIEF Global Executive Composite and the BASC-2 PRQ Relational Frustration subscale may be measuring very similar constructs or that one construct influences the other. It is certainly logical that a parent would be very frustrated in his or her parental interactions with a child who also does not demonstrate adequate problem-solving and self-regulatory skills, in reference to their same-age peer group. Of course, this may also be a "chicken and the egg" conundrum, as relational frustration would lead to increased negative parental reporting, but poor executive functioning would lead to considerable relational frustration. This warrants further research.

The fact that economic stress significantly predicted parental reports of EF both in the MANCOVA model and again in the regression while more traditional measurements of SES, such as parental education, did not, is an important finding. Economic stress measures more specifically how much pressure a parent is experiencing related to meeting his or her family's needs. This could significantly predict BRIEF GEC for several reasons. This may specifically relate to parental reports of EF because it is tapping into parental stress, which causes more negative views of their children's functioning. In this interpretation, true EF deficits may not be present. It could also be that the reporting is, in fact, accurate, and that EF is negatively impacted by parental stress in accordance with model presented by Conger and Elder (1994). Without consistent prediction across the EF measurements in this study, it is difficult to assess why this variable contributes to the prediction of parental reports of EF.

Hot and Cool EF

The present study also contributes to the literature regarding the measurement of hot and cool EF. The hot EF tasks included in the present study, Delay of Gratification and Less is More, have been theorized to measure hot EF due to their motivational components, in that they involve the use of EF components to obtain desired objects (e.g., candy, stickers, and/or pennies). Despite there being a theoretical reason to expect these tasks to be related and to measure the same construct, they were not significantly correlated in the present study. Hongwanishkul et al. (2005) found that the same Delay of Gratification task negatively correlated with performance on another hot EF measure, the Children's Gambling Task (Kerr & Zelazo, 2004). It may be that this task, Delay of Gratification, is not a valid or reliable measurement of hot EF or that there are multiple components to hot EF. More research is needed to further establish consistent measures that tap into hot EF. It may also be that hot EF as a construct needs to be further refined in order to adequately design tasks that measure it accurately.

Limitations

Several limitations of the present study have already been discussed in detail. These include the small sample size, the way in which bilingualism was measured, and the specific measures of EF selected for this study. Additionally, it is important to note that this was a sample of convenience in that only volunteers were included. Finally, this study was limited geographically, to just the southwestern region of the United States, and so should not be generalized to apply to bilingual and monolingual populations from other areas of the country or world without appropriate caution.

Future Research

The present study is an attempt to extend the research examining bilingual advantages in EF as well as exploring the role that variables associated with parenting and culture have in predicting EF in children. From these results, future research should focus on further understanding of the developmental trajectory of EF in bilingual and monolingual children. Neuroimaging studies would also add to the understanding of how EF may differ in these two groups. Additional efforts should be made to develop and establish valid measurements of hot EF in children. Finally, the role of environmental and psychosocial variables which impact the development of EF should be further explored and examined. It is impossible to inform clinical intervention regarding potential EF deficits without a clear understanding of how an environment variable such as culture or poverty negatively influences development. Additional studies are needed to assist in pinpointing specific areas in which potential intervention may be possible. It will also be necessary to identify those variables or experiences that promote resilience in children who are exposed to such risk factors. Early exposure to a second language, and subsequent bilingualism, may be one such experience that promotes resilience, in the form of EF development.

REFERENCES

Ackerly, S. S. (1964). A case of paranatal bilateral frontal lobe defect observed for thirty years. In J. M. Warren and K. Akert (Eds.), *Frontal Granular Cortex and Behavior* (pp. 192-218). New York: McGraw-Hill.

Adelman, N. E., Menon, V., Blasey, C. M., White, C. D., Warsofsky, I. S., Glover, G. H., et al. (2002). A developmental fMRI study of the Stroop Color-Word task. *NeuroImage, 16*, 61-75.

Alexander, G. E., DeLong, M. R., & Strick, P. L. (1986). Parallel organization of functionally segregated circuits linking basal ganglia and cortex. *Annual Review of Neuroscience, 9,* 357-381.

Amaral, D. G. & Price, J. L. (1984). Amygdalo-cortical projections in the monkey (macaca fasciculari). *The Journal of Comparative Neurology, 230*, 465-496.

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology, 8 (2),* 71-82.

Anderson, S. W., Damasio, H., Tranel, D., & Damasio, A. R. (2000). Long-term sequelae of prefrontal cortex damage acquired in early childhood. *Developmental Neuropsychology, 18 (3),* 281-296.

Ardila, A., Rosselli, M., Matute, E., & Guajardo, S. (2005). The influence of the parents' educational level on the development of executive functions. *Developmental Neuropsychology, 28 (1),* 539-560.

Asaad, W. F., Rainer, G., & Miller, E. K. (1998). Neural activity in the primate prefrontal cortex during associative learning. *Neuron, 21,* 1399-1407.

Asaad, W. F., Rainer, G., & Miller, E. K. (2000). Task-specific neural activity in the primate prefrontal cortex. *Journal of Neurophysiology,* 84, 451-459.

Ashby, F.G., Isen, A. M., & Turken, A. (1999). A neuropsychological theory of positive affect and its influence on cognition. *Psychological Review, 106,* 529-550.

Bachevalier, J. & Mishkin, M. (1986). Visual recognition impairment follows ventromedial but not dorsolateral prefrontal lesions in monkeys. *Behavioural Brain Research, 20,* 249-261.

Bachsbaum, B. R., Greer, S., Chang, W. L., & Berman, K. F. (2005). Meta-analysis of neuroimaging studies of the Wisconsin Card-Sorting task and component processes. *Human Brain Mapping, 25*, 35-45.

Backman Jones, L., Rothbart, M. K., & Posner, M. I. (2003). Development of executive attention in preschool children. *Developmental Science, 6 (5),* 498-504.

Baddeley, A. (2000). The episodic buffer: A new component of working memory? *Trends in Cognitive Sciences, 4 (11),* 417-423.

Baddeley, A. D. (2002). Is working memory still working? *European Psychologist, 7 (2),* 85-97.

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience, 4,* 829-839.

Baddeley, A. D. & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), *Recent Advances in Learning and Motivation* (Vol. 8, pp. 47-90). New York: Academic Press.

Baddeley, A. D. & Hitch, G. J. (1994). Developments in the concept of working memory. *Neuropsychology, 8*(4), 485-493.

Banich, M. T., Milham, M. P., Atchley, R., Cohen, N. J., Webb, A., Wszalek, T., et al. (2000a). fMRI studies of Stroop tasks reveal unique roles of anterior and posterior brain systems in attentional selection. *Journal of Cognitive Neuroscience, 12,* 988-1000.

