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Bilingualism, Executive Function, and Attention Deficit/hyperactivity Disorder

Carina Ann Beck
Southern Illinois University Carbondale, cbeck@siu.edu

BILINGUALISM, EXECUTIVE FUNCTION, AND ATTENTION DEFICIT/HYPERACTIVITY DISORDER

by

Carina Beck

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Approved by:
Dr. Stacy D. Thompson, Chair

Dr. Cathy Mogharreban

Dr. Valerie Boyer

Graduate School
Southern Illinois University Carbondale
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In an era where the diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) is as high as 7% in school-aged children, the search for causes and preventions has never been more important. Current research indicates a positive relationship between bilingualism, particularly native bilingualism, and executive function in normally developing individuals. This study served to examine the potential relationship between bilingual education in a public school setting and the presence of ADHD symptoms in that school's students. This was a comparative analysis comparing students in a South Florida School District's two-way immersion program with the national average in terms of frequency of ADHD symptoms using the NICHQ Vanderbuilt Assessment Scale and the Swanson,Nolan, and Pelham (SNAP). The results did not show any significant differences between groups in terms of language history, gender, race, or family structure.

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CHAPTER 1

INTRODUCTION

Research in the areas of bilingualism and executive function has shown that, when an individual acquires a second language, advances in all areas of executive function are seen. This suggests that there is some linkage between executive function and second language acquisition. Given that individuals with Attention Deficit/Hyperactivity Disorder have problems in the same areas, their executive function; it would seem that introducing a second language to a child early in their development might enhance their abilities compared to monolinguals. Would such an introduction have an impact on the severity of dysfunction such individuals face? An early enough introduction of a second language could even ameliorate such symptoms; making second language learning an important addition to curriculum in school. In an era where one in ten US School children are diagnosed with Attention Deficit/Hyperactivity Disorder (ADHD) (Singh, 2002), such research could change the way educators and doctors think about ADHD all together.

What does it mean to be bilingual?

In general terms bilingualism, or being bilingual, means that an individual can function comfortably in two languages. That is an English-speaking individual that is also bilingual can perform daily tasks in their native language, English, as well as their second language. Some individuals are even multilingual, meaning they can speak in and understand fluently three or more languages.

In more specific terms, bilingual carries different meanings when the timing and nature of the second language was learned. For a few individuals there may never

have even been a clear first or second language division. These individuals are known by an array of terms; two of which are native bilingual (Carlson, & Meltzoff, 2008), and simultaneous bilingual (Cenoz, & Genesee, 2001) and were exposed to dual languages from infancy. Individuals that appear to have mastered one language and are later exposed to and master a level of fluency in a different language are referred to as successive bilingual (Cenoz, & Genesee, 2001). It is important to note that in native or simultaneous bilingualism an individual learns both languages together. This is different than individuals in the successive group. Successive bilinguals may learn the second language at any point in their lives.

Much concern is placed on the question of when an individual acquires the second language. Does the timing of the second language have an impact on language acquisition and development? In the past, parents and caregivers were concerned that native bilingual children would demonstrate a delay in development because of two competing languages (King & Fogel, 2006). Current research indicates that learning a second language from childhood harbors no ill effect on the learner's development in language areas such as literacy and comprehension in either language (Barac & Bialystok, 2012). While this puts some families at ease, the effect that being bilingual has on higher thinking and executive function is a topic of much research.

What is Executive Function?

Executive Function has been defined many ways. Bialystok and Viswanathan indicates that it "refers to a set of interrelated processes in the frontal lobes" (2009, p. 494). They accepted the views of Miyake et al. (2000), that it "consists of three components: inhibition, updating…, and shifting" (Bialystok & Viswanathan, 2009, p. 494). The National Center for Learning Disabilities (NCLD) states "Executive function is

a set of mental processes that helps connect past experience with present action" (2012). Generally Speaking, executive function includes skills such as planning, organizing, attention, memory, and time management. A number of functional magnetic resonance imaging (fMRI) studies have linked these functions to the cortical areas of the brain such as the dorsolateral prefrontal cortex (DLPFC), right and left inferior frontal cortex (RIFC and LIFC), and the dorsal anterior cingulate cortex (ACC). These fMRI studies, which will be discussed later in this paper, associate neuropsychological firings in the brain with an array of tasks from the Wisconsin Card Sorting Test (Aron, Robbins, & Poldrak, 2004), to language switching (Hernandez, Martinez, & Kohnert, 2000).

Language acquisition, while only one in a list of abilities children learn, places the highest demands on executive functioning. Children, who are acquiring language skills, whether it is their first or second language, must pay attention to their environment, organize sounds and symbols into categories, store those categories into long-term memories, and skillfully retrieve those memories when necessary. While current research has not identified a specific region of the brain specifically responsible for language acquisition, it has identified two parts of the brain responsible for language comprehension (Wernicke's) and production (Broca's).

Wernicke's area gets its name from Karl Wernicke's research in the area of aphasia. Wernicke researched aphasia's related to comprehension (Kaan & Swaab,2002, p. 350-351). Wernicke's area tells the brain how to comprehend language. Near Wernicke's area is Broca's area. Broca's area was named after Paul Broca, who did research involving individuals with aphasias relating to speech production (Kaan & Swaab, 2002, p. 350-351). Broca's area is therefore thought to be

responsible for speech production. This means that when the brain comprehends what it has heard and is ready to respond with speech; the Broca's area tells the brain how to speak. Specific to bilingual and multilingual individuals is the need to first comprehend what language they are receiving; then comprehend the language itself. Aron et al. (2004) refers to this as language switching. The Broca's area has been seen, through fMRI, firing in inhibition studies (Aron et al., 2004) not associated with language switching. These fMRI studies serve to further the investigative link between executive function and language development; and more importantly, answer the question; does learning a second language alter the "wiring" of the brain?

Attention Deficit Hyperactivity Disorder (ADHD)

Research agrees that the prefrontal cortex is responsible for executive function (Aron et al., 2004). Specific to this study is the function, or dysfunction, of inhibition and the RIFC. Inhibition will be discussed in more detail later in this paper. Considering the localization of both Wernicke's and Broca's areas in this region of the brain the link researchers have found between bilingualism and executive function is no surprise. What happens when an individual has a brain injury, or other brain related disorder?

The most common diagnosis in children of a dysfunction involving inhibition related behaviors is ADHD, affecting as many as 7% of school-aged children (DSM-IV-TR, 2000, p. 90). Characterized by dysfunctions involving inattention, hyperactivity and impulsivity, the DSM-IV-TR separates symptoms of ADHD into three categories; Combined Type, Predominantly Inattentive Type, and Predominantly Hyperactive-Impulsive Type (DSM-IV-TR, 2000, p. 87). These differing types will be discussed later in this paper; however, it is important to note that simply displaying these symptoms on

occasion does not constitute a diagnosis of ADHD. Upon diagnosis, treatment of ADHD often involves the use of medications that are either stimulant or non-stimulants (CDC, 2012). Currently there is much research in the area of treating ADHD; however, there is little research in the area of prevention.

Perhaps the reason for lack of preventative research is that the science community still doesn't have an identifiable cause for the disorder. Some biological studies indicate, "family members of individuals with ADHD are at increased risk for developing the disorder" (Mulder, 2010, p. 46). Science has even gone as far as to implement specific genome types responsible for hormone production (Mulder, 2010). This suggestion of a genetic link might prove useful in identifying at risk individuals in future prevention trials. "In addition to genetics, scientists are studying other possible causes and risk factors including: brain injury, environmental exposures (e.g., lead), alcohol and tobacco use during pregnancy, premature delivery, and low birth weight" (CDC, 2012).

