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Auditory Selective Attention Performance In Older And Younger Bilingual Adults

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AUDITORY SELECTIVE ATTENTION PERFORMANCE IN

OLDER AND YOUNGER BILINGUAL ADULTS

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Dedication

This is for you, Mom, Dad and Marquito.

AUDITORY SELECTIVE ATTENTION PERFORMANCE IN OLDER AND YOUNGER BILINGUAL ADULTS

by

NINIVE GOMEZ

THESIS

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Abstract

Recent research has suggested that bilinguals may have enhanced cognitive abilities resulting from the constant management and maintenance of their two language systems. This cognitive advantage has been evidenced in studies showing that bilinguals outperform monolinguals on tasks of visual selective attention. However, very little is known regarding how bilingualism influences selective attention in the perception of auditory information. Thus, the purpose of this study was to examine the effects of bilingualism on auditory selective attention. A total of 61 participants were recruited to participate and divided into four participant groups: 15 younger monolinguals (between the ages of 18-25), 15 younger bilinguals, 15 older monolinguals (between the ages of 47-62) and 16 older bilinguals. All participants had hearing thresholds < 25 dBHL from 250 Hz to 4000 Hz, bilaterally (ANSI, 2003), and were right-handed according to the Handedness Questionnaire (Veale, 2014). 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.

On the Dichotic Listening Task, all groups showed a right-ear advantage across the forced-right condition. The results showed all participants reported more right ear responses than left responses across all attentional conditions. All monolingual participants reported more right-ear responses on the forced-left condition than the bilingual participants. The older

bilingual group outperformed the older monolinguals on the forced-left condition, thus demonstrating enhanced executive function control. On the Simon Task, all participants performed better on the congruent condition than the incongruent condition. The younger group performed better on the incongruent condition than the older group of participants. All participants performed faster on the congruent condition than the incongruent condition. In comparison to the older group, the younger group performed faster on the congruent and incongruent conditions. Additionally, the older bilinguals performed significantly slower than the older monolinguals across the congruent and incongruent conditions. In conclusion, a statistically significant difference was found in performance scores between the older bilinguals and monolinguals, as the bilinguals performed better on the forced-left condition. These findings suggest that older bilinguals have a cognitive advantage over older monolingual speakers.

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Chapter 1: Literature Review

1.1 Introduction

According to Grosjean (1994), an individual that uses two or more languages daily across different contextual situations is considered bilingual. Through a general perspective, this definition indicates that over half of the world is bilingual or multilingual. In the United States, the use of another language, in addition to English, has increased 148% between 1980 and 2009 (Shin & Ortman, 2011). In fact, the Hispanic population continues to grow primarily due to immigration, which in turn makes Spanish the non-English language that is spoken the most in the United States (Passel, Cohn, & Lopez, 2011).

By 2055, the United States is projected to become a minority-majority nation, which allows us to expect an increasing emergence of languages and cultures (Shin & Ortman, 2011). As opposed to monolingual speakers who control only one language system, individuals who are bilingual maintain syntactic, semantic, pragmatic, phonological and morphological representations of two language systems. For this reason, bilingualism was seen as detrimental to the brain (Fritz & Rankin, 1934; Hakuta & Diaz, 1985). This notion was supported by studies which showed that monolingual speakers performed better than bilingual speakers on general intelligence tests (Darcy, 1963). However, recent research has demonstrated that bilinguals may actually have a cognitive advantage compared to monolinguals as they have been shown to demonstrate better executive function control which, is the focus of the current study. Executive function is responsible for three core mental processes: inhibition and interference control (selective attention), working memory and cognitive control (mental flexibility) (Kane &

Engle, 2002). Thus, executive function control is often utilized by bilinguals as they must constantly activate one language (and suppressing the other) while simultaneously distinguishing irrelevant versus relevant linguistic information to attend to a conversation, receptively and expressively.

The review of the literature on the effects of bilingualism is still inconclusive. Such that, some studies claim bilinguals have enhanced executive function, while others fail to find any differences. Therefore, more research is needed to elucidate the effects of knowing two or more languages on the brain.

1.2 Theories on Bilingualism

Several researchers have developed theories in an attempt to explain how language is processed and managed in the mind of a bilingual. The theory developed by Grosjean (1985) known as the *Language Mode Continuum* emphasized the level of language activation within a bilingual speaker. Due to the different environments in which languages can be used, the range of language activation will vary in every situation (Grosjean, 1998). In Figure 1, Language A and Language B are presented on the vertical axis with squares that represent different levels of language activation (Grosjean, 1998). Specifically, the black square represents complete activation, the gray square represents intermediate activation, and the light gray represents slight activation (Grosjean, 1998). During the first instance shown on the left side of Figure 1, Language A is highly activated, while Language B remains slightly activated, indicating the bilingual speaker is suppressing one language over the other one (Grosjean, 1998). On the other hand, as shown on the right side, Language A highly activated and Language B is intermediately activated, depicting a circumstance in which a bilingual might be interacting with another

bilingual, where both languages can be used interchangeably (Grosjean, 1998).

