The Effects Of Bilingualism On Auditory Selective Attention In Normal-Hearing Adults

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THE EFFECTS OF BILINGUALISM ON AUDITORY SELECTIVE ATTENTION IN NORMAL-HEARING ADULTS

FRANCISCO FERNANDEZ
Master’s Program in Speech-Language Pathology

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Dedication

To my loving family who supported me through it all by never stopping to pray and by keeping my midnight candle lit. I thank God every day that you guys are in my life.
THE EFFECTS OF BILINGUALISM ON AUDITORY SELECTIVE ATTENTION IN NORMAL HEARING ADULTS

by

FRANCISCO FERNANDEZ, BA

THESIS

Presented to the Faculty of the Graduate School of
The University of Texas at El Paso
in Partial Fulfillment
of the Requirements
for the Degree of

MASTER OF SCIENCE

Master’s Program in Speech-Language Pathology
THE UNIVERSITY OF TEXAS AT EL PASO
May 2016
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This thesis is the result of the support of many different individuals and I would like to personally thank each and every one for their help.

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I would like to extend my thanks to all the faculty and staff at the University of Texas at El Paso who provided me with experiences and tools that will prove invaluable in my future practice. To my peers and colleagues who encouraged me through this paper, and provided constructive feedback in its construction.

I am indebted to my family for their support during this time in my life and the completion of this paper. I will never be able to pay back the nights you spent praying with me and for me, making sure I could always reach for the stars. To my Mother whose unending prayers have protected me and lead me through many the struggles in my life. To my Father, who has always provided for me (I pray to be half the man you are), and to my Little brother who knows the songs in my heart and always sings loud enough so I don’t forget the words.

And Mostly to my Lord and Savior. Let everything I do, let it be for the glory and honor of your name. For it is You who has provided me with the knowledge. My eternal gratitude is to You.
Abstract

**Background:** Bilingual speakers have been shown to be more adept than monolingual speakers at actively blocking useless information in the visual modalities. This advantage should be observed in both the visual and the auditory modalities using tasks of inhibitory control. However, very little is known regarding how bilingualism influences inhibitory control in the perception of auditory information. By using an auditory test of inhibition, such as the utilization of a Dichotic Listening task, bilinguals are expected to display an increased measure of cognitive ability.

**Purpose:** The purpose of this study is to examine the effect of bilingualism on auditory selective attention.

**Methods:** 20 English monolinguals, 18-31 years of age, and 19 Spanish-English bilinguals, 18-30 years of age, were recruited from the El Paso area. All participants had hearing thresholds < 25 dBHL from 250 Hz to 8000 Hz, bilaterally (ANSI, 2003), and were right-handed according to the Handedness Questionnaire (Coren, 1992). A language profile for each bilingual participant was obtained using The Language Experience and Proficiency Questionnaire (LEAP-Q; Blumenfeld & Kaushanskaya, 2007). All bilingual speakers in this study were early simultaneous bilinguals. Selective auditory attention was measured using The Dichotic Consonant Vowel (D-CV) Test (Auditec, St. Louis, MO). Participants were required to modulate their attention either to the right or the left ear in three attention conditions. In addition, each participant was administered The Simon task, a non-verbal, visual cognitive test of inhibition.

**Results:** Both groups demonstrated a significant right ear advantage on the auditory selective attention Dichotic Listening task. There were no significant differences between the participant groups across the three test conditions. On the visual Simon Task of selective attention, both groups performed better on the congruent trial than the incongruent trial. Both groups also performed significantly faster on the congruent trial than on the incongruent trial. However, there
were no significant differences in performance scores between monolinguals and bilinguals for any of the test conditions within The Simon Task.

**Conclusions:** No significant differences was found in performance scores between monolinguals and bilinguals on the auditory or visual tasks of selective attention. These findings suggest that bilinguals may not have a cognitive advantage over monolingual speakers.

**Keywords:** Bilingualism, Cognition, Dichotic-Listening, Speech Perception
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CHAPTERS

Chapter 1: Literature Review

1.1 Introduction

Current research has found that the continued use and modulation between two languages can: increase the density found in the inferior parietal cortex in both the gray and the white matter of the brain, protect against cognitive declines by providing advantages in executive control, and guard against dementia (Mechelli et al, 2004; Bialystok, Craik & Luk 2008; Bialystok, 2009). This is relevant because as of the year 2010, 20% of the population in the United States is bilingual and it is projected that this number will increase to 62% in 2020 (Shin & Ortman, 2011). According to the United States Census, it is estimated that by the year 2043, current minority groups will compromise the majority of the population (Yen, 2013). It is vital that we understand the effects of bilingualism in our current, diverse population.

Bilinguals use two language systems simultaneously, with similar ability and performance. Monolinguals on the other hand, only use one language system (Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Craik, & Freedman, 2007; Pelham & Abrams, 2014; Tremblay & Sabourin, 2012). An individual’s bilingualism can be classified based on the age when they acquired the second language, and their proficiency in using their second language. Specifically, early bilingualism is defined as when an individual learns two language systems in early childhood, usually before the age of six. Conversely, late bilingualism is defined as when an individual learns a second language system after the age of six. Balanced bilingualism refers to individuals who have equal proficiency in two language systems; and, un-balanced bilingualism refers to those individuals who are more proficient in one language system than another (Pelham & Abrams, 2014). Interestingly, the more proficient language in unbalanced bilinguals is independent of their first acquired language system (Pelham & Abrams, 2014).

Using self-report questionnaires, bilingual and monolingual speakers are commonly identified and characterized by age of acquisition and proficiency of languages (Cenoz &
Jessner, 2001). One of the most commonly used assessments is the Language Experience and Proficiency Questionnaire (LEAP-Q; Marin, Blumenfield, & Kaushanskaya, 2007). The LEAP-Q consists of 23 questions across three different categories including: general demographic information, self-identified first language proficiency, and self-identified second language proficiency. The Leap-Q has been shown to provide valid and reliable language profiles of bilingual speakers in multiple languages. Speaking proficiency, reading proficiency, and comprehension proficiency ratings of the Leap-Q have been found to best surmise second language competency (Marin, Blumenfield, & Kaushanskaya, 2007). The Leap-Q rating questions for second language acquisition were used in this study to help identify the bilingual participants.

1.2 **Bilingualism and Cognition**

Bilingualism has been associated with many different cognitive benefits such as having enhanced problem solving skills in comparison to monolinguals. For example, balanced bilingual students were shown to have performed better with problem solving skills in both verbal and nonverbal tests (Christoffels et al, 2015; Peal & Lambert, 1962). In addition, bilinguals outperformed their monolingual peers on conflict tasks which contained different visual stimuli that were incompatible with one another, requiring the selection of a specific visual stimuli (Hilchey & Klien, 2011). Moreover, monolinguals did not perform as well as bilinguals in episodic memory recall and letter fluency tasks (Ljunberg et al, 2013). Furthermore, bilingual speakers were shown to perform better on metalinguistic tasks, which include language knowledge tasks, specifically in the area of phonological awareness (Lauchlan, 2014).

It has also been suggested that bilingualism may enhance executive functions, such as the inhibition of irrelevant information- which is the focus of the present study (Bialystok, Craik, & Freedman, 2007; Soveri, Laine, Hamalainen & Hugdahl, 2010; Bialystok & Martin 2004; Bialystok, 2009; Bialystok, Craik & Luk, 2008). Executive function is typically defined as the cognitive process which requires the operation of mental behaviors to attain a select target goal (Kalia, Wilbourn, Ghio, 2014). Executive functioning encompasses three main components:
working memory, cognitive flexibility, and inhibitory control (Jalali-Moghadam and Kormi-Nouri, 2015).