Notably speaking, individuals with ADHD display problems in the areas of inhibition, particularly in the areas of response inhibition (Aron et al., 2004). As mentioned in the previous discussion on bilingualism, several studies on inhibition have been conducted using fMRI imaging. Broca's area is associated with motor control in speech production, but also lights up on fMRI scans during inhibition tests not involving speech (Aron et al., 2004). Does this mean that the area of the brain known as Broca's area could also be involved in inhibition control related to ADHD? If so then could learning a second language improve the development of Broca's area in a fashion

similar to lifting weights to improve muscle development? Could an improved Broca's area aid ameliorating the symptoms of ADHD in genetically predispose individuals?

Given the relationship between bilingualism and executive function already established, the real question is will individuals coming out of an elementary school two-way immersion bilingual program have a lower frequency rate of ADHD symptoms than their mainstream educated peers? This study is a comparative analysis of individuals that are near completion of a Kindergarten-5th grade two-way immersion bilingual education program and the national average. Family histories related to ADHD, second language exposure, and two standard ADHD rating scales will be used in the comparison. The purpose of this research is to compare the frequency rate of executive dysfunctions, seen as ADHD symptoms, of the two groups.

CHAPTER 2

LITERATURE REVIEW

How can the relationship between bilingualism, executive function, and ADHD be determined? The key to this question may exist in the development that occurs during early childhood. Could the linguistic development a child experiences during the early childhood period of development impact the effects of ADHD symptoms during the school years? Many child developmental researchers believe experiences that occur in early childhood have a major impact on development later in life. This chapter discusses: Nativist Theory in Language Acquisition, Executive Function, and ADHD.

Nature vs. Nurture

In terms of child development, there may be many factors that influence executive function and language acquisition. The Nature vs. Nurture debate has been a complex argument for decades. While Nurture is difficult to prove with science, and therefore a more qualitative perspective on child development; Nature is observable and measured scientifically by way of brain imaging, medical testing, and analytical observation. These scientific measures provide a more quantitative approach to child development, yet the biological underpinnings remain mysterious.

The most notable theorist to side with nature, regarding language development, was Noam Chomsky (Zahradníková, 2011, p. 10). Chomsky's theory is identified as the Nativist Theory. Chomsky believed all human beings were born hardwired to acquire language. He argued the language children received from their caregivers was imperfect and therefore could not be attributed to the successful acquisition of language on its own. The only reasonable explanation for successful language acquisition was

the idea that humans contain this innate capacity to learn language. "Chomsky called this innate capacity, the language acquisition device (LAD)" (Zahradníková, 2011, p. 11).

While science has not been able to identify a region of the brain solely devoted to acquiring language; Wernicke and Broca's areas have been identified as responsible for comprehension and production of language. These areas are of particular interest when discussing bilinguals, for exampling in understanding how bilinguals handle switching between two languages. While Chomsky believed the brain was wired with a LAD; Hernandez, et al. (2000) believed there might be a part of the brain responsible for switching between languages previously acquired. While their research did find a general connection between language switching and executive function, they were unable to locate an area of the brain devoted to language switching. Perhaps, as Hernandez, et al. (2000) suggested, the resolution necessary to pinpoint these specialized areas of the brain does not exist in current imaging devices. Perhaps Chomsky and Hernandez et al. are correct, and the brain is hardwired for language acquisition and language switching. Perhaps the brain is even wired with an executive function command center that is responsible for telling the brain how to behave.

Executive Function and Bilingualism

For now, the only thing researchers have proven is that language acquisition and executive function are closely tied together. How does language acquisition, primarily dual language acquisition, impact executive function in "typically developing" individuals? Is this relationship a natural hardwiring of the brain? Research indicates that individuals who are bilingual tend to have elevated executive function controls and

out perform their monolingual peers in nearly every executive functioning aspect (Bialystok, 2011). Bialystok and Viswanathan (2009) state that the relationship between executive function and language is so extreme that; “bilingualism is responsible for enhanced executive control” (p. 494). Why?

Costa, Hernandez, and Sebastian-Galles (2008) set out to understand the general relationship between bilingualism and attention networks. They recruited 200 participants equally divided between two groups, bilingual Catalan-Spanish speaking participants and monolingual Spanish speaking participants. The bilingual group was considered to be simultaneous bilingual because the individuals were all exposed to both languages from birth (Costa et al., 2008). These researchers used the Attentional Network Task (ANT) to measure the function of Attentional Networks in the brain. This task consists of a reaction time test in combination with a flanker task. In this study participants are asked to react to stimuli on a computer screen to determine which direction an arrow is pointing. Using the Attentional Network Task, they determined that, bilingual participants were faster than monolinguals in reaction time and tended to take more advantage of alerting cues, cues given on the screen to alert the participant where to expect the stimulus to be found (Costa et al., 2008). Their study concluded that “bilingualism has a positive effect on the achievement of more efficient functioning of two attentional networks: alerting network and executive control network” (Costa et al., 2008, p. 82).

While studying the executive function of inhibition in children who were bilingual, Bialystok (1999) assessed participants on their performance of the Dimensional Change Card Sort Task. In this task, participants are asked to identify visual and audio stimulus

as either animal or musical instruments, randomly alternating between the stimuli presented. This task measured inhibition rates in children that were bilingual and compared them to monolingual peers. In this task bilingual children achieved higher rates of success, results consistent with previous research conducted by Bialystok (Bialystok, 1999). When similar set switching tasks were studied using fMRI scans of Spanish-English Bilinguals, "participants showed slower reaction times and increased activation in the dorsolateral prefrontal cortex" (DLPFC) (Hernandez et al., 2000, p. 421). These participants were given a set of 180 pictures to identify in one of two languages. Instructions to "say" or "diga" indicated which language to use. While participants experienced a slowed reaction time or switch cost in mixed language tests, the same areas of the brain were used to process both languages. These studies indicate while, language switching may cause a short-term switching cost; or slowed reaction time overall executive functions are enhanced. This is suggestive of an innate relationship between language acquisition and executive function.

In terms of executive control, the question may arise regarding the timing of when an individual acquires a second language. As the research has pointed out, individuals with an early age of acquisition seem to have a higher level of proficiency than individuals that acquire their second language later in life. However, successive bilinguals that learn a second language late in life have also been found to have high levels of proficiency. These two areas are related, but not synonymous. Bialystok and Viswanathan (2009) were able to identify early developmental improvements of executive control in bilingual children when compared to their monolingual counterparts. Nativist theorists believe that all individuals have an innate capacity for all language.

They believe individuals are simply hardwired for language as a whole. If this is true, children ought to be able to acquire a second language from infancy, and use that language throughout their life. Previous research indicates this dual language acquisition from birth appears to have no major impact on overall language development. Given this information, is it necessary for individuals to learn a second language in early childhood to enjoy the same benefits of enhanced executive control? In 2008 Carlson and Meltzoff addressed this question.