Banich, M. T., Milham, M. P., Atchley, R. A., Cohen, N. J., Webb, A., Wszalek, T., et al. (2000b). Prefrontal regions play a predominant role in imposing an attentional 'set': evidence from fMRI. *Cognitive Brain Research, 10,* 1-9.

Barbas, H. (1993). Organization of cortical afferent input to orbitofrontal areas in the rhesus monkey. *Neuroscience, 56*, 841-864.

Barbas, H. (1997). Two prefrontal limbic systems: Their common and unique features. In H. Sakata, A. Mikami & J. Fuster (Eds.), *The Association Cortex: Structure and Function* (pp. 99-115). Amsterdam: Harwood Academic Publishers.

Barbas, H. (2000). Connections underlying the synthesis of cognition, memory, and emotion in primate prefrontal cortices. *Brain Research Bulletin, 52,* 319-330.

Barbas, H. & De Olmos, J. (1990). Projections from the amygdala to basoventral and mediodorsal prefrontal regions in the Rhesus monkey. *The Journal of Comparative Neurology, 300,* 549-571.

Barbas, H., Ghashghaei, H. T., Rempel-Clower, N. L., & Xiao, D. (2002). Anatomic basis of functional specialization in prefrontal cortices in primates. In F. Boller & J. Grafman (Eds.), *Handbook of Neuropsychology* (2nd ed., Vol. 7, pp. 1-27). New York: Elsevier.

Barbas, H., Haswell Henion, T. H., & Dermon, C. R. (1991). Diverse thalamic projections to the prefrontal cortex in the rhesus monkey. *The Journal of Comparative Neurology, 313,* 65-94.

Barbas, H., Zikopoulos, B., & Timbie, C. (in press). Sensory pathways and emotional context for action in primate prefrontal cortex. *Biological Psychiatry*.

Barone, P. & Joseph, J. P. (1989). Prefrontal cortex and spatial sequencing in the macaque monkey. *Experimental Brain Research, 78,* 447-464.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition, 50*, 7-15.

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275,* 1293 1295.

Bechara, A., Tranel, D., & Damasio, H. (2000). Characterization of the decision-making deficit of patients with ventromedial prefrontal cortex lesions. *Brain*, *123*. 2189 2202.

Berger, A., Jones, L., Rothbart, M. K., & Posner, M. I. (2000). Computerized games to study the development of attention in childhood. *Behavior Research Methods,* *Instruments, & Computers, 32*, 297-303.

Bialystok, E. (1988). Levels of bilingualism and levels of linguistic awareness. *Developmental Psychology, 24 (4),* 560-567.

Bialystok, E. (1992). Selective attention in cognitive processing: The bilingual edge. In R. J. Harris (Ed.), *Cognitive Processing in Bilinguals, Advances in Psychology* (pp. 501-513). Oxford, England: North-Holland.

Bialystok, E. (1999). Cognitive complexity and attentional control in the bilingual mind. *Child Development, 70 (3),* 636-644.

Bialystok, E. (2001). *Bilingualism in Development: Language, Literacy, and Cognition.* New York: Cambridge University Press.

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

Bialystok, E. (2007). Cognitive effects of bilingualism: How linguistic experience leads to cognitive change. *International Journal of Bilingual Education and Bilingualism*, *10 (3),* 210-223.

Bialystok, E. (2010). Global-local and trail-making tasks by monolingual and bilingual children: Beyond inhibition. *Developmental Psychology*, *46*, 93-105.

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., Craik, F. I. M., Grady, C., Chau, W., Ishii, R. Gunji, A., et al. (2005). Effect of bilingualism on cognitive control in the Simon task: Evidence from MEG. *NeuroImage, 24*, 40-49.

Bialystok, E. & Majumder, S. (1998). The relationship between bilingualism and the development of cognitive processes in problem solving. *Applied Psycholinguistics, 19 (1)*, 69-85.

Bialystok, E. & Martin, M. M. (2004). Attention and inhibition in bilingual children: Evidence from the dimensional change card sort task. *Developmental Science, 7 (3)*, 325-339.

Bialystok, E. & Senman, L. (2004). Executive processes in appearance-reality tasks: The role of inhibition of attention and symbolic representation. *Child Development, 75 (2)*, 562-579.

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

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

Bichot, N. P., Schall, J. D., & Thompson, K. G. (1996). Visual feature selectivity in frontal eye fields induced by experience in mature macaques. *Nature, 381*, 697 699.

Blair, C. & Razza, R. P. (2007). Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten. *Child Development, 78 (2)*, 647-663.

Blumenfeld, H. (2002). *Neuroanatomy through Clinical Cases*. Sunderland, MA: Sinauer Associates, Inc.

Bradley, R. H., Corwyn, R. F., Burchinal, M., Pipes McAdoo, H., & García Coll, C. (2001). The home environments of children in the United States part II: Relations with behavioral development through age thirteen. *Child Development, 72 (6),* 1868-1886.

Brodmann, K. (1909). *Vergleichende Lokalisationslehre der Grosshirnrinde in ihren Prinzipien dargestellt auf Grund des Zellenbaues*. Leipzig: Barth.

Brody, G. H., Dorsey, S., Forehand, R., & Armistead, L. (2002). Unique and protective contributions of parenting and classroom processes to the adjustment of African American children living in single-parent families. *Child Development, 73,* 274 286.

Buchsbaum, B. R., Greer, S., Chang, W., & Berman, K. F. (2005). Meta-analysis of neuroimaging studies of the Wisconsin Card-Sorting task and component processes. *Human Brain Mapping, 25,* 35-45.

Bull, R., Espy, K. A., & Senn, T. E. (2004). A comparison of performance on the Towers of London and Hanoi in young children. *Journal of Child Psychology and Psychiatry, 45 (4),* 743-754.

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

Butters, N. Soeldner, C., & Fedio, P. (1972). Comparison of parietal and frontal lobe spatial deficits in man: extrapersonal vs personal (egocentric) space. *Perceptual Motor Skills, 34,* 27–34.

Carlson, S. M., Davis, A. C., & Leach, J. G. (2005). Less is more: Executive function and symbolic representation in preschool children. *Psychological Science, 16 (8),* 609-616.

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

Carmichael, S. T. & Price, J. L. (1995). Limbic connections of the orbital and medial prefrontal cortex in Macaque monkeys. *The Journal of Comparative Neurology, 363,* 615-641.

Cavada, C., Compañy, T., Tejedor, J., Cruz-Rizzolo, R. J., & Reinoso-Suárez, F. (2000). The anatomical connections of the Macaque monkey orbitofrontal cortex: A review. *Cerebral Cortex, 10,* 220-242.