Different cognitive tasks of executive functioning are exercised to target these three behaviors. The first established exercise is an updating task, which requires a participant to monitor incoming information. The second, a shifting task, requires a participant to shift attention back-and-forth between multiple sets of information presented; and, an inhibition task, which requires the suppression of irrelevant information (Anderson, 2002). Specific inhibitory control tasks include: The Stroop test, card sorting tasks, and The Simon task (which is used in this study). Research has found that tasks used to target executive functioning, such as inhibitory control, can be measured in different modalities (including using the visual and auditory modalities). Knowing that executive functioning can be measured in different modalities is relevant to the assessment of the target population of bilinguals in this study because executive functioning has largely only been assessed in this population in the visual modalities (Kalia, Wilborn, Ghio, 2014; Jacques & Zelasco, 2001).

Bilinguals manage two language information systems, simultaneously. In the present study, we will be focusing on individuals who are Spanish-English Bilingual. We must understand how Spanish-English bilinguals access both language systems at the same time, including all lexical representations of concepts and words. For example, during spontaneous conversation between a Spanish-English bilingual and a communication partner, the label for concept of the color “red” would activate the words “red” and “rojo” simultaneously for the bilingual in someone who is Spanish-English bilingual. Depending on the language used by the communication partner, the bilingual speaker would then select the appropriate label for the color red in order to respond. The bilingual speaker constantly modulates from one lexical system to the other in real-time, depending on the communication environment and
communication partner (Costa, Carmazza, & Sebastian-Galles, 2000). This consistent shifting between the two lexicons provides anecdotal evidence of enhanced cognitive processing and lexical access, because bilingual speakers are constantly manipulating one system and ignoring the other in real time more often than their monolingual peers. This constant practice and manipulation of the systems is thought to afford them more practice, and thus allow them to be better than, then their monolingual peers in executive processing.

In addition to the aforementioned processes; cognitive processing and lexical access in early and later bilinguals has also been examined in research to support the claims of strengthened connections in executive functions against that of monolinguals. Thirty monolinguals and 60 Spanish-English bilinguals (30 early bilinguals and 30 late bilinguals) were asked to name stimuli in a series of pictures (n= 90). In that study, bilinguals showed increased lexical access by identifying more stimuli then their monolingual peers. Also, a visual attention task was administered to these individuals, requiring them to press a predetermined button dependent on the color of a visual stimuli that was presented on a computer monitor. These visual stimuli were presented on either the left side or the right side of a computer monitor. As part of this study, these groups were occasionally also presented with some stimuli that were randomly displayed on the opposite of the screen to the button press assigned for the stimuli, hereby increasing the cognitive load of the task. Results showed that both earlier and later bilinguals had a benefit in executive control in ignoring irrelevant in the task, evidenced by higher accuracy scores on the button pressing activity.

Additionally, bilinguals did not display cognitive advantages in all areas of this study. Some lexical access deficits were noted in bilinguals, compared to monolinguals, in the form of slower response times and less words named overall. This led to the conclusion that bilinguals
had a cognitive advantage in the visual attention task due to the habitual use of two different language systems (Pelham & Abrams 2014). The authors note that the longer response times show that the bilingual is utilizing more cognitive resources to respond. This mental manipulation also strengthens cognitive connections by providing additional practice in inhibition which is unavailable in their monolingual speaking peers (Bialystok, Craik, Klein, & Viswanathan, 2004).

Acquisition of two or more languages may provide a greater linguistic cognitive load than the use of only one language system because the management of the two systems is active and interact with each other constantly (Bialystok, Craik & Luk 2008). There is some debate on how these systems interact with each other. While some researchers argue that individual’s acquired languages act in mutually exclusive ways (Costa Caramazza, & Sebastian-Galles, 2000), Bialystok et al. (2008) posit that within all connectionist theories of activation, all languages are active and all languages interact within the individual whenever they are communicating (Costa, Roelstrate, & Hartsuiker, 2006; Gollan et al, 2002; Bialystok et al 2008). Having these different systems active drives the bilingual speaker to select one language and reject another in real time (i.e. inhibition of irrelevant information or selective attention).

1.3 Inhibition

The action of being presented with different stimuli and choosing one over the other by blocking, or ignoring the irrelevant information is defined as inhibition (Soveri, Laine, Hamalainen, & Hugdahl, 2011). Inhibition as a measure of executive control has been studied in bilingual speakers. Bilinguals were found to exhibit increased executive control using visual tasks of inhibition (Bialystock, 2009; Pelham & Abrams, 2014).
Bialystok et al (2008) examined the performance of monolingual and bilingual speakers on several executive control tasks of inhibition (i.e. Simon Arrows Task, Stroop color-naming, and a Sustained attention to response), lexical access (i.e. PPVT, Boston Naming Task, and a Category and Letter fluency) and working memory (i.e. Corsi Blocks and self-ordered pointing). Four groups of participants were included in this study: 24 young monolinguals, 24 young bilinguals, 24 older bilinguals, and 24 older monolinguals. The second language of bilingual speakers varied among participants. Results showed that both bilinguals and monolinguals had similar results on the working memory tasks. Even though monolinguals performed better on lexical access tasks compared to the bilinguals, interesting to this study, bilinguals performed better on executive control tasks. Bialystok et al. concluded that their results support the theory that bilinguals exhibit greater executive control. Also, this increase in executive control in inhibitory processing may come at a cost in the form of a detrimental effect on the lexical access abilities of bilinguals, giving monolinguals an advantage in lexical access tasks (Bialystok, Craik, & Luk, 2008).

Through additional research, Bialystok et al (2004) sought to determine if the cognitive advantage in inhibition in bilinguals persisted into adulthood, and if it diminished the effect of aging on cognition. In the study, using three different variations of the Simon task, 40 participants were divided into younger (mean age of = 43.0 years) and older (Mean age = 71.9) groups that were either monolingual or Tamil-English bilingual. Participants were administered a computerized Simon Task. Results showed that in general, younger participants performed better than older participants; and, the bilingual participants performed better than their monolingual counterparts. They concluded that maintaining two languages strengthens an individual’s ability to inhibit irrelevant information into adulthood.
In a similar study, Bialystok et al (2004) examined executive processing in inhibition in groups of age-matched younger (Mean age = 42.6) and older (70.3) bilingual and monolingual adults. The participants were administered: an Alpha Span Task, which measured working memory; a sequencing working memory task; and the Simon task of inhibition. The younger participants displayed higher accuracy than older participants across tasks; and, bilinguals performed better than the monolinguals. Thus, younger bilinguals performed best on tasks of inhibition. Bilinguals also showed the least amount of working memory strains. Their conclusion was that inhibition was more cognitively strenuous to monolinguals than to bilinguals who are more practiced in inhibition control.

It was not outlined in the methodologies of this study if the speakers identified as either proficient in one language or the other. Further, it is not specified if the bilinguals used both languages consistently, or if their language environment consisted primarily of the use of only one the two languages. There is disagreement in the literature on bilingualism’s effect on inhibition control which is relevant to the findings of this paper (Hilchey & Klein 2011).

In a meta-analysis, which examined the effects of bilingualism on executive control, Hilchey and Klein (2011) found that 31 studies were difficult to replicate because of their complex and vague methodologies. In addition, the language profiles included in these studies were unclear in describing the speaker’s language dominance and in establishing well-defined bilingual participants. They argued that this meta-analysis showed evidence that there was no increase in executive control in either children or young bilingual adults. Additionally, they contended that bilingualism did not have a positive effect on inhibitory control processes, which are associated with executive control benefits. The authors found it was a, “leap to conclude that a lifetime in managing a different language system,” explains why enhanced inhibitory controls
result from the habitual use and modulation of two language systems. Further, they argued that these effects only last for a short amount of time in younger populations, then dissipate as the bilingual ages. This argument is based on the scarcity of research that has focused on the effects of bilingualism in older bilingual speakers.