Carlson and Meltzoff (2008) examined 50 kindergarten students from three groups; native bilingual, language immersion, and monolingual. The bilingual participants were all exposed to both Spanish and English from birth, indicating they were simultaneous bilinguals. The immersion group was made up of students in either a half-day Spanish kindergarten or a half-day Japanese kindergarten. In this group, during the first half of the day, all curriculum areas were taught in English and during the second half of the day all curriculum areas were taught in Spanish or Japanese, respectively. The third group consisted of all monolingual English-speaking students. The overall composite executive function scores were higher for the native bilingual group than for either of the other two groups (Carlson, & Meltzoff, 2008, p. 291). This suggests that immersing children from infancy in a second language may have a better impact on overall executive function later in life than waiting to introduce a second language in elementary school. This solidifies the idea of an innate relationship between language acquisition and executive function.

Thus far, the research has hinted at and suggested a relationship between language acquisition and executive function. The nature vs. nurture debate continues

to question if this relationship is hardwired or simply a coincidence. The research conducted by Perani et al (1998) aids in answering this question. PET scan imaging conducted on individuals who had learned a second language before the age of ten were compared to PET scan individuals that had learned a second language after the age of ten. Participants were asked to listen to two stories in their native language and two stories in their second language. Preliminary results indicated the same cortical areas of the brain, largely in the left hemisphere, were used to process both languages in all of the participants (Perani et al., 1998). However these results were found in participants who were all deemed to have a high level of proficiency in both languages. In PET scan images of participants with low proficiency of the second language, different regions of the brain were used to process the second language (Perani et al., 1998). Therefore, at least in terms of comprehension of language, proficiency level appears to be more important than age of acquisition.

In terms of early bilingual language acquisition, fMRI studies have found very few differences in brain activity between first and second languages (Hernandez et al., 2000). Evidence from multiple studies as cited by Hernandez and colleagues (2000), indicate a primary activation of the DLPFC when discussing language switching. Coincidently fMRI research, not related to language studies, has indicated activation of the DLPFC in terms of inhibition studies. When discussing inhibition and other executive function in young children, Carlson and Meltzoff (2008) came across another variable that may have an impact. In their study, the bilingual students were also the students with the lowest socioeconomic status. Executive function composite scores were significantly related to socioeconomic status. However when controlling for

socioeconomic status “bilinguals performed significantly better than both immersion students and controls ($p < .01$ and .05 respectively)” (Carlson & Meltzoff, 2008, p. 291).

All of this research indicates that bilingualism does have a positive impact on the development of executive function. Timing of the acquisition of the second language and proficiency of the second language seem to have a significant impact on the development of executive function. At this point it seems that the introduction of bilingual curriculum does not have a negative impact on individual overall development. Individuals who develop a high proficiency for a second language activate the DLPFC to process language and are more adept at inhibitory tasks than their monolingual peers. Carlson and Meltzoff’s (2008) research results suggest that the introduction of bilingual curriculum may actually be a good thing allowing students in poverty stricken homes to “do more with less” (p. 293).

As noted in the above discussion on bilingualism, a general relationship between bilingual speech production and attention seems to exist (Costa et al., 2008). FMRI studies related to inhibition, as well as fMRI studies related to language switching indicate that both functions occur in the DLPFC. Bialystok (2011) indicated, “experience in managing attention to two language systems improves performance broadly and extends to other systems on the activation and attention to two representations” (p. 466). This research seems to suggest an overall hardwired relationship; but research on the actual topic of improving executive dysfunction by introduction of a second language still needs to be conducted.

Bilingualism, Executive Function, and ADHD

If individuals with bilingual language skills exhibit increased executive functions, it may be possible that individuals with brain injury or other executive dysfunction could develop improved skills. Research indicates that "patients with frontal cortical damage are notoriously bad at the change stage" of the Wisconsin Card Sorting test (Aron et al., 2004, p. 170). Research involving bilingual aphasics, individuals that have suffered the loss of one, or part of one, language but not the other, observed that many factors affect recovery (Hernandez et al., 2000). These factors include age of acquisition, proficiency prior to aphasia, order of acquisition, and what languages were acquired (Hernandez et al., 2000). Stroke victims, for instance, demonstrate impairment of just a single language. One explanation for this is that dual language learners somehow store each language in a different part of the brain (Hernandez et al., 2000). As mentioned in Chapter 1, Karl Wernicke researched individuals with aphasias involving comprehension. Paul Broca did similar research with aphasia patients involving production issues. Perhaps it is not that bilinguals store languages in areas (e.g. Broca's or Wernicke's) of the brain, but that these two functions of language are represented in separate regions of the Wernicke and Broca's areas in the brain. Some individuals with brain damage will recover in a matter of weeks, while others may suffer permanent damage (Hernandez et al., 2000). Individuals dealing with a lesion near Wernicke's area may be affected by a comprehension aphasia involving comprehension of only one language. Those with lesions near Broca's area may experience production aphasias of only one language. The area of the brain injured has just as much to do

with recovery as acquisition and proficiency of the languages involved in the aphasia. Clearly, in terms of identifiable brain damage in individuals there are a great many factors that determine recovery bilingualism is only one.

Can individuals with other executive dysfunctions actually improve their executive function skills by acquiring a second language? As previously mentioned, the most widely diagnosed executive dysfunction in childhood is Attention Deficit Hyperactivity Disorder (ADHD), which the DSM-IV-TR separates by symptoms into three categories; Combined Type, Predominantly Inattentive Type, and Predominantly Hyperactive-Impulsive Type (DSM-IV-TR, 2000, p. 87). In Attention Deficit Hyperactivity Disorder (ADHD), Predominantly Inattentive Type, individuals display symptoms that are inappropriate for their developmental level in tasks such as (DSM-IV-TR, 2000, p. 92):

1 Failing to give close attention to details in schoolwork, work, or other activities.

2 Failing to keep attention focused on task or play activity.

3 Not appearing to listen when someone speaks to them directly.

4 Failure to follow through on direct instruction.

5 Difficulty staying organized.

6 Avoiding tasks that require mental effort for sustained amounts of time.

7 Easily loses things necessary for daily activities.

8 Appears easily distracted.

9 Is often forgetful.

Individuals displaying symptoms of ADHD, Predominantly Hyperactive-Impulsive Type exhibit hyperkinetic symptoms such as (DSM-IV-TR, 2000, p. 92):

1 Often Fidgets with Hands or Feet.

2 Cannot remain seated even when doing so is expected of others

3 Excessively runs or climbs in environments where doing so are inappropriate.

4 Does not seem to be able to play quietly.

5 Appears to be driven by a motor

6 Often talks excessively.

7 Often blurts out answers in class.

8 Demonstrates difficulty taking turns

9 Often interrupts others.

Individuals with ADHD, Combined type exhibit dysfunctions in all of the above areas (DSM-IV-TR, 2000, p. 93). Research involving symptoms closely related to ADHD have been around for nearly a century. In the 1930's, 40's, and 50's individuals with a disorder known as Minimal Brain Dysfunction, MBD, displayed symptoms similar to those of ADHD: hyperactivity, inattention, mood swings, and learning disabilities (Singh, 2002). In the 1930's Charles Bradley began treating these symptoms with Benzedrine, a stimulant medication. In 1957, citing improvement of hyperkinetic symptoms with amphetamines, MBD got a new name, Hyperkinetic Disorder (Singh, 2002, p. 361). Focus remained on hyperactivity as the most problematic symptom until 1980 when inattention became center stage again. With the publication of the DSM-III a new name for this disorder surfaced; Attention Deficit Disorder (ADD). A diagnosis with ADD meant that the child did not have to be considered hyperactive to receive treatment (Singh, 2002). The DSM-IIIR changed the name of the disorder once again, this time to AD/HD emphasizing the shift away from hyperactivity as a key indicator of the disorder.