Chambers, C. D., Bellgrove, M. A., Stokes, M. G., Henderson, T. R., Garavan, H., Robertson, I. H., et al. (2006). Executive “brake failure” following deactivation of human frontal lobe. *Journal of Cognitive Neuroscience, 18,* 444-455.

Chambers, C. D., Garavan, H., & Bellgrove, H. (2009). Insights into the neural basis of response inhibition from cognitive and clinical neuroscience. *Neuroscience and Biobehavioral Reviews, 33,* 631-646.

Chao, L. L. & Knight, R. T. (1995). Human prefrontal lesions increased distractibility to irrelevant sensory inputs. *NeuroReport, 6,* 1605 –1610.

Chavis, D. A. & Pandya, D. N. (1976). Further observations on corticofrontal connections in the Rhesus monkey. *Brain Research, 117,* 369-386.

Chikazoe, J. (2010). Localizing performance of go/no-go tasks to prefrontal cortical subregions. *Current Opinion in Psychiatry, 23,* 267-272.

Chow, K. L. & Hutt, P. J. (1953). The "association cortex" of Macaca Mulatta: A review of recent contributions to its anatomy and functions. *Brain, 76,* 625-677.

Conger, R. D. & Elder, G. H. (1994). *Families in Troubled Times: Adapting to Change in Rural America*. Hawthorne, NY: Aldine DeGruyter.

Conger, R. D., Ge, X., Elder, G. H., Jr., Lorenz, F. O., & Simons, R. L. (1994). Economic stress, coercive family process, and developmental problems of adolescents. *Child Development, 65 (2),* 541-561.

Cote, L. R., & Bornstein, M. H. (2003). Cultural and parenting cognitions in acculturating cultures: 1. Cultural comparisons and developmental continuity and stability. *Journal of Cross-Cultural Psychology, 34,* 323-349.

Crone, E. A. & van der Molen, M. W. (2004). Developmental changes in real life decision making: Performance on a gambling task previously shown to depend on the ventromedial prefrontal cortex. *Developmental Neuropsychology, 25,* 251 279.

Crone, E. A. & van der Molen, M. W. (2007). Development of decision making in school-aged children and adolescents: Evidence from heart rate and skin conductance analysis. *Child Development, 78,* 1288-1301.

Crone, E. A., Wendelken, C., Donohue, S., van Leijenhorst, L., & Bunge, S. A. (2006). Neurocognitive development of the ability to manipulate information in working memory. *Proceedings of the National Academy of Sciences of the United States of America, 103 (24),* 9315-9320.

Cummins, J. (1978). Bilingualism and the development of metalinguistic awareness. *Journal of Cross-Cultural Psychology, 9 (2),* 131-149.

Cunningham, W. A. & Zelazo, P. D. (2007). Attitudes and evaluations: A social cognitive neuroscience perspective. *TRENDS in Cognitive Science, 11*, 97-104.

Damasio, A. (1994). *Descartes' Error: Emotion, Reason, and the Human Brain.* New York: Penguin Books.

Dempster, F. N. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review, 12*, 45-75.

Dennis, J. M., Parke, R. D., Coltrane, S., Blacher, J., & Borthwick-Duffy, S. A. (2003). Economic stress, maternal depression, and child adjustment in Latino families: An exploratory study. *Journal of Family and Economic Issues, 24*(2), 183-202.

Desimone, R. & Duncan, J. (1995). Neural mechanisms of selective visual attention. *Annual Review of Neuroscience, 18*, 193-222.

Diamond, A. (1990). The development and neural bases of memory functions as indexed by the AB and Delayed Response tasks in human infants and infant monkeys. *Annals of the New York Academy of Sciences, 608,* 267-317.

Diamond, A., Kirkham, N., & Amso, D. (2002). Conditions under which young children can hold two rules in mind and inhibit a prepotent response. *Developmental Psychology, 38 (3),* 352-362.

Diamond, A. & Taylor, C. (1996). Development of an aspect of executive control: Development of the abilities to remember what I said and to "Do as I say, not as I do." *Developmental Psychobiology, 29 (4),* 315-334.

Duncan, J. (1986). Disorganisation of behaviour after frontal lobe damage. *Cognitive Neuropsychology, 3,* 271-290.

Dunn, L. M., & Dunn, L. M. (2007). *Peabody Picture Vocabulary Test—Fourth Edition*. Circle Pines, MN: American Guidance Service.

Dunn, L. M., Padilla, E. R., Lugo, D. E., & Dunn, L. M. (1986) *Test de Vocabulario en Imagenes Peabody*. Circle Pines, MN: American Guidance Service.

Elder, G. H., Jr., Conger, R. D., Foster, E. M., & Ardelt, M. (1992). Families under economic stress. *Journal of Family Issues, 13 (1),* 5-37.

Elliott, R., Frith, C. D., & Dolan, R. J. (1997). Differential neural response to positive and negative feedback in planning and guessing tasks. *Neuropsychologia, 35 (10),* 1395-1404.

Farah, M. J., Shera, D. M., Savage, J. H., Betancourt, L., Giannetta, J. M., Brodsky, N. L., et al. (2006). Childhood poverty: Specific associations with neurocognitive development. *Brain Research, 1110*, 166-174.

Feldman, R., Masalha, S., & Alony, D. (2006). Microregulatory patterns of family interactions: Cultural pathways to toddlers' self-regulation. *Journal of Family Psychology, 20 (4)*, 614-623.

Feng, X., Harwood, R. L., Leyendecker, B., & Miller, A. M. (2001). Changes during the first year of life in infants' daily activities and social contacts among middle class Anglo and Puerto Rican families. *Infant Behavior & Development, 24*, 317 339.

Frey, S., Kostopoulos, P., & Petrides, M. (2000). Orbitofrontal involvement in the processing of unpleasant auditory information. *European Journal of Neuroscience*, *12*, 3709-3712.

Fuster, J. M. (2008). *The Prefrontal Cortex* (4th ed.). Oxford, England: Academic Press.

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

Garbin, G., Sanjuan, A., Forn, C., Bustamante, J. C., Rodriguez-Pujadas, A., Belloch, V., et al. (2010). Bridging language and attention: Brain basis of the impact of bilingualism on cognitive control. *NeuroImage, 53*, 1272-1278.

Garcia-Preto, N. (2005). Latino families: An overview. In M. McGoldrick, J. Giodarno, & N. Garcia-Preto (Eds.), *Ethnicity and Family Therapy* (3rd ed., pp. 153-165). New York: The Guilford Press.

Garon, N. & Moore, C. (2004). Complex decision-making in early childhood. *Brain and Cognition, 55*, 158-170.

Geier, C. F., Garver, K., Terwilliger, R., & Luna, B. (2009). Development of working memory maintenance. *Journal of Neurophysiology, 101*, 84-99.