A large-scale study conducted by Dunabeitia et al. (2014) looked at selective attention using the Simon task and the Stroop task. Basque-Spanish (n=252) and monolingual Spanish speakers (n=252), under the age of 16, were examined across 6 different elementary levels of education for cognitive advantages. The results showed that bilinguals and their monolingual counterparts performed similarly across all 6 grade levels (Dunabeitia et al 2014). The results showed that even with large-scale studies which include a substantial sample size to reduce the risk of type one errors, the bilingual advantage in selective attention is unclear because it was not evident in younger school-aged bilingual children.

The claim that bilingualism provides a cognitive benefit in executive control, and a “guard against dementia” in older bilingual adults has also been contested in current research (Bialystok et al, 2011; Ansaldo, Ghazi-Saidi, Adrover-Roig 2014). In one such study, Bialystok et al. (2011) attributes better education with the similar performance scores of older bilinguals and monolinguals on a visual Simon task rather than the speaker either being monolingual or bilingual. This researcher group argues that it was the aforementioned factors that guarded against early onset of dementia. In fact, the researchers note that bilingualism is much too multifaceted to find causality that it alone protects individuals from dementia. They concluded that other information, such as socio-economic status, needs to be obtained in conjunction with a language profile to show how bilinguals tap into executive control. In addition to these external
factors Ansaldo, Ghazi-Saidi, & Adrover-Roig researched internal factors by looking at brain’s neural pathways (2014).

Using a Functional Magnetic Resonance Imaging (or fMRI), Ansaldo, Ghazi-Saidi & Adrover-Roig found that bilingual speakers more frequently used a different neural pathway, in activating visuospatial information. This pathway is less prone to aging compared to the pathways utilized by their monolingual peers. They concluded that this use of a different neural pathway explained why a cognitive advantage was probably seen in older bilinguals and not younger bilinguals. The literature argues that it is the use of the different neural pathways that is providing the cognitive advantage and not being either monolingual or bilingual (Ansaldo, Ghazi-Saidi, & Adrover-Roig, 2014). Thus, it remains unclear if a bilingual advantage is present on tasks of visual inhibition.

1.4 Measuring Inhibition in Visual and Auditory Modalities

It has been suggested that if bilinguals do have an advantage in the inhibition of irrelevant information in the visual modality, then this advantage should generalize across modalities (e.g. auditory modality) (Soveri et al., 2014). In order to investigate this hypothesis, inhibition in the auditory and visual modalities must be measured and analyzed for generalizability.

Inhibition has been largely measured by the current research using a variety of established visual tasks such as the Stroop task (Milham et al. 2002) which requires the suppression of useless color information and the Simon test (Martin-Rhee & Bialystok 2008). Specifically, The Simon task was created by Simon & Rudell (1967) and is used in studies to measure an individual’s ability to inhibit and/or suppress irrelevant information. The Simon task taps processes of “selective attention” which is thought to play a large role in suppressing irrelevant information without the use of language (Hommel, 1993). Specifically, the Simon task requires a participant to observe a blue or red square on the left or the right side of a
computerized display. The participant is asked to associate either the left or right shift key on a keyboard with either red or blue squared stimuli. The stimulus will appear on the side of the display that is associated with the matching key on the keyboard during a consistent trial, or it can appear on the opposite side of the matching key during an inconsistent trial (Simon, 1969).

Inhibition of irrelevant information can also be measured in the auditory modality using an established dichotic listening task. In a dichotic listening task, two different auditory stimuli are presented simultaneously to each ear. The participant is asked to actively select one stimulus and inhibit the other in real-time. The participant must identify the stimulus that is being presented in the right or left ear. The task can be adjusted so that the participant must listen to either: the right ear (called forced-right condition), the left ear (called the forced-left condition), or to repeat the speech sound they heard most clearly (called the non-forced condition). The task can be administered at either the phonological level (with speech sounds), the word level, or the phrase level (Cherry, 1953; Millisecond, 2012).

1.5 Right Ear Advantage

Souveri, Laine, Hamalainen, and Hugdahl (2011) examined the bilingual advantage using an auditory dichotic listening task that utilized the forced attention paradigm to measure executive control. They hypothesized that bilingual speakers should have had an advantage when being asked to suppress irrelevant information from the opposite ear. This finding is based on the current research that has found similar advantages using the visual modality (Bialystok, 2004; Bialystok, 2009; Bialystok, Craik & Luk, 2008).

It was first posited by Paul Broca (1865) that people that were right handed had left-hemisphere dominance. Wada (1960) was the first to prove this using Sodium Amaytal tests that looked at handedness as a general marker for brain lateralization. It is now, then, generally accepted that language is processed in the left hemisphere for most right-handed individuals and spatial concepts are often processed in the right hemisphere. Dichotic listening tasks can be used to show lateralization of language in the brain and the hemispheric dominance of language in an
individual (Techentin and Voyer, 2007; Bryden & MacRae, 1989; Leshem, 2013). A structural model discussed by Hugdahl (2000) states that because of the contralateral wiring of the brain and the ears, we can see a right ear advantage (REA) for sound stimuli that are related to: speech, verbal, and linguistic material; and, a left ear advantage (LEA) for sound stimuli that are not related to speech sounds. A dichotic listening task shows that when a speech sound is presented to both ears simultaneously, the brain will process the stimuli presented in the right ear more efficiently than stimuli presented in the left ear (Leshem, 2013).

Sixty-five Finnish monolingual and Finnish-Swedish bilingual participants were put into two age groups: 30-50 years of age and 60-74 years of age. The participants were given a background questionnaire that asked general questions about their medical background and a Wechsler Adult Intelligence Scale- Third Edition (WAIS-4, 2008). The participants were then administered a dichotic consonant-vowel listening task with three manipulation conditions: forced-right, forced-left, and non-forced.

Results showed that there was a right ear advantage in the non-forced conditions for all participants, which is consistent with prior research that shows that right-handed speakers typically have a language dominant left hemisphere (Hugdahl et al, 2009). In both the Forced-Right ear and the Forced-Left ear conditions, bilinguals performed better in inhibiting conflicting stimuli than their age-matched monolingual peers. This suggests that bilinguals have an executive advantage over their monolingual peers. Soveri et al. (2011) concluded that being bilingual, and constantly switching between the two language systems provides a benefit in inhibition of irrelevant information.

In the present research by Soveri et al. (2011) it was found that they were unable to see a shift from right ear advantage to left ear advantage in any of the older bilingual speakers. The participant’s inability to modulate their performance between the two ear conditions was one of the unexpected outcomes of their study. They argued that the results do not clearly show if bilinguals were exhibiting complete inhibitory control or not. One such explanation that was given for not seeing the modulation into a LEA was that the adults in their study had a higher
educational level compared to previous studies. This increased level of education (>14 years) could have skewed the results of the cognitive examinations and limited the ability to see an advantage in the adults. They argued that because the bilingual speaker groups were highly educated, it could have been that the subjects' history of having higher cognitive demands at school and at work that gave them a cognitive advantage, not necessarily being bilingual.