Presently the disorder is referred to as Attention Deficit/Hyperactivity Disorder (ADHD) (Singh, 2002).

This change in diagnostic criteria has spawned numerous debates in the matter of cause. As previously mentioned, one key symptom of ADHD is difficulty with inhibition. This manifests itself either as impulsivity, or distractibility. At this point it seems necessary to identify what inhibition is, and what signals inhibitory reactions. Inhibition is considered a biological "mechanism that reduces or dampens neuronal, mental, or behavioral activity" (Friedman, & Miyake, 2004, p. 102). Inhibition thus far has been discussed only in an executive function context. It is important to understand that not all inhibition occurs at the executive level. Motivational inhibition drives individual behaviors just as much as executive inhibition. In the case of motivational inhibition, individuals are driven by perceived rewards, threats, or punishment (Nigg, 2001).

Inhibition can also be addressed through questions relating to cause, which can be intentional or unintentional. In the case of unintentional inhibition, the reaction is subconscious, or automatic. Intentional inhibition is the result of a stimulus classification as irrelevant or unnecessary and is therefore suppressed. Inhibition can further be broken down into behavioral and cognitive domains. Behavioral inhibition controls behaviors by inhibiting motor responses. Cognitive inhibition controls mental processes such as attention and memory (Friedman & Miyake, 2004). Individuals with ADHD, Predominantly Hyperactive-Impulsive Type, or Combined Type may have dysfunctions in behavioral inhibition. Inhibitory controls that would cause an individual to remain seated and not get up are overridden or simply not present, resulting in the

individual getting up from their seat. Individuals with ADHD, Predominantly Inattentive Type or Combined Type experience a dysfunction of cognitive inhibitory controls. Irrelevant stimuli are not classified as such by the brain and an individual's thoughts are not suppressed resulting in daydreaming or forgetting instructions for the task in front of them.

Social scientists point to changes in modern day culture as the culprit behind ADHD diagnosis. There is some suggestion that labeling an individual with ADHD only provides an excuse for otherwise socially unacceptable behavior. Some would even postulate that the real problem of ADHD is one of self-control (Singh, 2002). On the surface, this seems to be a matter of nurture instead of nature. Yet self-control is a behavior controlled by inhibition. Behavior inhibition is controlled through working memory, and is considered a biological function (Friedman, & Miyake, 2004). Even this suggests that ADHD is a biological problem.

A case for motivational inhibition can be the real source of impulsivity issues. One only needs to evaluate the perceived outcomes to determine what action to take, and if they were wrong, well it was because of ADHD. Even so motivational inhibition is directly related to executive inhibition in some degree. In order to assess whether something is a threat, or poses a possible reward, a certain level or executive thought is involved. Once such an assessment is made motivational inhibition dictates reaction. Both of these functions require some type of cortical or subcortical interaction (Nigg, 2001). Even when blame is placed on social situations, it can be directed back to brain function.

In an effort to study this, fMRI scans have indicated possible changes in the function of the brains of individuals with ADHD. These studies are indicative of changes in the prefrontal cortex (Mulder, 2010). This may be the Aha moment science has been looking for. Recall from the previous discussion that executive inhibition and language switching are associated with the DLPFC. In terms of inhibition, response inhibition was measured through task-set switching that resulted in activation of the DLPFC, RIFC and occasionally the LIFC (Aron et al., 2004). In terms of language switching activation of the DLPFC and LIFC were noted (Hernandez et al., 2000).

However, these scans may be misleading because fMRI scans of individuals with ADHD only compare individuals who have already started medication to control individuals (Timimi & Taylor, 2004). Further MRI scans need to be conducted in a diagnostic fashion, before medication is started, in order to determine actual differences in the brain activity of individuals with ADHD.

It is important to note that as with other disorders, ADHD is not a US pop culture disorder. In a comparative analysis of the US, UK, Australia, New Zealand, and Canada, it was noted that the prevalence rate of ADHD symptoms was similar among all participating nations (Faraone et al., 2003). Another study indicated the percentage of school age children prescribed medication for the treatment of ADHD symptoms was similar between the US and the UK (Singh, 2002). ADHD isn't restricted to developed nations either. Although previously diagnostic rates for ADHD in developing countries were thought to be relatively low, new research indicates that rate is increasing. Some, perhaps those on the side of nurture, hypothesize that this is due to an increase in Western influence (Kuruppuarachchi, & Wijerante, 2004). Clearly, cultural influence

isn't the only factor causing dysfunction of inhibitory controls such as those indicative of ADHD. As mentioned repeatedly in this paper, symptoms are linked to various cortical activities involving inhibition and language. These studies only serve to indicate that ADHD is not exclusive to other language systems. It is still possible that by introducing young children in these cultures to a second language we may see a decrease in ADHD symptoms.

Language Development and ADHD

Before we can jump to conclusions surrounding the possibility of bilingualism improving executive function in individuals with ADHD we must understand the language development of such individuals. Recall that in the initial discussion of ADHD impulsive symptoms such as blurting out answers, difficulty with turn taking, and frequent interruptions were identified. These symptoms can also be indicative of language impairment. More specifically these symptoms are indicative of an impairment related to the mastery of pragmatics. One study indicated 68% of children with a diagnosis of either the DSM-III's ADD or the DSM-IV's ADHD demonstrated speech and language problems (Kim, and Kaiser, 2000). It is difficult to determine if the speech and language problems are caused by ADHD, or if ADHD is simply a symptom of an underlying speech and language problem. While some studies indicate common ground between ADHD and Language Impairments, it is difficult to postulate which influences which. Additionally, there is a strong association between language impairment and psychiatric disorders in general (Cohen et al., 2000). Given the relationship between inhibitory control and language processing with the prefrontal

cortex it seems reasonable that individuals exhibiting either Language Impairment or ADHD would also exhibit symptoms of the other.

What the research has shown us thus far is that bilingualism:

1 Increases the rate in which children develop inhibitory controls (Carlson & Meltzoff, 2008, p. 282).

2 Allows individuals that are in lower socioeconomic situations to achieve the same result as their higher earning peers (Carlson & Meltzoff, 2008, p. 293).

3 And improves overall executive performance “based on the activation and attention to two representations” (Bialystok, 2011, p. 466).

We also know that, despite the cause, individuals with ADHD have a significant decrease in executive function. This can be seen through fMRI imaging as well as repeated experiments involving response inhibition. It has also been indicated that individuals with ADHD are likely to be diagnosed with language impairment, and that individuals with language impairment are likely to be diagnosed with ADHD.

What we don’t know is the relationship between language development and ADHD. It appears to be a “which came first” scenario that requires further study. Does language development directly impact inhibitory controls that later lead to a diagnosis of ADHD or does the genetic predisposition to ADHD impact inhibitory controls that later influence language development? Given the assertion that “bilingualism is responsible for enhanced executive control” (Bialystok, & Viswanathan, 2009, p. 494), and that “inhibitory control over attentional resources, develops more rapidly in children with extensive bilingual experience” (Carlson, & Meltzoff, 2008, p. 282), it is safe to postulate that the introduction of a second language curriculum in infancy would not be harmful.