Gerardi-Caulton, G. (2000). Sensitivity to spatial conflict and the development of self regulation in children 24-36 months of age. *Developmental Science, 3 (4),* 397 404.

Gershberg, F. B. & Shimamura, A. P. (1995). Impaired use of organizational strategies in free recall following frontal lobe damage. *Neuropsychologia*, *13,* 1305-1333.

Gerstadt, C. L., Hong, Y. J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3 ½-7 years old on a Stroop-like-day-night test. *Cognition*, *53*, 129-153.

Ghashghaei, H. T. & Barbas, H. (2001). Neural interaction between the basal forebrain and functionally distinct prefrontal cortices in the rhesus monkey. *Neuroscience, 103,* 593-614.

Ghashghaei, H. T., Hilgetag C. C., & Barbas H. (2007). Sequence of information processing for emotions based on the anatomic dialogue between prefrontal cortex and amygdala. *Neuroimage, 34*, 905–923.

Giedd, J. N., Blumenthal, J., Jeffries, N. O., Castellanos, F.X., Liu, H., Zijdenbox, A., et al. (1999). Brain development during childhood and adolescence: A longitudinal MRI study. *Nature Neuroscience, 2,* 861-863.

Gilboa, A., Alain, C., Stuss, D. T., Melo, B., Miller, S., & Moscovitch, M. (2006). Mechanisms of spontaneous confabulations: A strategic retrieval account. *Brain, 129,* 1399-1414.

Gioia, G. A., Isquith, P. K., Kenworthy, L. & Barton, R. M. (2002). Profiles of everyday executive function in acquired and developmental disorders. *Child Neuropsychology, 8 (2),* 121-137.

Goldman, P. S. & Nauta, W. J. H. (1976). Autoradiographic demonstration of a projection from prefrontal association cortex to the superior colliculus in the rhesus monkey. *Brain Research, 116,* 145-149.

Goldman-Rakic, P. S. & Porrino, L. J. (1985). The primate mediodorsal (MD) nucleus and its projection to the frontal lobe. *The Journal of Comparative Neurology, 242,* 535-560.

Goldman-Rakic, P. S., Selemon, L. D., & Schwartz, M. L. (1984). Dual pathways connecting the dorsolateral prefrontal cortex with the hippocampal formation and parahippocampal cortex in the rhesus monkey. *Neuroscience, 12*, 719-743.

Gómez-Beldarrain, M., Grafman, J., Pascual-Leone, A., & García-Monco, J. C. (1999). Procedural learning is impaired in patients with prefrontal lesions. *Neurology, 52,* 1853-1860.

Grant, D. A. & Berg, E. A. (1948). A behavioral analysis of degree of reinforcement and ease of shifting to new responses in a weigl-type card-sorting problem. *Journal of Experimental Psychology, 38 (4),* 404-411.

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

Guariglia, C., Padovani, A., Pantano, P., & Pizzamiglio, L. (1993). Unilateral neglect restricted to visual imagery. *Nature, 364,* 235-237.

Halsband, U. & Passingham, R. E. (1985). Premotor cortex and the conditions for movement in monkeys. *Behavioral Brain Research, 18,* 269-276.

Hammill, D.D., Pearson, N.A., & Wiederholt, J.L. (1997). *Comprehensive Test of Nonverbal Intelligence (C-TONI).* Austin, TX: Pro-Ed.

Harwood, R. L., Shoelmerich, A., Schulze, P. A., & Gonzalez, Z. (1999). Cultural differences in maternal beliefs and behaviors: A study of middle-class Anglo and Puerto Rican mother infant pairs in four everyday situations. *Child Development, 70 (4),* 1005-1016.

Hedden, T. & Gabrieli, J. D. E. (2010). Shared and selective neural correlates of inhibition, facilitation, and shifting processes during executive control. *NeuroImage, 51,* 421-431.

Hernandez, A. E. (2009). Language switching in the bilingual brain: What's next? *Brain & Language, 109*, 133-140.

Hernandez, A. E., Dapretto, M., Mazziotta, J., & Bookheimer, S. (2001). Language switching and language representation in Spanish-English bilinguals: An fMRI study. *NeuroImage, 14,* 510-520.

Hernandez, A. E., Martinez, A., & Kohnert, K. (2000). In search of the language switch: An fMRI study of picture naming in Spanish-English bilinguals. *Brain and Language, 73*, 421-431.

Heyder, K., Suchan, B., & Daum, I. (2004). Cortico-subcortical contributions to executive control. *Acta Psychologica, 115*, 271-289.

Hollingshead, A. A. (1975). *Four-factor Index of Social Status.* New Haven, CT: Yale University.

Hongwanishkul, D., Happaney, K. R., Lee, W. S. C., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology, 28 (2),* 617-644.

Hopstock, P. J. & Stephenson, T.G. (2003). Descriptive study of services to LEP students and LEP students with disabilities. Special topic report #1. Native languages of LEP students. *U.S. Dept. of Ed. Office of English Language Acquisition, Language Enhancement and Academic Achievement of LEP Students (OELA).*

Hornak, J., Rolls, E. T., & Wade, D. (1996). Face and voice expression identification in patients with emotional and behavioural changes following ventral frontal lobe damage. *Neuropsychologia, 34 (4),* 247-261.

Houck, G.M. & LeCuyer-Maus, E.A. (2004). Maternal limit setting during toddlerhood and self-regulation at 5 years. *Infant Mental Health Journal, 25,* 28-46.

Hughes, C. & Ensor, R. (2005). Executive function and theory of mind in 2 year olds: A family affair? *Developmental Neuropsychology, 28 (2),* 645-668.

Hughes, C. & Ensor, R. (2006). Behavioural problems in 2-year-olds: Links with individual differences in theory of mind, executive function and harsh parenting. *Journal of Child Psychology and Psychiatry, 47 (5),* 488-497.

Hui, C. H. & Triandis, H. C. (1986). Individualism-collectivism: A study of cross cultural researchers. *Journal of Cross-Cultural Psychology, 17 (2),* 225-248.

Ilinsky, I. A., Jouandet, M. L., & Goldman-Rakic, P. S. (1985). Organization of the nigrothalamocortical system in the rhesus monkey. *The Journal of Comparative Neurology, 236,* 315-330.

Izquierdo, A. & Murray, E. A. (2004). Combined unilateral lesions of the amygdala and orbital prefrontal cortex impair affective processing in rhesus monkeys. *Journal of Neurophysiology, 91,* 2023-2039.

Jacobson, S. & Trojanowski, J. Q. (1975). Amygdaloid projections to prefrontal granular cortex in rhesus monkeys demonstrated with horseradish peroxidase. *Brain Research, 100,* 132-139.

Jennings, K. D., Sandberg, I., Kelley, S. A., Valdes, L., Yaggi, K., Abrew, A., et al. (2008). Understanding of self and maternal warmth predict later self-regulation in toddlers. *International Journal of Behavioral Development, 32,* 108-118.