1.6 Purpose of Study

The bilingual advantage in executive function remains unclear (Morton & Harper, 2007; Bialystock et al., 2006); and, most studies have only assessed inhibition of irrelevant information in bilinguals using non-verbal, visual tests (Bialystock, 1999). If the bilingual advantage in visual tasks is a valid finding, it should then generalize to auditory tasks utilizing these functions (Soveri et al., 2014). Thus, bilinguals should show an advantage in forced-attention dichotic listening due to better inhibition skills compared to monolinguals. If the findings on a Dichotic listening task show better inhibitory control in bilinguals, then bilingualism may enhance executive functions (Bialystok, 2009). The focus of this study is to examine the effects of bilingualism on auditory selective attention on inhibition of task irrelevant information and to compare the bilinguals’ performance results to their monolingual peers.

The specific aim of this project was to determine whether performance on a forced attention dichotic listening task differs between monolingual and Spanish-English bilingual adults.

It is hypothesized that bilingual speakers will show an advantage on a forced-attention dichotic listening task and a non-verbal visual inhibition task compared to monolingual speakers.
Chapter 2: Methods and Procedures

2.1 Participants

The University of Texas at El Paso Institutional Review Board for Human Subjects approved this study. Participants were recruited from the El Paso area using poster canvasing, referrals from students, and using social media to establish a sample of convenience. Participants were offered $20 monetary compensation for completing the study. The funding for the incentive was donated from Dr. Jamie L. Desjardin’s UTEP Audiology Lab start-up fund. Each participant gave a written informed consent prior to participation in the study. Twenty English monolinguals aged 18-31 (SD= 3.84) years of age and twenty Spanish-English bilinguals aged 18-31 (SD= 5.94) years of age participated and were included in the present study. (See Table 1 for participant characteristics).

Table 2.1: Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Monolinguals (English)</th>
<th>Bilinguals (Spanish-English)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>23.75 (SD = 3.84, range = 18 to 31)</td>
<td>22.12 (SD = 5.94, range =18 to 30)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (%)</td>
<td>3 (15%)</td>
<td>10 (53%)</td>
</tr>
<tr>
<td>Female (%)</td>
<td>17 (85%)</td>
<td>9 (47%)</td>
</tr>
<tr>
<td>Digit Span (number correct)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forward</td>
<td>7.2 (SD = .77)</td>
<td>7.05 (SD = .78)</td>
</tr>
<tr>
<td>Backwards</td>
<td>7.05 (SD = .83)</td>
<td>7.11 (SD = .94)</td>
</tr>
<tr>
<td>Combined</td>
<td>14.25 (SD = 1.45)</td>
<td>14.16 (SD = 1.54)</td>
</tr>
<tr>
<td>PTA Average</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Ear</td>
<td>-4.4375</td>
<td>.13</td>
</tr>
<tr>
<td>Left Ear</td>
<td>-3.875</td>
<td>1.38</td>
</tr>
<tr>
<td>Handedness Questionnaire</td>
<td>34.9 (SD = 1.48 “Strongly Right Handed”)</td>
<td>34.84 (SD = 1.33 “Strongly Right Handed”)</td>
</tr>
</tbody>
</table>
All participants had hearing thresholds < 25 dBHL from 250 Hz to 8000 Hz, bilaterally (ANSI, 2003), and were right handed according to the Handedness Questionnaire (Coren, 1992). (See Figure 2.3 for participant hearing thresholds).

Table 2.2: Participant Hearing Thresholds

<table>
<thead>
<tr>
<th></th>
<th>250 Hz</th>
<th>500 Hz</th>
<th>1000 Hz</th>
<th>2000 Hz</th>
<th>4000 Hz</th>
<th>8000 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>M01</td>
<td>R 10/L 0</td>
<td>R 0/L 0</td>
<td>R -5/L 0</td>
<td>R 5/L -10</td>
<td>R 0/L 5</td>
<td>R 10/L 15</td>
</tr>
<tr>
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</table>

A language profile for each bilingual participant was obtained using The Language Experience and Proficiency Questionnaire (LEAP-Q; Blumenfeld & Kaushanskaya, 2007). Bilingual participants reported to be at least “8=Very Good” in speaking skills of their second language and at least “8= Very Good” in reading and comprehension skills of their native language. In the present study, participants were named as bilingual speakers and included in the bilingual category if they self-identified as at least “4=Adequate” in their speaking skills of their second language and at least “4=Adequate” in their reading and comprehension skills in their native language. All bilingual and monolingual speaking participants that were tested, were included in the present study. (See Table 2.3 for LEAP-Q Questionnaire results)
Table 2.3: LEAP-Q Questionnaire results. Results based on an 11 point Likert scale. 0 is considered no proficiency and 10 is considered perfect proficiency

<table>
<thead>
<tr>
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<th>First Language</th>
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<tr>
<td>Age Language Acquired (years)</td>
<td>1.22 (SD = 1.31, range = 0 to 5)</td>
<td>4.11 (SD 2.19 , range = 0 to 7)</td>
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<tr>
<td>Speaking proficiency</td>
<td>9 (SD = 1.24, range = 5 to 10)</td>
<td>8.72 (SD = 1.18, range = 7 to 10)</td>
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<tr>
<td>Reading Proficiency</td>
<td>8.72 (SD = 1.27, range = 6 to 10)</td>
<td>8.56 (SD = 1.38, range = 5 to 10)</td>
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<tr>
<td>Comprehension Proficiency</td>
<td>9.16 (SD = 1.04, range = 6 to 10)</td>
<td>9.28 (SD = .75, range = 8 to 10)</td>
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</table>

The Digit Span (Forward and Backward recall conditions) subtest in the *Wechsler Adult Intelligence Scale- Third Edition* (Wechsler, 1997) was used to measure working memory function in the bilingual and monolingual participant groups. (See table 2.1 for Digit span scores)

### 2.2 Test Measures

**Dichotic Consonant Listening task**

An English Version of the Selective Attention Dichotic Listening task (Audiotec, St Louis MO) was administered to all participants. The participants were presented with conflicting speech sounds in the right and left ear simultaneously through a pair of head phones. In order to minimize the effects of language as much as possible, consonant vowel pairs were used in the present study as the conflicting speech stimuli. The task stimuli contained consonants that are present in both Spanish and English. Consonant-vowel (CV) stimuli were presented dichotically in three different attention conditions (i.e. Forced-Right, Forced-left, and Non-Forced). Participants were instructed to either repeat the CV pair heard in the right ear (in the Forced-Right condition), the CV pair heard in the left ear (in the Forced-Left condition), or to repeat the CV pair heard most clearly regardless of ear presentation (in the Non-Forced condition). Six different syllables that consisted of a consonant followed by the /a/ vowel sound (i.e. /b, p, t, d, g, k/) were recited by a male voice with constant intonation and intensity (Audiotec, St Louis MO). Each syllable was presented at a length of 350 ms with an inter-trial interval of 4 seconds. In
each condition, participants were randomly presented 30 CV syllables. The test was scored as the percentage correct syllables repeated for the three test conditions (Non-forced, forced-right, and forced-left) in both ears (right and left).

**Simon Task**

A computerized version of the Simon task was used to assess non-verbal/visual selective attention (Millisecond, 2012). Participants were presented with a series of visual stimuli (circles) on a Dell computer high resolution monitor and were instructed to press the right and left shift keys depending on the color of stimuli presented (red or blue respectively), regardless of location on the computer screen (right or left side). There were two test conditions: 1) congruent-where the stimuli on the screen was presented on the same side of the shift key press (for example the red circle appearing on the right side of the screen, which matches the right sided button press) and 2) non-congruent conditions- where the side the stimuli on the screen was presented and the shift key were on opposite sides of the screen (for example the red circle appearing left side of the screen, which is opposite of the button press). The test was scored as the percentage of correct trials in the congruent and incongruent conditions respectively. In addition, the response latency (in ms) it took for the participants to respond from the time the stimuli was presented was recorded for each test condition.