One could even postulate that, given the link between ADHD and language processes in the prefrontal cortex, such an introduction could be beneficial.

Children in these programs may be cared for by bilingual caregivers that speak to the children in both of the caregiver's languages. Stories read may be read in both languages. Every activity of the day, from diaper changes, to meal times, to sensory activities may be spent immersed in both languages. This type of curriculum may be similar to the level of immersion in older bilingual programs where half the day is spent in one language and the other half of the day is spent in a second language. It is important that the infant or young child receive exposure to both languages in equal parts in order for the curriculum to reach maximum beneficially. If this curriculum is not harmful, and is truly beneficial, wouldn't this be classified as best practice?

CHAPTER 3

METHOD

The purpose of this research was to compare the frequency rate of executive dysfunctions, seen as ADHD symptoms, of a group of students involved in a two-way immersion bilingual program in a South Florida School District (SFSD) with national averages. It was expected that students in the two-way immersion program would have a lower frequency rate of ADHD indicators than that of the national average despite family histories. Students were recruited directly from the two-way immersion program by way of school administrators.

Procedure

Parents of male and female 4th grade students in the two-way immersion program were the participants and were contacted to participate through the respective classroom teachers and school administration. SFSD was chosen because of its program design. The target school houses students from Pre-K through 5th grade. Students begin the program in either Pre-K or kindergarten and continue through the 5th grade. All students that attend the school participate in the two-way immersion program. Students in the 4th grade were chosen because this is near the end of the program and students would have been exposed to both languages for at least five years.

Students are exposed to a curriculum consisting of 60% English language and 40% Spanish language instruction. Reading, Language Arts, and Math content are taught during both portions of the day, but in separate settings. An English Speaking teacher teaches content in English, and a Spanish speaking teachers teaches content

in Spanish. In the event that a student requires education in a self-contained classroom, the teacher in that classroom teaches in both languages. The objective of the program is to create a bilingual, biliterate, and bicultural community.

According to district statistics, SFSD's enrollment for pre-k thru 5th grade included 7.49% white, 23.34% Black, 67.19% Hispanic, 1.11% Asian, and 0.87% other ethnic groups. In addition, 76.08% qualified for free or reduced lunches. The 4th grade at the targeted school had an enrollment of 8 white students, 60 Hispanic students, and 1 Asian student.

One of the targeted school's 4th grade classrooms participated in this research study, with nine families choosing to participate. Participants consisted of four female and five male students. Students ranged in age from 9 years of age to 10 years of age with a mean age of 9.8 years. Participants reported a range of race/ethnicities: four reported white ethnicity, three reported Hispanic, one reported Asian, and one reported a mixed race of Hispanic/White.

Participant's confidentiality was protected by randomly assigning participant numbers in place of participant names. These numbers were assigned by numbering: the Family History, Language Survey, and assessment scales together and randomly handing them out to participants. Identification of students in the two-way immersion program was presumed due to the school policy. Frequency rates for ADHD indicators in the two-way immersion program were averaged and compared.

Upon Human Subjects approval, each 4th grade student was given an informed consent form for their parents to complete along with the following: Family History Questionnaires, Language Survey's, and two standard ADHD rating scales.

Measures

Data was gathered through parent participants in the following manner: The student and family medical history was reported through a Family History Questionnaire, the student's language history was gathered through the Language Survey, and executive dysfunction measurements, measured through ADHD symptoms, were gathered using the Swanson, Nolan and Pelham (SNAP) and the NICHQ Vanderbilt Assessment Scale—PARENT Informant. As mentioned in the executive function sections of this paper, executive function includes skills such as planning, organizing, attention, memory, and time management. The SNAP and NICHQ Vanderbilt Assessment Scale—PARENT Informant address potential dysfunctions in these areas using the DSM-IV diagnostic criteria mentioned in Chapter 2 of this paper.

Family History Questionnaire:

As mentioned in Chapter 1 of this paper, individuals with a family history of ADHD are at an increased risk of developing ADHD. In addition symptoms of ADHD are similar to other childhood mental illnesses (e.g. Depression and Autism). It was not only necessary to identify a history of ADHD, but it was also necessary to determine a family history of other issues. The family history portion of this study gathered historical information about ADHD, Autism, Depression, Drug and Alcohol abuse, and other issues that may mimic ADHD. This information was expected to be a good predictor of the appearance of ADHD symptoms in the current participants.

Language Survey:

The language survey was designed to obtain a basic language history for the participant. Questions pertaining to the child's first speech aided in determining if they

were bilingual from an early age. Questions pertaining to home language usage were used to determine proficiency in a second language. All participants received at least part of their instruction in English, so it was expected that they would each have some proficiency in the English language. Not all participants were native Spanish Speakers, therefore they were not all expected to have a proficiency in Spanish. Given the relationship between bilingualism and executive function it was expected information on language history would aid in understanding frequency rates of ADHD in the two different groups.

Swanson, Nolan, and Pelham (SNAP):

The Swanson, Nolan, and Pelham (SNAP) rating scale is a 90-question Likert-type scale. This rating scale assesses all three types of ADHD and Oppositional Defiant Disorder (ODD) via the DSM-IV diagnostic standards. The SNAP was used to assess executive dysfunctions seen as symptoms of ADHD. Individual items are rated on a 4-point scale (0 for not at all to 3 for very much). Items are separated into domains: inattention, hyperactive/impulsivity, and ODD. Items for each subdomain are averaged giving a domain score. The two domains of interest for this study were the ADHD Inattentive, and ADHD Hyperactive/Impulsive. Each domain score is calculated by adding the total responses for all items in a subset and then dividing by the number of items in that subset. Diagnostic cutoff scores are listed on the scoring instructions as: ADHD Inattentive 1.78, ADHD Hyperactive/Impulsive 1.44, and ADHD Combined types 1.67. This scale is available for print on the author's website (http://ADHD.net), along with its scoring instructions. In one study the internal reliability was measured through a series of coefficient alphas. "Coefficient alpha for overall ratings was .94. For

the inattentive, hyperactive/impulsive, and ODD subdomains, coefficient alphas were .90, .79, and .89 respectively" (Bussing et al., 2008, p. 5). In a second study reliability was measured in a test-retest format with a score of .77 to .80 (Pelham, Fabiano, & Massetti, 2005).

The NICHQ Vanderbilt Assessment Scale—PARENT Informant:

The NICHQ Vanderbilt Assessment Scale—PARENT Informant is comprised of 55 questions on a Likert type scale. Like the SNAP, the Vanderbilt addresses symptoms of all three types of ADHD as well as ODD. In addition the Vanderbilt addresses issues relating to Anxiety or Depression. The first 47 questions use a scale of Never (0), Occasionally (1), Often (2), and Very Often (3) to address DSM-IV symptoms of ADHD, ODD, Anxiety, and Depression. Questions numbered 48-55 address performance issues for the same disorders using a scale of Excellent (1), Above Average (2), Average (3), somewhat of a Problem (4), and Problematic (5). In one study the Vanderbilt had an internal consistency rating of .90 to .94 (Pelham et al., 2005, table 1, p. 454). In addition Flowers and McDougle (2010) found the Vanderbilt Assessment Scale to be one of two assessment scales they considered valid for African American populations giving it "acceptable internal consistency when compared with the Vanderbilt Attention-Deficit/Hyperactivity Disorder Teacher Rating Scale (VADTRS) and the Computerized Diagnostic Interview Schedule for Children Version IV (Cronbach a ≥ 0.90)" (p.372). This population of students is of particular importance due to the large number of minority students at SFSD.