Jetter, W., Poser, U., Freeman, R. B., & Markowitsch, H. J. (1986). A verbal long term memory deficit in frontal lobe damaged patients. *Cortex, 22,* 229-242.

Jones, E. G. & Powell, T. P. S. (1970). An anatomical study of converging sensory pathways within the cerebral cortex of the monkey. *Brain, 93,* 793-820.

Kanemura, H., Aihara, M., Aoki, S., Araki, T., & Nakzawa, S. (2003). Development of the prefrontal lobe in infants and children: A three-dimensional magnetic resonance volumetric study. *Brain & Development, 25,* 195-199.

Keller, H., Yovsi, R., Borke, J., Kärtner, J., Jensen, H., & Papaligoura, Z. (2004). Developmental consequences of early parenting experiences: Self-recognition and self-regulation in three cultural communities. *Child Development, 75 (6),* 1745-1760.

Kerr, A. & Zelazo, P. D. (2004). Development of "hot" executive function: The children's gambling task. *Brain and Cognition, 55*, 148-157.

Klenberg, L., Korkman, M., & Lahti-Nuuttila, P. (2001). Differential development of attention and executive functions in 3- to 12-year-old Finnish children. *Developmental Neuropsychology, 20 (1),* 407-428.

Kline, R. B. (2005). *Principles and Practice of Structural Equation Modeling* (2nd ed.). New York: The Guilford Press.

Korkman, M., Kirk, U., & Kemp, S. (1998). *NEPSY: A Developmental Neuropsychological Assessment.* San Antonio, TX: Psychological Corporation.

LeCuyer-Maus, E.A. & Houck, G.M. (2002). Mother-toddler interaction and the development of self-regulation in a limit-setting context. *Journal of Pediatric Nursing, 17,* 184-200.

Levelt, W. J. M., Roelefs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22,* 1-75.

Leimkuhler, M. E. and Mesulam, M.-M. (1985). Reversible go–no go deficits in a case of frontal lobe tumor. *Annals of Neurology, 18,* 617–619.

Lipina, S. J. & Colombo, J. A. (2009). *Poverty and Brain Development During Childhood: AnApproach From Cognitive Psychology and Neuroscienc*e. Washington, D.C.: American Psychological Association.

London, E. D., Ernst, M., Grant, S., Bonson, K., & Weinstein, A. (2000). Orbitofrontal cortex and human drug abuse: Functional imaging. *Cerebral Cortex, 10,* 334-342.

Lu, M., Preston, J. B., & Strick, P. L. (1994). Interconnections between the prefrontal cortex and the premotor areas in the frontal lobe. *The Journal of Comparative Neurology, 341,* 375-392.

MacDonald, A. W., Cohen, J. D., Stenger, V. A., & Carter, C. S. (2000). Dissociating the role of dorsolateral prefrontal cortex and anterior cingulate cortex in cognitive control. *Science, 288,* 1835-1838.

Mangels, J. A., Gershberg, F. B., Shimamura, A. P., & Knight, R. T. (1996). Impaired retrieval from remote memory in patients with frontal lobe damage. *Neuropsychology, 10,* 32-41.

Martin-Rhee, M. M. & Bialystok, E. (2008). The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism: Language and Cognition, 11 (1),* 81-93.

McFie, J. & Thompson, J. A. (1972). Picture arrangement: A measure of frontal lobe function? *British Journal of Psychiatry, 121,* 547-552.

McLardy, T. (1950). Thalamic projection to frontal cortex in man. *Journal of Neurology, Neurosurgery, and Psychiatry, 13,* 198-202.

McNab, F., Leroux, G., Strand, F., Thorell, L. Bergman, S. & Klingberb, T. (2008). Common and unique components of inhibition and working memory: An fMRI, within-subjects investigation. *Neuropsychologia, 46,* 2668-2682.

Medalla, M. & Barbas, H. (2010). Anterior cingulate synapses in prefrontal areas 10 and 46 suggest differential influence in cognitive control. *The Journal of Neuroscience, 30,* 16068-16081.

Metcalfe, J. & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: Dynamics of willpower. *Psychological Review, 106,* 3-19.

Meyer, A., Beck, E., & McLardy, T. (1947). Prefrontal leucotomy: A neuroanatomical report. *Brain, 70,* 18-49.

Mezzacappa E. (2004). Alerting, orienting, and executive attention: Developmental properties and socio-demographic correlates in an epidemiological sample of young, urban children. *Child Development*, 75, 1-14.

Miller E. K. (1999). The prefrontal cortex: Complex neural properties for complex behavior. *Neuron*, 22, 15–17.

Miller, D. C. (2001). Test review of the NEPSY. In B. S. Plake & J. C. Impara (Eds.), *The Fourteenth Mental Measurements Yearbook* [Electronic version]. Retrieved August 29, 2008 from http://web5s.silverplatter.com.ezproxy.tamu.edu:2048/webspirs/start.ws?customer=c245&databases=YB.

Miller, E. K. & Cohen, J. D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience, 24,* 167-202.

Miller, E. K., Erickson, C. A., & Desimone, R. (1996). Neural mechanisms of visual working memory in prefrontal cortex of the Macaque. *The Journal of Neuroscience, 16,* 5154-5167.

Mirenowicz, J. & Schultz, W. (1994). Importance of unpredictability for reward responses in primate dopamine neuron. *Journal of Neurophysiology, 72,* 1024-1027.

Mirenowicz, J. & Schultz, W. (1996). Preferential activation of midbrain dopamine neurons by appetitive rather than aversive stimuli. *Nature, 379,* 449-451.

Mistry, R. S., Vandewater, E. A., Huston, A. C., & McLoyd, V. C. (2002). Economic well-being and children's social adjustment: The role of family process in an ethnically diverse low income sample. *Child Development, 73 (3),* 935-951.

Nakata, H., Sakamoto, K., Ferretti, A., Perrucci, M. G., Del Gratta, C., Kakigi, R., et al. (2008). Somato-motor inhibitory processing in humans: An event-related functional MRI study. *NeuroImage, 39,* 1858-1866.

Noble, K. G., Norman, M. F., & Farah, M. J. (2005). Neurocognitive correlates of socioeconomic status in kindergarten children. *Developmental Science, 8 (1),* 74-87.

Ochoa, S. H. (2005). English-language learners in U.S. public schools: A heterogeneous population. In R. L. Rhodes, S. H. Ochoa & S. O. Ortiz (Eds.), *Assessing Culturally and Linguistically Diverse Students: A Practical Guide* (p. 1-14). New York: The Guilford Press.