**2.3 Procedures**

All Testing was performed in one 2-hour test session. Bilingual participants completed the LEAP-Q Questionnaire. Participants then completed a handedness questionnaire (Coren, 1992) which was used to confirm hand dominance. Hearing thresholds were then measured at octave frequencies from 250 Hz to 8000 Hz (ASHA, 2003) in the right and left ears. Following audiometric testing, each participant completed a computerized version of the digit span subtest (Wechsler, 1997).
The dichotic consonant vowel test, as described previously, was administered in the Forced right (FR), Forced left (FL) and Non-forced (NF) conditions in a random order. Prior to experimental testing, the participant was administered a list of 25 CV syllables presented to the right ear, and a second list of 25 CV syllables presented to the left ear. The practice syllables were used to confirm that participants were able to identify all 6 of the CV pairs in their right and left ears. Following the practice items, the participant was presented with the three manipulation conditions in a random order: FR, FL, NF. In the NF condition the participant was asked to listen to the CV that was presented dichotically and then report in the oral and written modality which CV pair they heard most clearly regardless of the ear they heard it in. In the FL and FR condition the participant was asked to listen to the CV that was presented dichotically and then report in the oral and written modality the CV pair that they heard in either the Left or Right ears depending on the condition. The Simon task was administered as described, in the congruent and incongruent conditions in a random order. Presentation of the Simon task and the Dichotic consonant vowel task was computer randomized for each participant.

2.4 Data Analysis

Statistical analysis of the data was performed using the IBM SPSS v22 (SPSS Inc., Chicago Ill.) software. The data (with the exception of the response latency for the Simon task) was transformed using an Arcsine transformation resulting in Rationalized Arcsine Units (RAU) as the unit of measure. The Dichotic consonant vowel listening task was analyzed using a Repeated Measures Analysis of Variance (RMANOVA) across conditions (FR, FL, and NF), group (Monolingual and bilingual) and ear (Right and left). The Simon Task was also analyzed using a RMANOVA across conditions (congruent, incongruent, total) and group (monolingual and bilingual). A 0.05 significance level was used for all analyses in the present study.
Chapter 3: Results

3.1 Dichotic Consonant Vowel Listening Task

Figure 3.1 shows participant performance on the Dichotic Consonant Vowel (D-CV) task for the monolingual and bilingual participants on the Non-forced (NF), Forced-Right (FR), and Forced-Left (FL) conditions for the right and left ears. On the D-CV listening task, the percent of the correct responses for three conditions in both ears for the monolingual group were as follows: 55.67% (SD 14.51) for the RE, 30% (SD 12.33) for the LE in the NF condition, 59.50% (SD 12.15) for the RE, 25.5% (SD 9) for the LE in the FR condition, 28.67% (SD 13.13) for the RE, and 52.67% (SD 17.32) for the LE in the FL condition. On the D-CV listening task, the percent of the correct responses for three conditions in both ears for the bilingual group was as follows: 50.89% (SD 13.69) for the RE in the NF condition, 30.37% (SD 11.59) for the LE in the NF condition, 60.88% (SD 11.7) for the RE in the FR condition, 22.67% (SD 9.04) for the LE in the FR condition, 30.52% (SD 12.49) for the RE in the FL condition, and 46.84% (SD 15.29) for the LE in the FL condition.

To compare participants’ performance within and across the two groups, a Repeated Measures Analysis of Variance (RMANOVA) was performed using the FR, FL, and NF variables. All post hoc multiple comparisons were performed using a Bonferroni adjusted critical alpha level.

A 3x2x2 (condition, ear, group) RMANOVA showed that both groups had a significant main effect of condition \[F(2,74) = 5.41, p=.006, \eta^2_p = .128\]. That is, both groups performed significantly better on the FR condition and the NF conditions, compared to the FL condition.

There was also a significant main effect for ear \[F(1, 37) = 32.394, p<.001, \eta^2_p = .467\]. Both groups demonstrated a RE advantage on the D-CV task where the participants’ performance was better in the RE compared to the LE.

In addition, there was a significant interaction between condition x ear \[F(2, 74) = 56.369, p<.001, \eta^2_p = .616\]. Post hoc testing showed that both participant groups had significantly
(p<.05) better performance scores for the RE on the FR and NF conditions, compared to the left ear performance scores.

There were no other significant main effects or interactions. Thus, there was no significant (p<.05) difference in the performance between the monolingual and bilingual speakers for the three test conditions, indicating that both groups performed similarly on all three test conditions of the D-CV task.
Figure 3.1: RAU scores on the Dichotic Consonant Vowel Results: a) non-forced, b) forced right and the c) forced left conditions.
3.2  Simon Task Total scores

Figure 3.2 shows participant performance on the Simon Task for the Total, Congruent, and Incongruent trials for the monolingual and bilingual participants. On the Simon task of visual attention, the percent correct responses for the three conditions for the monolinguals were as follows: 93.24% (SD 4.77) for the Total trial, 96.07% (SD 5.9) for the Congruent trial, and 90.33% (SD 8.44) for the Incongruent trial. On the Simon task of visual attention, the percent correct responses for the three conditions for the bilinguals were as follows: 93.11% (SD 5.2) for the Total trial, 94.74% (SD 5.76) for the Congruent trial, and 91.34% (SD 8.10) for the Incongruent trial.

To compare participant’s performance within and across the two groups, we performed a RMANOVA. All Post hoc multiple comparisons were performed using a Bonferroni adjusted critical alpha level.

A 3x2 (condition, group) RMANOVA showed that both groups had a significant main effect of condition \( [F (2, 74) = 7.76, p=.001, \eta^2_p = .173] \). Both groups performed significantly better on the congruent conditions, compared to the incongruent condition.

There was no other significant main effects or interactions. Thus, there was no significant (p<.05) difference between the monolingual and bilingual speakers for the three test conditions, indicating that both groups performed similarly on all three test conditions of the Simon task.
Figure 3.2: RAU scores on the Simon Task for Total, Congruent, and Incongruent trial conditions.

3.3 Simon Task Latency Response times

Figure 3.3 shows participant response latency (in ms) on the Simon Task for the Total, Congruent, and Incongruent trials for the monolingual and bilingual participants. On the Simon task of visual attention, the response latency for the three conditions for the monolinguals were as follows: 372.63 ms (SD 12.46) for the total condition, 368.6 ms (SD 13.48) for the congruent condition, and 379.73 ms (SD 12.79) for the incongruent condition. On the Simon task of visual attention, the response latency for the three conditions for the bilinguals were as follows: 381.21 ms (SD 13.483) for the total condition, 357.97 ms (SD 13.83) for the congruent condition, and 399.47 ms (SD 13.13) for the incongruent trial.
To compare participant’s response latencies within and across the two groups, we performed a RMANOVA. All Post hoc multiple comparisons were performed using a Bonferroni adjusted critical alpha level.

A 3x2 (condition, group) RMANOVA showed that there was a significant main effect of condition [$F (2,74) = 13.965, p< .005, \eta^2_p = .274$]. This indicates that the response times were significantly faster on the congruent condition compared to the incongruent condition.

There was no other significant main effects or interactions. Thus, there was no significant (p<.05) difference between the response times in monolingual and bilingual speakers for the three test conditions, indicating that both groups response times were similar on all three test conditions of the Simon task.

Figure 3.3: Response times in ms for the Simon task for the Total, Congruent, and Incongruent trials.
Chapter 4: Discussion

The aim of the present study was to investigate the effect of bilingualism on the inhibition of task irrelevant information in the auditory and visual modalities. Specifically, in the present study we examined auditory selective attention using a dichotic consonant vowel listening task that required forced attention to three different test conditions in both ears, as well as a visual test of selective attention known as the Simon task in monolingual and bilingual individuals.