According to the Vanderbilt Scoring Instructions, in order for a participant to meet diagnostic criteria for Inattentive or Hyperactive/Impulsive type, the participant must

respond to 6 items in the respective category with a response of 2 or 3 and at least one item in the performance questions with a score of 4 or 5. In order for the participant to meet criteria for the combined type of ADHD, the participant must meet the criteria for each of the categories individually. These scoring instructions work to identify the presence of disordered executive functions, seen as ADHD symptoms, which are considered problematic. The presence of disordered executive functions, which are not significant enough to be considered problematic, may indicate a risk for the development of problematic behaviors later, as physiological behavior increases.

In May of 2013, during the course of conducting this research study, the American Psychiatric Association (APA) changed the diagnostic standards for ADHD in the DSM-5. These new standards change the age of onset from 7 to 12, representing a five-year age gap during which new patients may exhibit an onset of symptoms. These symptoms may be present in individuals at an earlier age in a diminished capacity. While the main purpose of this investigation was to compare participant frequency rates of ADHD with the national averages, it was also necessary to determine if symptoms were diminished due to bilingualism. In an effort to identify the presence of milder behaviors, criterion was adjusted to include any positive response of 1, 2, or 3. Responses of 0 were considered a negative response because 0 indicates that the behavior is not present at all.

Plan of analysis:

This study was a multi-tiered comparative analysis. First, the study population was compared to the national average in terms of ADHD frequency using the Family History Questionnaire. Language history involving first language, and length of

bilingualism were collected from the Language History Survey. Additionally the study population was compared against itself to determine statistical significance of demographic variables in terms of the emergence of ADHD symptoms. These variables included: length of bilingualism, gender, ethnicity, and income structure. ANOVAs were used to compare groups based on length of bilingualism. T-tests were used to compare groups based on gender, ethnicity, and family income structure.

CHAPTER 4

RESULTS

The purpose of the present study was to compare students in a two-way immersion bilingual school program in terms of executive dysfunctions, seen as symptoms of ADHD. Parents of the students were asked to complete surveys, which consisted of a Family History Questionnaire, a Language History Survey, and two diagnostic inventories. Variables involving length of bilingualism, race/ethnicity, gender, and family income structure were compared to determine if there was a statistically significant impact of each variable on the presence of executive dysfunction.

Family History Questionnaire and Demographics:

Demographic information was collected through the Family History Questionnaire. All participants were families of fourth grade students in the targeted school. A group of nine families chose to participate in the study. The participant pool consisted of four female and five male students. Students ranged in age from 9 to 10 years with a mean age of 9.8 years. Participants reported a range of race/ethnicities: four reported White ethnicity, three reported Hispanic, one reported Asian, and one reported a mixed race of Hispanic/White (see Table 1 for demographics).

Socioeconomic status was not referred to directly in the demographic portion of the Family History Questionnaire; however, participants were asked if they came from a single income earning household, a two-income earner household, or a single earning household where the earner has more than one job. Responses were nearly equal in division with five participants reporting a household with two income earners, and four participants reporting a household with a single income earner.

The majority of participants, six participants, came from a family home with both natural parents. For the other three, one participant each indicated that the child lives with grandparents as guardians, lives with a stepparent in the home, and lives with a single mother.

Medical history information was also collected through the Family History Questionnaire. All nine participants reported not having a family history of ADHD, or other mental illness. Of the participants eight also reported not having a history of food allergies, hearing, or vision problems. One participant reported having a history of food allergies and vision problems in the child's father. This same participant reported having vision problems severe enough to require wearing corrective lenses.

Table 1

Participant Demographics

Participant Number	Age	Race/ Ethnicity	Gender	Family Income Structure	Family Structure	Bilingual from Age
138	10	Hispanic	Female	Two Income	Two Parents	4-5 years
134	10	Hispanic	Female	Two Income	Two Parents	1-2 years
123	10	Multiracial	Female	Single Income	Single Mom	Birth
149	10	White	Female	Two Income	Mom and Step-Father	Birth
147	10	Asian	Male	Single Income	Two Parents	1-2 years
129	10	Hispanic	Male	Two Income	Two Parents	Birth
132	10	White	Male	Single Income	Grandparents	4-5 years
114	10	White	Male	Single Income	Two Parents	2-3 years
139	9	White	Male	Two income	Two Parents	1st grade

Language Survey:

Participant's language history was collected through the Language Survey. They were asked when the child began speaking a second language, what was the first language the child spoke, and what language does the child use socially. Three participants reported having spoken Spanish and English from birth. Two participants reported speaking dual languages by the second year of life. One of those participants reported speaking Spanish as a first language and English as a second language. The other reported speaking a non-Spanish language as the primary and English as a second language. One participant reported speaking dual languages by age 3 with Turkish as the first language and English as the second language. Two Spanish-speaking participants reported learning English as a second language in preschool, between the ages of 4 and 5. One participant reported English as a first language and not learning Spanish as a second language until transferring to the program in the first grade. This participant reported only speaking Spanish in school.

Based on the established diagnostic cutoffs for the SNAP, one participant meets diagnostic criteria for ADHD Combined type. Based upon initial diagnostic standards for the Vanderbilt, the same participant meets the criteria for an ADHD diagnosis, the combined type. No participants meet criteria for Inattentive or Hyperactive/Impulsive type separately. These results are consistent with the national average of 7%, despite the participants' access to bilingual education. Only one additional participant meets the diminished criteria for Inattentive type. The diminished criteria for the Vanderbilt failed to return any additional respondents with a positive diagnosis for Hyperactive or combined types.

The single student to meet diagnostic requirements for ADHD was a ten-year-old multiracial (White/Hispanic) female from a single income home headed by a single mother. According to the Bureau of Labor Statistics (BLS), families headed by single women were more likely to be members of the "working poor" than families headed by single men, or married couple families (A profile of the Working Poor, BLS, 2011). It is likely that this female-headed single income family was a low-income family. According to the CDC, children who were on the government's Medicaid program, a program for low-income families, were most likely to be diagnosed with ADHD (CDC.gov). Additionally, this student was multiracial. The CDC also reports that rates of ADHD diagnosis were highest among multiracial families (CDC.gov). She reported no family history of ADHD, food allergies, or hearing or vision problems. Thus far, this particular student's demographics are consistent with common risk factors for ADHD. However, this student is female. The CDC states "Boys (13.2%) were more likely than girls (5.6%) to have ever been diagnosed with ADHD" (CDC.gov). She was also reported to be bilingual Spanish/English from birth. The hypothesis of this study was that bilingual students would have a lower frequency of ADHD symptoms than their monolingual peers. It seems this participant's report does not support that hypothesis.

In addition to the one participant who meets diagnostic requirements, one student reported no symptoms were present, scoring zeros in both subtypes for both measures. This participant was also female, but was very different from the ADHD participant. This participant was a ten-year-old Hispanic female from a two-income, two-parent home. This participant reported having a family history of food allergies, and having a personal history of vision problems. She only became bilingual in preschool

(between 4 and 5). Aside from a family history of food allergies, she had no risk factors for ADHD. This significant difference between two participants gives further support to the CDC's reported statistics.