O'Doherty, J., Rools, E. T., Francis, S., Bowtell, R., McGlone, F., Kobal, G., et al. (2000). Sensory-specific satiety-related olfactory activation of the human orbitofrontal cortex. *NeuroReport, 11,* 893-897.

Owen, A. M., Downes, J. J., Sahakian, B. J., Polkey, C. E., & Robbins, T. W. (1990). Planning and spatial working memory following frontal lobe lesions in man. *Neuropsychologia, 28,* 1021-1034.

Pascual-Leone, J. (1969). *Water Level Test.* Toronto, Ontario, Canada: York University.

Parke, R. D., Coltrane, S., Duffy, S., Buriel, R., Dennis, J., & Powers, J. (2004). Economic stress, parenting, and child adjustment in Mexican American and European American families. *Child Development, 75 (6),* 1632-1656.

Peers, P. V., Ludwig, C. J., Rorden, C., Cusack, R., Bonfiglioli, C., Bundesen, C., et al. (2005). Attentional functions of parietal and frontal cortex. *Cerebral Cortex, 15,* 1469-1484.

Petrides, M. (1985). Deficits in non-spatial associative-learning after selective prefrontal lesions in the monkey. *Behavioral Brain Research, 16,* 95-101.

Petrides, M. (1990). Nonspatial conditional learning impaired in patients with unilateral frontal but not unilateral temporal lobe excisions. *Neuropsychologia, 28,* 137 149.

Petrides, M. & Pandya, D. N. (2002). Association pathways of the prefrontal cortex and functional observations. In Donald T. Stuss & Robert T. Knight (Eds.), *Principles of Frontal Lobe Function* (pp. 31-50). New York: Oxford University Press, Inc.

Poulin-Dubois, D., Blaye, A., Coutya, J., & Bialystok, E. (2011). The effects of bilingualism on toddlers' executive functioning. *Journal of Experimental Child Psychology, 108,* 567 579.

Porrino, L. J., Crane, A. M., & Goldman-Rakic, P. S. (1981). Direct and indirect pathways fromthe amygdala to the frontal lobe in Rhesus monkeys. *The Journal of Comparative Neurology, 198,* 121-136.

Prencipe, A. & Zelazo, P. D. (2005). Development of affective decision making for self and other: Evidence for the integration of first- and third-person perspectives. *Psychological Science, 16 (7),* 501-505.

Qu, L. & Zelazo, P. D. (2007). The facilitative effect of positive stimuli on 3-year-olds' flexible rule use. *Cognitive Development, 22*, 456-473.

Rader, N. & Hughes, E. (2005). The influence of affective state on the performance of a block design task in 6- and 7-year-old children. *Cognition and Emotion, 19*, 143-150.

Reynolds, C. R., & Kamphaus, R. W. (2004). Behavior Assessment System for Children (2nd ed.). Circle Pines, MN: American Guidance Service.

Robila, M. & Krishnakumar, A. (2006). Economic stress and children's psychological functioning. *Journal of Child and Family Studies, 15*, 435-443.

Rogers, R. D., Everitt, B. J., Baldacchino, A., Blackshaw, A. J., Swainson, R., et al. (1999). Dissociable deficits in the decision-making cognition of chronic amphetamine abusers, opiate abusers, patient with focal damage to prefrontal cortex, and tryptophan-depleted normal volunteers: Evidence for monoaminergic mechanisms. *Neuropsychopharmacology, 20 (4),* 322-339.

Rolls, E. T., (2000). The orbitofrontal cortex and reward. *Cerebral Cortex, 10,* 284-294.

Rolls, E. T. (2004). The functions of the orbitofrontal cortex. *Brain and Cognition, 55,* 11-29.

Rosenblum, T. & Pinker, S. A. (1983). Word magic revisited: Monolingual and bilingual children's understanding of word-object relationship. *Child Development, 54 (3),* 773-780.

Rosene, D. L. & van Hosen, G. W. (1977). Hippocampal efferents reach widespread areas of cerebral cortex and amygdala in the rhesus monkey. *Science, 198,* 315-317.

Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at 3–7 years: The Children's Behavior Questionnaire. *Child Development, 72,* 1394–1408.

Sabbagh, M. A., Xu, F., Carlson, S. M., Moses, L. J., & Lee, K. (2006). The development of executive functioning and theory of mind: A comparison of Chinese and U.S. preschoolers. *Psychological Science, 17 (1),* 74-81.

Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science, 275,* 1593-1599.

Schultz, W. & Dickinson, A. (2000). Neuronal coding of prediction errors. *Annual Review of Neuroscience, 23,* 473-500.

Schulze, P. A., Harwood, R. L., & Schoelmerich, A. (2001). Feeding practices and expectations among middle-class Anglo and Puerto Rican mothers of 12-month old infants. *Journal of Cross-Cultural Psychology, 32 (4)*, 397-406.

Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London, B, 298, 199*-209.

Shallice, T. & Burgess, P. W. (1991). Higher-order cognitive impairments and frontal lobe lesions in man. In H. S. Levin, H. M. Eisenberg, & A. L. Benton (Eds.) *Frontal Lobe Function and Dysfunction* (pp. 125-138). New York: Oxford University Press.

Shonkoff, J. P., & Phillips, D. A. (2000). *From Neurons to Neighborhoods: The Science of Early Childhood Development.* Washington, D.C.: National Academy Press.

Siegert, R. J. & Warrington, E. K. (1996). Spared retrograde memory with anterograde amnesia and widespread cognitive deficits. *Cortex, 32,* 177-185.

Singelis, T. M., Triandis, H. C., Bhawuk, D., & Gelfand, M. J. (1995). Horizontal and verticaldimensions of individualism and collectivism: A theoretical and measurement refinement. *Cross-Cultural Research, 29*, 240-275.

Smetana, J.G., Kochanska, G., & Chuang, S. (2000). Mothers' conceptions of everyday rules for young toddlers: A longitudinal investigation. *Merrill-Palmer Quarterly, 46,* 391-416.

Sowell, E. R., Thompson, P. M., Holmes, C. J., Jernigan, T. L., & Toga, A. W. (1999). *In vivo* evidence for post-adolescent brain maturation in frontal and striatal regions. *Nature Neuroscience, 2,* 859-861.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18 (6),* 643-662.

Stuss, D.T. (1991). Self, awareness, and the frontal lobes: A neuropsychological perspective. In J. Strauss & G. R. Goethals, (Eds.), *The Self: Interdisciplinary Approaches* (pp. 255-278). New York: Springer-Verlag.

Swick, D. & Turken, A. U. (2002). Dissociation between conflict detection and error monitoring in the human anterior cingulate cortex. *Proceedings of the National Academy of Sciences of the United States of America, 16,* 354-316, 359.