Performance on the dichotic listening task in the right ear was significantly better (p < 0.001) than the left ear performance across the three test conditions for both monolingual and bilingual listeners. As has been stated, it is generally accepted that the processing of language and speech is dominant in the left hemisphere in right handed individuals (Hugdahl, 2000), thus this finding was not surprising. It is thought that the right ear is significantly better in the interpreting and processing of speech sounds and language because the the speech signals enter the left auditory cortex directly through the right ear due to contralateral wiring of the brain (Bryden, 1988). Consistent with this result, Soveri et al. (2014), found that both monolingual Finnish and bilingual Finnish-Swedish Adults had a right ear advantage in the processing of simple speech sounds in a dichotic listening task. Though not everyone has found this right ear advantage, some researches argue that it is not uncommon to see no ear advantage or even a left ear advantage in some speakers (Schmithorst, Farah, and Keith, 2013).

Surprisingly, results from this study showed that bilinguals did not differ significantly (p<.05) in performance on the dichotic listening test from their aged matched monolingual peers in tasks of ignoring task-irrelevant stimuli in the auditory modality. This finding was inconsistent with research that found a difference between the monolingual and bilingual groups in the control of inhibition in the auditory modality (Soveri et al., 2014). The findings by Soveri et al. (2014) demonstrated increased inhibition of task irrelevant information in the auditory modality for bilingual speakers. They attributed this finding to the constant manipulation of the two
language systems in bilinguals. The conclusion by Soveri et al. was not supported by the present study, where an increase in executive control was not evident in bilingual speakers.

On the Simon task, both groups performed significantly (P<.01) better on the congruent trial compared to the incongruent trial. The congruent trial required a button press on the same side the stimulus was presented. The incongruent trial required a button press on the opposite side of the stimulus presentation, making the incongruent condition more cognitively demanding. The better performance scores on the congruent trial is not surprising, because the cognitive load of the congruent trial is less than the incongruent trial which required more processing of the visuospatial information in order to process and inhibit the task irrelevant information.

The reason for decreased performance of the incongruent trial can be attributed to it being more difficult than the congruent trial. This was supported by the latency results in the present study. These results show that the bilinguals and monolinguals both performed significantly faster (p>.05) on the congruent trials and total trials against that of the incongruent trials due to the increased cognitive strain of the incongruent trial compared the congruent trial.

Of note, both groups had worse scores on the incongruent trial than on the congruent trial but neither group performed significantly better on either of the conditions. Not only was their performance similar, but neither of the two groups were statistically faster or slower than the other in regard to latency response times.

Interestingly, results from this study showed that bilinguals did not differ significantly (p<.05) in performance on the Simon task from their aged matched monolingual peers in tasks of ignoring task-irrelevant stimuli in the visual modality. This finding is inconstant with research that has found a difference between the two groups performance in the visual modality in their ability to ignore irrelevant information (Bialystok, Craik, Klein & Viswanathan, 2004; Bialystok, Craik, & Freedman, 2007). It was found that unlike the aforementioned studies, both groups had similar accuracy scores, as well as response latencies, across both test conditions.

The results from the present study suggest that bilinguals are not more effective in inhibiting task irrelevant information than their monolingual peers in the auditory or visual
modality. This result is consistent with the Ansaldo, Ghazi-Saidi and Adrover-Roig (2014) who found that during a visual Simon task, elderly bilingual and monolingual adults performed similarly. They contributed their results to outside factors such as socio-economic status, education background, and non-linguistic outside factors and not to bilingualism.

The reason that differences were not seen between the two groups in the present study may be attributed to things such as the cognitive demands of the being in the university being high for both monolingual and bilingual speakers, to sample size, and to the inclusion and selection of bilingual participants. All of the bilingual speakers and the monolingual speakers were recruited from the University of Texas at El Paso. It can be theorized that because the cognitive demands at the university level are higher, a cognitive advantage might not be evident because both groups were performing at their optimal intellectual levels. The increased cognitive demands of being at the university could have masked the advantages in the bilingual group making it difficult to see a benefit.

Research in the area does give us insight as to why another the lack of differences in group performance could have occurred: we utilized a smaller sample size. It has been argued that the research in the field on the present area of study utilize smaller sample sizes because the researchers, “want to find evidence to support the claim that bilingualism provides a cognitive advantage”. Paab, Johnson, and Sawi (2014) argue this point by saying that the research in the field of bilingualism and cognitive advantages is much too small for us to generalize the findings into the mainstream by performing a large scale study that showed different results. In one of their larger scale (n=120) studies, they found that the results actually disproved the hypothesis by showing no increased performance scores in inhibition in bilinguals.

Another reason the findings of the present study may differ from those of other researchers that show a cognitive advantage, may be attributed to two other methodological factors: the inclusion criteria, and the age of the bilingual participants. Like the research presented by Paab, Johnson, and Sawi (2014), our participants had homogenous life experiences in that the participants were from the same area around the university, had homogenous
acquisition of their second language in their early years, and equal exposure to area Spanish. The El Paso area is unique in that 73% of the total population identifies as bilingual (U.S. Census, 2007).

This could have impacted the present study for the monolingual speakers because the monolinguals in the area do have more opportunities to experience a second language than the national average. With such a high rate of bilinguals in the El Paso area, monolinguals are constantly exposed to a second language. Though they couldn’t identify as proficient in the other language, being surrounded by another language can be giving them the same cognitive advantages as their bilingual speaking peer, thus making it difficult to see a cognitive advantage. Conversely, the bilinguals have more practice in the modulation between their two languages due to the increased number of second language partners as well as their constantly shifting linguistics environments at school and at home. The population pool that was selected was meticulously narrowed to meet the criteria for the present study using the LEAP-Q. Though no definitive formal language test exists, the use of the LEAP-Q self-report questionnaire has been shown to be a reliable in developing language profiles for each participant, thus making it sensitive for this population in this area.

In the present study, the bilinguals acquired both languages before the age of 6. This is important because research has long suggested a critical age for acquisition for language proficiency. The younger the individual is when they acquire their first language, the better control of the two languages systems they are able to develop (Snow, 1978). This cognitive advantage of inhibition might be so sensitive that it might better be seen in older early bilingual speakers doing the same task and comparing the results to age matched older monolingual speakers. These results would then need to be compared to the results of younger bilingual speakers that acquired language at the same time in life.

The age of the participants could have influenced the difference in performance because only younger college aged bilinguals were in the sample of convenience. Research indicates that bilingualism has a long term effect on selective attention (Soveri et al, 2014). If that is the case,
then the limited time exposed to the “practice” of bilingualism due to young age may make the effects on selective attention not yet evident. Research in the field argues that for young adults, cognition is at its peak and any advantage is not evident (Bialystok, Martin & Viswanathan, 2005). Though there has been very little evidence has looked at older bilingual populations, Bialystok, Craik, & Ryan (2006), show a cognitive advantage in older bilinguals over their aged matched monolinguals. Then, the bilinguals that have been selected for the present study may be too young for the cognitive advantage to be seen because they are performing similarly to their monolingual peers at their current age. In the present study, there is no data that looks at these young bilingual’s performances compared to older bilingual adults.

When looking at the effect of bilingualism on older speakers, it is important, then, to acquire a comprehensive language profile. It could be that the constant use from a young age is what is causing the bilingual cognitive advantage. Creating a reliable language profile was completed in the present study using the LEAP-Q. In the present study, it can be noted that early bilinguals may not have a cognitive advantage compared to their monolingual peers but we can’t say if that the cognitive advantage does not carry over into adult hood.