After determining that the frequency rate of ADHD symptoms in this participant pool was consistent with the national average, tests for significant differences between participants were conducted to determine if other variables could influence the presence of these symptoms. ANOVAs to test for significant differences were conducted for: length of bilingual history using both the SNAP and the Vanderbilt, using diminished criteria for the Vanderbilt. One-tailed t-tests were run for race/ethnicity, gender, and income structure.

Language History Effect. Contrary to the initial hypothesis, which indicated that those with a longer history of bilingualism would be less likely to test positive for symptoms of inattentiveness or hyperactivity, the results indicate something different. Language history was divided into three categories: those who were bilingual from birth, those who became bilingual during the toddler years (ages 1-3) and those that became bilingual at or after age 4. One-way ANOVAs were conducted to compare the effect of bilingual history on ADHD Inattentive and ADHD Hyperactive symptoms using the Vanderbilt. In this study there appeared to be no significant difference of bilingual history on ADHD Inattentive symptoms [$F(2,6)= 4.69$, $p= 0.06$]. Likewise, there appeared to be no significant difference of bilingual history on ADHD Hyperactive symptoms [$F(2,6)=3.80$, $p=0.086$]. One-way ANOVAs were also conducted to compare the same effect of bilingual history on ADHD Inattentive and ADHD Hyperactive symptoms using the SNAP. Once again, there appeared to be no significant difference

of bilingual history on ADHD Inattentive symptoms [F(2,6)= .1.49, p=0.30]. As with the Vanderbilt, there appeared to be no significant difference of bilingual history on ADHD Hyperactive symptoms [F(2,6)=1.11, p=0.39].

Race/Ethnicity. The CDC claims that children of Hispanic heritage are less likely to develop symptoms of ADHD than their non-Hispanic counterparts. One-tailed t-tests were conducted to determine if individuals of Hispanic heritage were any less likely to have symptoms of ADHD Inattentive or ADHD Hyperactive type, these results can be seen in Table 2. Using the SNAP to measure ADHD Inattentive Type, there was no significant difference between Hispanic and White participants t(5)=1.25, one-tail p=0.13. In addition, there was no significant difference between Hispanic and White participants in terms of ADHD Hyperactive symptoms t(5)=0.91, one-tail p=0.20. As was with the SNAP, in terms of ADHD Inattentive Type using the Vanderbilt there was no significant difference between Hispanic and White participants t(5)=0.04, one-tail p=0.49. In addition, there was no significant difference between Hispanic and White participants in terms of ADHD Hyperactive symptoms on the Vanderbilt t(5)=1.12, one-tail p=0.16.

Table 2

Individual t-tests comparing scores on the Vanderbilt and SNAP by Race/Ethnicity

Variable Measures	Hispanic (*n* = 3) Mean (SD)	White (*n* = 4) Mean (SD)	*t*-score	*P value*
Vanderbilt				
Hyperactive Type	2.25 (2.917)	2.334 (16.334)	.038	.490
Inattentive Type	1.25 (2.25)	.300 (7.000)	1.32	.160
SNAP				
Hyperactive Type	.556 (.107)	.259 (.078)	1.254	.130
Inattentive Type	.111 (.016)	.037 (.004)	.908	..200

*p< .05, **p< .01.

Gender. According to the CDC, “boys are 2.8 times more likely to take medication than girls,” (CDC, 2012) for ADHD symptoms. Scores were calculated for both genders. One-tailed t-tests were conducted to determine if there was a significant effect of gender on ADHD Inattentive and ADHD Hyperactive types in the present study (See Table 3). According to the Vanderbilt, there were no significant differences for gender on either types: Inattentive type t(7)=0.eE+0, one-tail p=0.5, and Hyperactive type t(7)=1.13, one-tail p=0.15. In terms of ADHD Inattentive type using the SNAP, there appeared to be no significant difference between the genders t(7)=0.59, one-tail p=0.29. The same was true for ADHD Hyperactive symptoms when measured by the SNAP t(7)=0.81, one-tail p=.22.

Table 3

Individual t-tests comparing scores on the Vanderbilt and SNAP by Gender

Variable	Female (*n* = 4)	Male (*n* = 5)	*t*-score	*P value*
Measures	Mean (SD)	Mean (SD)		
Vanderbilt				
Hyperactive Type	3 (18.000)	3 (8.700)	0.00E+00	.500
Inattentive Type	24.20 (.36)	27.07 (3.06)	-1.80*	.150
SNAP				
Hyperactive Type	.778 (1.129)	.489 (.103)	1.037	.290
Inattentive Type	.583 (1.048)	.200 (.077)	.813	.220

*p< .05, **p< .01.

Income structure. Finally, using one-tailed t-tests, the effect of income structure on the appearance of ADHD symptoms was tested (See Table 4). Participants selected only two of the possible three responses: single income earner and two-income earners. Using the SNAP to measure Inattentive type, there was no significant difference of income structure on the appearance of symptoms t(7)=1.04, one-tail p=0.17. In addition, there was no significant difference of income structure on hyperactive symptoms t(7)=1.63, one-tail p=0.07. One-tailed t-tests were also run using the Vanderbilt to measure ADHD symptoms. In terms of ADHD Inattentive symptoms, there was no significant difference of income structure t(7)= 0.20, one-tail p= 0.41. The same was true for ADHD Hyperactive symptoms t-(7)= 1.63, one-tail p= 0.07.

Table 4

Individual t-tests comparing scores on the Vanderbilt and SNAP by Family Income Structure

Variable Measures	Both (*n* = 4) Mean (SD)	Single (*n* = 5) Mean (SD)	*t*-score	*P value*
Vanderbilt				
Hyperactive Type	3.25 (15.584)	2.8 (8.700)	0.197	.410
Inattentive Type	3.5 (15.000)	2.2 (5.200)	.632	.070
SNAP				
Hyperactive Type	.889 (1.048)	.400 (.078)	1.037	.170
Inattentive Type	.750 (.899)	.066 (.011)	1.631	.070

*p< .05, **p< .01.

CHAPTER 5

DISCUSSION

The present study compared a South Florida School District (SFSD) two-way immersion program's 4th grade students with national averages in terms of executive dysfunctions, seen as ADHD symptoms. It was expected that students in the two-way immersion program would have a lower frequency rate of ADHD symptoms than that of the current national school age average, 7% (DSM-IV-TR, 2000, p. 90). This study was a small comparative analysis involving nine students enrolled in the two-way immersion bilingual program. The study concluded with one out of nine participants meeting diagnostic criteria for ADHD. This outcome is consistent with the previously reported national average, despite access to bilingual education.

Previous research involving bilingual immersion curriculum has had similar results. In a 2008 published study researching immersion curriculum and executive function, Carlson and Meltzoff found that native bilinguals outperformed both their monolingual peers, and those participating in a two-way immersion program at their public kindergarten (ps < .01 and .05 respectively). In this study immersion and monolingual controls were nearly equal on every study. Their study involved 50 kindergarten students with an average age of 6 years. In their study, 12 participants were native Spanish/English bilinguals, 17 were English monolinguals, and 21 had been exposed to either Spanish or Japanese as a second language for six months. Carlson and Meltzoff's immersion students and control groups reported having English as a first language. Their bilingual participants had at least one parent who spoke Spanish as a first language.