Teuber, H.-L. (1964). The riddle of frontal lobe function in man. In J.M. Warren & K. Akert (Eds.), *The Frontal Granular Cortex and Behavior* (pp. 410-477). New York: McGraw-Hill.

Teuber, H.-L. (1966). The frontal lobes and their functions: Further observations on rodents, carnivores, subhuman primates, and man. *International Journal of Neurology, 5,* 282-300.

Tremblay, L. & Schultz, W. (2000). Modifications of reward expectation-related neuronal activity during learning in primate orbitofrontal cortex. *Journal of Neurophysiology, 83,* 1877-18985.

Triandis, H. C. (1989). The self and social behavior in differing cultural contexts. *Psychological Review, 96 (3),* 506-520.

Triandis, H. C. (1995). *Individualism & Collectivism*. Boulder, CO: Westview Press.

Triandis, H. C. & Gelfand, M. J. (1998). Converging measurement of horizontal and vertical individualism and collectivism. *Journal of Personality and Social Psychology*, *74*, 118-128.

Tsujimoto, S., Yamamoto, T., Kawaguchi, H., Koizumi, H., & Sawaguchi, T. (2004). Prefrontal cortical activation associated with working memory in adults and preschool children: An event-related optical topography study. *Cerebral Cortex*, *14*, 703-712.

U.S. Census Bureau. (2009). 2009 American Community Survey. Retrieved April 20, 2011 from http://factfinder.census.gov/servlet/ADPTable?_bm=y& geo_id=01000US&ds_name=ACS_2009_1YR_G00_&-_lang=en&_caller=geoselect&-format=.

Vendrell, P., Junqué, C., Pujol, J., Jurado, M. A., Molet, J., & Grafman, J. (1995). The role of prefrontal regions in the Stroop task. *Neuropsychologia, 33,* 341-352.

Watanabe, M. (1981). Prefrontal unit activity during delayed conditional discriminations in the monkey. *Brain Research, 225,* 51-65.

Watanabe, M. (1990). Prefrontal unit activity during associative learning in the monkey. *Experimental Brain Research, 80,* 296-309.

Wechsler, D. (1974). *Wechsler Intelligence Scale for Children-Revised*. New York: Psychological Corporation.

Welsh, M. C., Pennington, B. F. & Groisser, D. B. (1991). A normative-developmental study of executive function: A window on prefrontal function in children. *Developmental Neuropsychology, 7*(2), 131-149.

Wilkins, A. J., Shallice, T., & McCarthy, R. (1987). Frontal lesions and sustained attention. *Neuropsychologia, 25,* 359-365.

Windmann, S., Wehrmann, M., Calabrese, P., & Guntürkun, O. (2006). Role of the prefrontal cortex in attentional control over bistable vision. *Journal of Cognitive Neuroscience, 18,* 456-471.

Zalla, T., Plassiart, C., Pillon, B., Grafman, J., & Sirigu, A. (2001). Action planning in a virtual context after prefrontal cortex damage. *Neuropsychologia, 39*, 759-770.

Zehler, A. M., Fleischman, H. L., Hopstock, P. J., Pendzick, M. L. & Stephenson, T. G. (2003) Descriptive study of services to LEP students and LEP students with disabilities. Special topic report #4. Findings on special education LEP students. *United States Department of Education Office of English Language Acquisition, Language Enhancement and Academic Achievement of LEP Students (OELA).*

Zelazo, D. P., Jacques, S., Burack, J. A., & Frye, D. (2002). The relation between theory of mind and rule use: Evidence from persons with autism-spectrum disorders. *Infant and Child Development, 11,* 171–195.

Zelazo, P. D. & Müller, U. (2002). Executive function in typical and atypical development. In U. Goswami (Ed.), *Handbook of Childhood Cognitive Development* (pp. 445-469). Oxford, England: Blackwell.

Zelazo, P.D., Qu, L. & Kesek, A. C. (2010). Hot executive function: Emotion and the development of cognitive control. In S. D. Calkins & M. A. Bell (Eds.), *Child Development at the Intersection of Emotion and Cognition* (pp. 97-111). Washington, D.C.: American Psychological Association.

Zelazo, P. D., Qu, L. & Müller, U. (2005). Hot and cool aspects of executive function: Relations in early development. In W. Schneider, R. Schumann-Hengsteler, & B. Sodian (Eds.), *Young Children's Cognitive Development: Interrelationships among Executive Functioning, Working Memory, Verbal Ability, and Theory of Mind* (pp. 71-93). Mahwah, NJ: Erlbaum.

APPENDIX A

Table 1

Demographic Data

Variable	Total (n = 67)	Monolingual (n = 48)	Bilingual (n = 19)	t-statistic
Age	6.23 (.707)	6.11 (.625)	6.54 (.82)	-2.299*
Economic stress	6.86 (2.89)	6.29 (2.81)	8.39 (2.60)	-2.750**
Parental education	15.87 (4.56)	17.80 (2.70)	11.17 (4.81)	6.908***
Parental occupation	22.03 (16.78)	26.11 (16.13)	12.37 (14.47)	3.207**
Number in home	4.58 (1.25)	4.59 (1.38)	4.58 (.90)	.023
PPVT-4 score	105.15 (17.54)	112.44 (13.46)	86.74 (12.43)	7.191***
Disciplinary practices	49.84 (10.30)	49.00 (10.28)	52.29 (10.34)	-1.031
Relational frustration	49.05 (8.77)	50.02 (8.43)	46.21 (9.45)	1.416
Horizontal individualism	55.49 (7.78)	55.11 (7.41)	56.49 (8.82)	-.637
Vertical individualism	35.78 (11.78)	36.98 (11.80)	32.53 (11.40)	1.340
Horizontal collectivism	58.54 (7.63)	56.85 (7.38)	63.12 (6.49)	-3.087**
Vertical collectivism	49.18 (9.39)	47.96 (8.75)	52.30 (10.50)	-1.728

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 2

Correlational Data

Variable	Economic Stress	Age	Parental Education	Parental Occupation	PPVT Score	Delay of Gratification	Tower
Economic Stress	---	.051	-.398**	-.197	-.354**	.181	.235*
Age		---	-.154	-.196	-.317**	.014	.331**
Parental Education			---	.536**	.690**	-.021	.223*
Parental Occupation				---	.396**	-.105	.063
PPVT Score					---	.115	.141
Delay of Gratification						---	.017

Table 2 (Continued)