As a person naturally ages, research demonstrates that there is a natural decline in performance in dichotic listening tasks (Hommet et al 2010). It is thought that as a person ages, it becomes more difficult to process the speech information presented during the dichotic listening task. Thus making the task more difficult for older monolingual and bilingual speakers compared to their younger peers. The effect of increased inhibition of irrelevant auditory information during a dichotic listening test might then be significantly different for both older monolinguals and bilinguals.

Even the idea of a cognitive advantage for older bilinguals is not unanimously agreed upon. Studies place emphasis more so on things like education, social economic status, and amount of time speaking the two languages as the cause of the bilingual advantage rather than just having two languages (Souveri et al 2014). More research can be done to see how the effect of bilingualism for older individuals compare to the performance of younger bilinguals in order
to research the long term effect of the bilingualism on cognitive advantages. If a cognitive advantage is seen in the older bilingual populations, then this could lend evidence to the hypothesis that states: it is the long term and habitual inhibition of one language, and the selection of the other in real time that gives the cognitive advantage to the bilingual speaker (Soveri et al 2014).

It is important then to obtain information on the amount of “practice” the participant has had in both of their languages in order to ascertain if they are consistently and habitually using both languages. This was done using the LEAP-Q in the present study. The local area is prime, because: the bilinguals learned both languages early and have constant exposure to both language systems.

Ansaldo, Ghazi-Saidi, and Adrover-Roig suggest that during functional magnetic resonance imaging that bilinguals are using a different substrate of their brain compared to their monolingual peers (left inferior parietal lobule vs the right middle frontal gyrus respectively) (2014). It has been suggested that being bilingual protects against aged related cognitive declines and provides protection against dementia (Mechelli et al, 2004; Stern, 2002; Bialystok, Craik & Luk 2008; Bialystok, 2009). It is possible that bilingualism may provide a cognitive advantage that may be seen in older bilinguals (>50 yrs.), but was not evident in the current sample due to their younger age (<31 yrs.).

Another factor that could have influenced the performance of bilingual speakers was self-perceived language dominance. Most bilinguals stated that they spoke Spanish at home and then began acquiring English some period of time after that. The present study had the stimuli presented with natural speech in a standard American English pronunciation that was exported through an auditory filter producing cleaner sounding speech. This could have impacted the speakers that had identified as having equal or nearly equal English-Spanish Language dominance, but actually had a language dominance that is stronger in their first language. This unbalanced dominance could have made it more difficult to understand and accurately produce the standard American English production of the consonant vowel pairs.
We did not formally assess this in the present study, but it was interesting to note, anecdotally, that for both monolinguals and bilingual speakers it was much more difficult to perceive the voiceless /k/ sound. In nearly every trial for both groups that the /k/ sound was presented, the sound was one of the most missed sounds. In nearly every case that the /k/ sound was presented to the participant, this sound was perceived as a /t/ sound and identified as such. During the training before the actual dichotic listening task, the participants were not given feedback to which sound was missed and this could have also negatively affected their future perception of the /k/ sound. The participants were informed of all the different consonant vowel powers that would be presented for both the monolingual and bilingual speakers.

It has been theorized that the cognitive advantage may be attributed to other factors that are not due to the manipulation of two languages at all, but rather varied demographic information. Hilchey and Klein (2011) state that some of the differences between the groups can be related to things other than the bilingualism. Some such suggestions by the authors include: years of education of the sample, socioeconomic status, and sample size. When a sample has this information that varies across the participants, it could make arriving at any results difficult because all these variables have an impact on cognitive test scores. In the present study, this kind of demographic information was not captured and is a limitation to the results. Further research is needed to see how the effect of bilingualism has on the inhibition of task irrelevant information. With this in mind, the results can help to provide the insight necessary to understanding if there is a bilingual advantage that aids executive functioning benefits that is not available to monolinguals.
Chapter 5: Conclusions

The El Paso area is unique in that more than three quarters of the population self-identifies as Spanish-English bilingual. What is interesting is that though the national average may have been 20% self-identified bilingual in 2010, by 2020 it is estimated that the national average will be closer to 62% bilingual (Shin & Ortman, 2011). This number shows that research into the area of bilingualism and its influence to one’s cognition plays a huge impact in the immediate geographic area, and very soon to the nation as a whole. Similar to the population of the city, the sample of the present study was also unique in that all the participants were from the university and were in their twenties. The participants had similar life experiences and were brought up in the El Paso and surrounding areas, and so are exposed to two languages regularly at school, work, and other social gatherings that they may attend.

It is thought that this constant switching between two languages gives bilinguals a cognitive advantage compared to their monolingual peers, in the inhibition of irrelevant information. Significantly, if this cognitive effect can delay Alzheimer’s and slow general cognitive decline (Mechelli et al, 2004; Bialystok, Craik & Luk 2008; Bialystok, 2009) then the clinical significance for research in the area has large implications for future practice by Speech and Language Pathologists and Audiologists in the field. Bilingualism can be used as a therapy to guard cognition in the geriatric population and can be used to guard against general cognitive decline. Then the clinical importance of the present study merits discussion and future research.

The primary findings from this study were that both groups demonstrated a significant right ear advantage on the Dichotic consonant vowel tasks, specifically in the Forced-Right and Non-Forced condition. Due to the aforementioned contra-lateral wiring of the brain, this finding was expected. In the visual Simon task, both groups had faster response times and performed significantly better for the congruent condition compared to the incongruent condition. This finding was also expected given the cognitive load of the incongruent trial compared to the congruent trial.
The initial hypothesis of the study stated that bilingual speakers would show an advantage on a forced-attention dichotic listening task and a non-verbal visual inhibition task compared to monolingual speakers, but the results yielded a different result. We have concluded that there was no significant performance difference between the monolingual and bilingual group in the three test conditions on the auditory dichotic listening task of inhibition and that there was no significant difference in performance or latency between the monolingual and bilingual groups across the three test conditions on the visual Simon Task of inhibition. The study concluded that for both the visual and the auditory task of inhibition, there was no significant difference between the monolingual English group and the bilingual Spanish-English group in either performance or in response latency.

The results of this study suggest that balanced Spanish-English bilinguals may not have an advantage in the inhibition of irreverent information compared to English monolinguals. This finding is different than the initial hypothesis of the study. This conclusion questions the initial research that theorized it is the constant practice of switching between two languages in bilingualism that provides a cognitive benefit in young bilingual individuals (Bialystok, 2008).

Future studies should then focus on the difference between younger and older bilinguals to see if that this practice provides a benefit later in life. Based on the results of the current study, it could be of clinical significance to look at the relationship between younger and older bilinguals to confidently attribute the benefit to continued practice of two language systems to increased executive control. It is also important to note that future studies should also look at socio-economic information to ascertain if the difference that was seen in the present study was attributed to differences in socio-economics or due to language. This information was not obtained in the present study, but could provide additional insight as to the group differences in the present study.
References


Kalas, V., Wilbourn, M. P., & Ghio, K. (2014). Better early or late? Examining the influence of
age of exposure and language proficiency on executive function in early and late bilinguals. *Journal Of Cognitive Psychology*, 26(7), 699-713.


Appendix A

Handedness Questionnaire

Most people are either right-handed or left-handed. However, there are different "degrees" of handedness. Some people use one hand for jobs that require skill and the other hand for jobs that involve reaching. Other people use the same hand for these different jobs. Use this "Handedness Questionnaire" to measure the strength of handedness. Place a mark in a box for each question that describes you best.