Carlson and Meltzoff's study used active observation through the use of multiple measures to determine executive function of each participant. As mentioned earlier, inhibition is a problematic characteristic among children with ADHD-Hyperactive/Impulsive type. Specific to language, individuals with Hyperactive/Impulsive type often exhibit problematic inhibitory behaviors involving: conversational turn taking, interrupting others, blurting out answers and talking in excess. In terms of diagnostic standards questions 11-19 of the SNAP and 10-18 of the Vanderbilt measure inhibitory behaviors. A common measure that Carlson and Meltzoff chose to employ to measure inhibitory behaviors in their participants was the Dimensional Change Card Sort. This measure studies inhibition by asking participants to sort cards based on a series of conflicting rules. Their study concluded with a significant effect of language history on inhibition control with bilinguals outperforming the other two groups ($p < .05$) (Carlson & Meltzoff, 2008, p. 292).

Inattention is the primary characteristic of ADHD-Inattentive type. Individuals with this type of ADHD appear forgetful, easily distracted, and have difficulty giving and maintaining attention on a particular subject. In terms of diagnostic standards questions 1-9 on both the SNAP and the Vanderbilt address attention behaviors. The Attention Network Task (ANT) was used to measure the executive function of attention in Carlson & Meltzoff's study. This computerized game measures attention by creating distractors and measuring the length of time needed to respond as well as if the response was correct. Additionally two tests involving delayed gratification were used to measure

impulse control. In Carlson & Meltzoff's study bilinguals did not appear to hold any significant advantages in these tests.

The results from the current study seem to agree with those of Carlson & Meltzoff in terms of inattention. The single individual to score high enough for an ADHD diagnosis was in fact a native bilingual participant. However, the results for inhibition are conflicting given the bilingual participants hyperactive scores were equally as high as her inattention scores.

The present study used parental reported observation measures to determine the presence of executive dysfunction rather than measure observable levels of executive function and resulted in no significant differences between groups based on length of bilingual exposure. On the other hand, the present group, of participants, was significantly older. Immersion participants, who were not considered native bilinguals, had been exposed to a second language for a minimum of three academic years. It is possible the lack of statistical difference has more to do with the longer length of exposure to a second language.

In Carlson and Meltzoff's study, language history effect was greatest in native bilinguals. This suggests that the act of learning a second language may not be enough; usage and fluency may also be involved. Their immersion participants had only received second language exposure for six months. It is possible their results would have been similar to the present study if older, or more second language proficient students had been studied. Due to the length of exposure to a second language that the immersion participants in the present study experienced, perhaps their cortical stimulation was altered in terms of inhibition control.

The research conducted by Perani et al (1998) examines that possibility. Participants of two groups, bilingual before age 10 and bilingual after age 10, were considered highly proficient in both languages. PET scans identified nearly equal left hemisphere cortical activity for both groups. These results were compared with PET scan images of participants with low proficiency of the second language. This second set of images indicated different regions of the brain were used to process the second language (Perani et al., 1998). This may indicate a relationship between proficiency and cortical development. Age of acquisition and proficiency appear related, but not the same.

Limitations:

While the present study's results did not agree with the initial hypothesis, it is important to note that there may have been a number of outside influences that impacted the present study's results. As this was a small sample, it may not reflect actual frequency rates in the target population.

Demographics: The present sample was less than 2% of the target population, and did not adequately reflect the overall student population. In addition, the target population varied greatly with those collected for the present study.

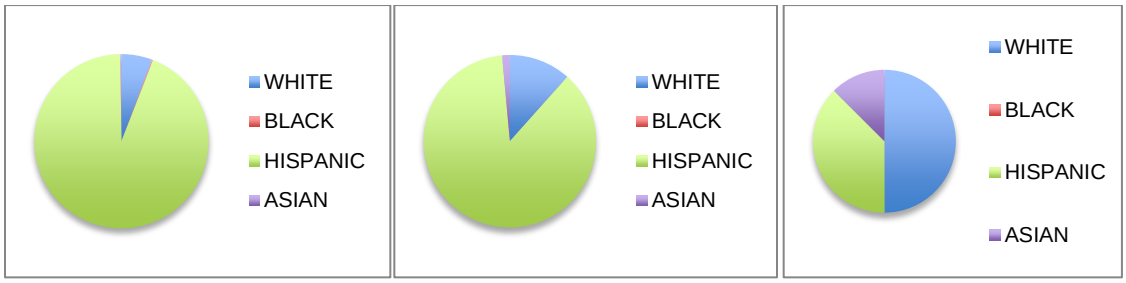

Figure 1 Pie Charts illustrating Ethnic percentages for the School District, Target Classroom, and Study Sample

The target population's ration was 1 white student to 15 Hispanic students, yet the study population's ratio was 4:3. Based on national averages, an estimated 34 students would have a clinical diagnosis of ADHD given the target population's size. Yet CDC reports indicate a lower frequency of clinical ADHD in Hispanic populations. As such, the frequency rate of ADHD in the target population should be smaller, yet the sample's results were consistent with national averages.

Language Barriers: Additionally, a language barrier could have presented an issue, and contributed to the small size of the study. All but one of the participants reported having a first language other than English. It is possible that the participating parents had a limited understanding of the questions contained in the research instruments and therefore failed to respond correctly to the questions being asked. Future studies, where all research materials are offered in a variety of languages, may result in a larger sample size; and more statistically significant results.

Implications on Future Studies:

The present study focused on the presence of executive dysfunctions instead of positive executive function skills. Executive dysfunctions were measured by examining the absence or presence of ADHD symptoms using common diagnostic tools. The diagnostic tools of this study were based on the standards reported in the DSM-IV-TR, published in 2000. Yet as recently as May of 2013 (as data collection was ending), the APA published newer diagnostic standards in the DSM-5. These new standards change the age of onset from 7 to 12, representing a five-year age gap during which new patients may exhibit an onset of symptoms. The average age of the study's participants was 9.8. With this change in diagnostic standards, it is possible the

participants of this study may still experience an onset of symptoms in the next two years.

Considering these new standards, future Studies involving ADHD symptoms in school aged participants may yield different results than those of years past. The later onset of symptoms may provide for a greater frequency of ADHD diagnosis in pediatric patients. This study also made use of diminished diagnostic criteria, accepting any positive response on the Vanderbilt as a sign of executive dysfunction. Future studies using similar criteria may illustrate a presence of symptomatic behavior before it becomes a large enough problem to warrant diagnosis. Monitoring individual progress of students that score high in these diminished criteria cases may be a good way to identify ADHD before it becomes problematic.

Additionally, the literature involving executive functions in bilingual and multilingual children and adolescence is expansive, but the literature involving ADHD in bilingual and multilingual children is minimal at best. This discrepancy itself paves the way for further research involving immersive bilingual curriculum and ADHD in public schools.

Conclusion

Despite the limitations of the present study, there is reasonable evidence that bilingualism has a positive effect on executive function behaviors and is indicative of further research. It is important to consider that enhancement of executive function may also reduce symptoms and therefore facilitate positive learning environments for all. Additionally further research may assist in enhanced diagnosis methods and provide a

clearer profile of the ADHD learner. Finally research that leads to a reduction of symptoms may improve quality of life for those at greatest risk of ADHD.

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VITA

Graduate School
Southern Illinois University

Carina A Beck

Carinabck@gmail.com

Southern Illinois University Carbondale
Bachelor of Arts, University Studies, August 2010

Thesis Title:
BILINGUALISIM, EXECUTIVE FUNCTION, and Attention Deficit/Hyperactivity Disorder
Major Professor: Dr. Stacy D Thompson