Variable	Economic Stress	Age	Parental Education	Parental Occupation	PPVT Score	Delay of Gratification	Tower
Day/Night	-.048	-.066	.337**	-.023	.341**	.026	.080
Less is More	.191	-.039	-.360**	-.124	-.308**	.032	-.164
BRIEF GEC	.174	.102	241*	-.016	.175	.185	.140
Disc. Prac.	-.040	-.057	-.238*	-.047	-.016	-.148	.110
Rel. Frus.	-.031	.024	.251*	.042	.236*	-.296**	.173
Hor. Ind.	.115	.013	-.111	-.089	-.040	-.178	.085
Ver. Ind.	-.130	-.152	.242*	.060	.263*	-.296**	.173
Hor. Col.	.093	.052	-.464**	-.202	-.318**	-.075	-.032
Ver. Col.	.176	.105	-.256*	-.006	-.290**	-.122	-.204

Table 2 (Continued)

Variable	Day/Night	Less is More	BRIEF GEC	Disc. Prac.	Rel. Frus.	Hor. Ind.	Ver. Ind.	Hor. Col.	Ver.Col.
Day/Night	---	-.197	.094	.053	.092	.008	.213*	-.127	-.145
Less is More		---	.065	-.134	-.020	.000	.131	.103	.086
BRIEF GEC			---	-.122	.706**	-.097	.110	-.270**	.052
Disc. Prac.				---	-.197	.231*	.135	.282*	-.040
Rel. Frus.					---	-.070	.217	-.256*	.063
Hor. Ind.						---	.310**	-.027	-.228*
Ver. Ind.							---	-.090	-.111
Hor. Col.								---	.273*
Ver. Col.									---

* $p < .05$. ** $p < .01$. *Note*. Disc. Prac. = Disciplinary Practices. Rel. Frus. = Relational Frustration. Hor. Ind. = Horizontal Individualism. Ver. Ind. = Vertical Individualism. Hor. Col. = Horizontal Collectivism. Ver. Col. = Vertical Collectivism.

Table 3

Multivariate Results for Language Groups and Covariates

Source	Hypothesis df	Error df	*F*	Partial η^2	*p*
Eco Stress	5	45	1.920	.176	.110
Age	5	45	1.839	.170	.124
Parental Education	5	45	1.008	.101	.424
PPVT Score	5	45	1.932	.177	.108
Hor. Collectivism	5	45	.263	.028	.931
Language Group	5	45	1.009	.101	.423

Table 4

Multivariate Parameter Estimates for Imputed Datasets

Variable	*B*	*SE B*	*t*
	BRIEF GEC		
Economic stress	1.0721	0.466	2.2999*
Age	2.5256	1.826	1.383
Parental education	0.2929	0.436	0.671
PPVT score	0.0239	0.126	0.19
Hor. Collectivism	-0.1455	0.171	-0.852
Language Group	5.25	4.02	1.306
	Day/Night		
Economic stress	0.147	0.125	1.174
Age	0.1489	0.482	0.309
Parental education	0.1182	0.12	0.987
PPVT score	0.0434	0.031	1.38
Hor. Collectivism	0.0143	0.047	0.302
Language Group	-0.2017	1.044	-0.193
	Tower		
Economic stress	-0.1558	0.141	-1.105
Age	1.728	0.542	3.199**

Table 4 (continued)

Variable	*B*	*SE B*	*t*
Parental education	0.2427	0.131	1.849
PPVT score	0.037	0.035	1.044
Hor. Collectivism	0.0284	0.052	0.551
Language Group	-2.1139	1.262	-1.674
	Less is More		
Economic stress	0.0029	0.016	0.176
Age	-0.0672	0.062	-1.083
Parental education	-0.0138	0.015	-0.898
PPVT score	-0.0037	0.004	-0.871
Hor. Collectivism	0.0006	0.006	0.098
Language Group	-0.0067	0.136	-0.049
	Delay of Gratification		
Economic stress	0.1661	0.133	1.247
Age	0.2	0.506	0.395
Parental education	-0.0599	0.119	-0.503
PPVT score	0.0339	0.03	1.136
Hor. Collectivism	-0.0429	0.049	-0.875
Language Group	-0.2217	1.1	-0.202

* $p < .05$. ** $p < .01$. *Note*. Hor. Collectivism = Horizontal Collectivism

Table 5

Summary of Multiple Regression Analyses for Psychosocial Variables Predicting EF

Variable	*B*	*SE B*	β	*t*	Sig.
			Hot EF Regression Model		
Constant	29.257	6.999		4.180	.000
Rel. Frustration	.091	.060	.217	1.508	.139
Disc. Practices	.063	.054	.163	1.151	.256
Hor. Individualism	-.092	.066	-.195	-.1386	.173
Ver. Individualism	-.130	.044	-.414	-2.923	.005
Hor. Collectivism	-.015	.073	-.032	-.205	.839
Ver. Collectivism	-.124	.062	-.305	-2.000	.052
			Cool EF Regression Model		
Constant	11.717	8.454		1.386	.173
Rel. Frustration	.113	.069	.240	1.647	.107
Disc. Practices	-.024	.064	-.055	-.370	.713
Hor. Individualism	.058	.076	.113	.760	.451
Ver. Individualism	.022	.052	.062	.420	.677
Hor. Collectivism	.089	.083	.170	1.075	.288
Ver. Collectivism	-.219	.072	-.481	-3.059	.004
Age	1.328	.813	.223	1.634	.110

Table 5 (continued)

Variable	*B*	*SE B*	β	*t*	Sig.
		BRIEF GEC Model			
Constant	20.071	12.733		1.576	.122
Rel. Frustration	.822	.117	.715	7.039	.000
Disc. Practices	-.117	.111	-.109	-1.045	.302
Hor. Individualism	-.054	.133	-.043	-.404	.688
Ver. Individualism	.079	.087	.093	.901	.373
Hor. Collectivism	-.074	.141	-.058	-.524	.603
Ver. Collectivism	-.059	.125	-.053	-.476	.636
Economic stress	.939	.365	.249	2.574	.014

Note. Rel. Frustration = Relational Frustration. Disc. Practices = Disciplinary Practices. Hor. Individualism = Horizontal Individualism. Ver. Individualism = Vertical Individualism. Hor. Collectivism = Horizontal Collectivism. Ver. Collectivism = Vertical Collectivism.

APPENDIX B

Demographic Questionnaire

1. How old is your child? ____
2. Where was your child born (country, city)? ________________________________
3. What was your child's first language? ___________________________________
4. Which language do you speak to your child at home? ______________________
5. Which language does your child speak at school? __________________________
6. Which language does your child speak at home? ___________________________
7. How many years has your child lived in the United States? _________________
8. What is the highest level of education/grade you completed? _______________
9. What is your current occupation? _______________________________________
10. How many people currently live in your home? ___________________________
    a. How many generations of your family currently live in your home?_____
11. On a scale from 1 to 5, please rate your ability to pay your family's bills each month.

1	2	3	4	5
No difficulty				Much difficulty

12. On a scale from 1 to 4, please indicate how much money you have left over at the end of the month.

1 2 3 4

Plenty of money Not enough money to “make ends meet”

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