<table>
<thead>
<tr>
<th></th>
<th>LEFT Hand</th>
<th>RIGHT Hand</th>
<th>EITHER Hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Which hand do you use to write?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Which hand do you use to draw?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Which hand do you use to throw a ball?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Which hand do you hold a tennis racket?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. With which hand do you hold a toothbrush?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Which hand holds a knife when you cut things?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Which hand holds a hammer when you nail things?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Which hand holds a match when you light it?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Which hand holds an eraser when you erase things?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Which hand removes the top card when you deal from a deck?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Which hand holds the thread when you thread a needle?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Which hand holds a fly swatter?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How to Determine your Score

1. Count the number of LEFT, RIGHT and EITHER responses.
2. Multiply the number of RIGHT responses by 3. This number = R
3. Multiply the number of EITHER responses by 2. This number = E
4. Add R + E + (number of LEFT responses). This sum is your score.

Here is a table to help:
Number of RIGHT responses x 3 = ___
Number of EITHER responses x 2 = ____
Number of LEFT responses = ____
TOTAL = __________

How to Interpret Your Score

<table>
<thead>
<tr>
<th>Score</th>
<th>Handedness</th>
</tr>
</thead>
<tbody>
<tr>
<td>33 to 36 = Strongly Right-Handed</td>
<td></td>
</tr>
<tr>
<td>29 to 32 = Moderately Right-Handed</td>
<td></td>
</tr>
<tr>
<td>25 to 28 = Weakly Right-Handed</td>
<td></td>
</tr>
<tr>
<td>24 = Ambidextrous</td>
<td></td>
</tr>
<tr>
<td>20 to 23 = Weakly Left-Handed</td>
<td></td>
</tr>
<tr>
<td>16 to 19 = Moderately Left-Handed</td>
<td></td>
</tr>
<tr>
<td>12 to 15 = Strongly Left-Handed</td>
<td></td>
</tr>
</tbody>
</table>

(This questionnaire was adapted from the handedness questionnaire by Stanley Coren, *The Left-Hander Syndrome: The Causes and Consequences of Left-Handedness*, Free Press, New York, 1992.)
Appendix B

Northwestern Bilingualism & Psycholinguistics Research Laboratory


Language Experience and Proficiency Questionnaire (LEAP-Q)

<table>
<thead>
<tr>
<th>Last Name</th>
<th>First Name</th>
<th>Today’s Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Date of Birth</td>
<td>Male □ Female □</td>
</tr>
</tbody>
</table>

(1) Please list all the languages you know in order of dominance:

1  
2  
3  
4  
5

(2) Please list all the languages you know in order of acquisition (your native language first):

1  
2  
3  
4  
5

(3) Please list what percentage of the time you are currently and on average exposed to each language.

(Your percentages should add up to 100%):

<table>
<thead>
<tr>
<th>List language here</th>
<th>List percentage here</th>
</tr>
</thead>
</table>

(4) When choosing to read a text available in all your languages, in what percentage of cases would you choose to read it in each of your languages? Assume that the original was written in another language, which is unknown to you.

(Your percentages should add up to 100%):

<table>
<thead>
<tr>
<th>List language here</th>
<th>List percentage here</th>
</tr>
</thead>
</table>

(5) When choosing a language to speak with a person who is equally fluent in all your languages, what percentage of time would you choose to speak each language? Please report percent of total time.

(Your percentages should add up to 100%):

<table>
<thead>
<tr>
<th>List language here</th>
<th>List percentage here</th>
</tr>
</thead>
</table>

(6) Please name the cultures with which you identify. On a scale from zero to ten, please rate the extent to which you identify with each culture. (Examples of possible cultures include US-American, Chinese, Jewish-Orthodox, etc):

| List cultures here | (click here for scale) | (click here for scale) | (click here for scale) | (click here for scale) | (click here for scale) |

(7) How many years of formal education do you have?

Please check your highest education level (or the approximate US equivalent to a degree obtained in another country):

- Less than High School
- High School
- Professional Training
- Some College
- College
- Some Graduate School
- Masters
- Ph.D./M.D./J.D.
- Other:

(8) Date of immigration to the USA, if applicable ________________________________

If you have ever immigrated to another country, please provide name of country and date of immigration here. ___________________________________________________________________

(9) Have you ever had a vision problem □, hearing impairment □, language disability □, or learning disability □? (Check all applicable). If yes, please explain (including any corrections): ____________________________________________________________
Language:

This is my (please select from pull-down menu) language.

All questions below refer to your knowledge of ___.

(1) Age when you...:

<table>
<thead>
<tr>
<th>began acquiring fluent in</th>
<th>began reading in</th>
<th>became fluent reading in</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) Please list the number of years and months you spent in each language environment:

<table>
<thead>
<tr>
<th>Language</th>
<th>Years</th>
<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>A country where ___ is spoken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A family where ___ is spoken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A school and/or working environment where ___ is spoken</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) On a scale from zero to ten, please select your level of proficiency in speaking, understanding, and reading ___ from the scroll-down menus:

- Speaking (click here for scale)
- Understanding spoken language (click here for scale)
- Reading (click here for scale)

(4) On a scale from zero to ten, please select how much the following factors contributed to your learning ___:

- Interacting with friends (click here for pull-down scale)
- Interacting with family (click here for pull-down scale)
- Reading (click here for pull-down scale)
- Language tapes/self-instruction (click here for pull-down scale)
- Watching TV (click here for pull-down scale)
- Listening to the radio (click here for pull-down scale)

(5) Please rate to what extent you are currently exposed to ___ in the following contexts:

- Interacting with friends (click here for pull-down scale)
- Interacting with family (click here for pull-down scale)
- Watching TV (click here for pull-down scale)
- Listening to radio/music (click here for pull-down scale)
- Reading (click here for pull-down scale)
- Language-lab/self-instruction (click here for pull-down scale)

(6) In your perception, how much of a foreign accent do you have in ___?

(click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in ___:

(click here for pull-down scale)
Language:

This is my (please select from pull-down menu) language.

All questions below refer to your knowledge of .

(1) Age when you...:

<table>
<thead>
<tr>
<th>began acquiring in</th>
<th>became fluent in</th>
<th>began reading in</th>
<th>became fluent reading in</th>
</tr>
</thead>
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<table>
<thead>
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<th>Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>A country where is spoken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A family where is spoken</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A school and/or working environment where is spoken</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) On a scale from zero to ten please select your level of proficiency in speaking, understanding, and reading from the scroll-down menus:

- Speaking (click here for scale)
- Understanding spoken language (click here for scale)
- Reading (click here for scale)

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- Reading (click here for pull-down scale)
- Language tapes/self instruction (click here for pull-down scale)
- Watching TV (click here for pull-down scale)
- Listening to the radio (click here for pull-down scale)

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- Interacting with family (click here for pull-down scale)
- Watching TV (click here for pull-down scale)
- Listening to radio/music (click here for pull-down scale)
- Reading (click here for pull-down scale)
- Language-lab/self-instruction (click here for pull-down scale)

(6) In your perception, how much of a foreign accent do you have in ?

(click here for pull-down scale)

(7) Please rate how frequently others identify you as a non-native speaker based on your accent in :

(click here for pull-down scale)
Vita

Francisco Fernandez was born in El Paso, Texas. The first born son of Francisco Fernandez and Patricia Fernandez, he graduated from Canutillo in the top 10 in the spring of 2009 and entered El Paso Community College that fall before transferring to the University of Texas at El Paso the next spring. While pursuing a bachelor’s degree, he worked full time at Sears as well as at the University as a student intern at the office of admissions. He graduated Cum Laude with his Bachelor of Arts in Linguistics with a minor in Speech and Language Pathology the spring of 2014. That Fall, he entered the Graduate School at the University of Texas at El Paso Master of Science where he began working as a research assistant under Jamie L. Desjardins, PhD., CCC-A from 2014-2015. During this time he presented his research at the November 2015 American Speech-Language Hearing Association Convention in Denver, Colorado.

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