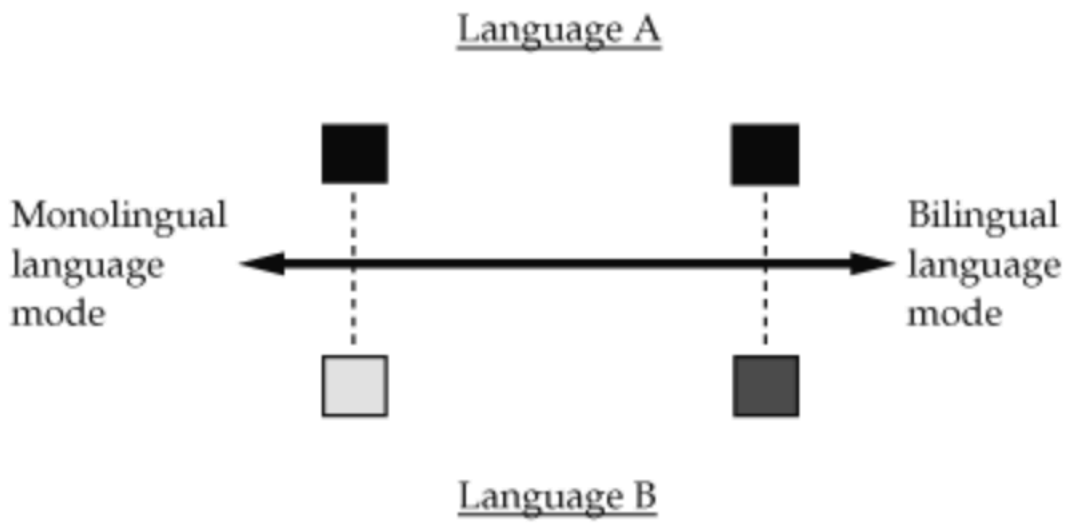

Figure 1.1: The Language Mode Continuum from Grosjean (1998)

The *Revised Hierarchical Model* describes the interconnection between lexical links and conceptual links across two languages (de Groot, Barry & Kroll, 1995). According to this model, it is assumed an individual's L1 (first language) will serve as a mediator to learn L2 (second language) (de Groot, Barry & Kroll, 1995). This in turn allows for stronger interconnections between L2 to L1 than L1 to L2, as L2 is mapping concepts from the dominant language, L1(de Groot, Barry & Kroll, 1995). In addition, the existent interconnections from L1 to L2 are weaker as their might be a lack of direct translation from L1 to L2, resulting in inconsistent lexical models (de Groot, Barry & Kroll, 1995). The dependence of L2 on L1 was evidenced as the translation between languages is faster and more accurate from L2 to L1 than L1 to L2. Green (1998) suggested a plausible explanation by inferring the stronger language requires "higher inhibitory processes" to successfully translate between languages, meaning it would take greater cognitive control to focus on the less active language/s (L2). Both language

models, the *Language Mode Continuum* and *Revised Hierarchical Model,* illustrate how bilinguals continually suppress the activation of one language when using their other language, which has been thought to provide a cognitive advantage in bilinguals.

1.3 Language Profile

The performance of bilinguals on cognitive processing tasks has been shown to be directly influenced by the age at which the bilingual individual acquired their languages (e.g., simultaneous vs. sequential), how proficient they are in each of their languages (e.g., balanced vs. unbalanced) and whether they are more dominant in one language compared to their other language (Bak, Vega-Mendoza & Sorace, 2014; Marian, Blumenfeld & Kaushanskaya, 2007). Individuals that learned both their first and second language at the same time are considered simultaneous bilinguals, while late or sequential bilinguals learned their second language at a later stage in life (Marian, Blumenfeld & Kaushanskaya, 2007). Balanced bilinguals are those who are equally proficient in both languages and unbalanced bilinguals are more proficient in one language than the other (Marian, Blumenfeld & Kaushanskaya, 2007).

A common tool used to measure language proficiency is the Language Experience and Proficiency Questionnaire (LEAP-Q). The LEAP-Q, a self-assessment questionnaire, has been shown to provide reliable and accurate language profiles for bilinguals (Marian, Blumenfeld & Kaushanskaya, 2007). Specifically, the questionnaire assesses the following domains: age of acquisition, language use, language proficiency (in speaking, reading, writing and understanding), preference, and accent ratings (Marian, Blumenfeld & Kaushanskaya, 2007). The speaking, reading and understanding rating measures of the LEAP-Q have proven to most accurately determine language proficiency (Marian,

Blumenfeld & Kaushanskaya, 2007).

A recent study by Shi (2015) examined whether bilingual language rating scales can serve as predictors of performance on a speech recognition test in quiet and in background noise. Participants rated their proficiency in reading, speaking and understanding their second language using the LEAP-Q (Marian, Blumenfeld & Kaushanskaya, 2007). Results showed that the self-ratings were accurate in predicting participants' performance on speech recognition tests. Overall, this study emphasized that the use of self-ratings serve as accurate measures of language proficiency.

1.4 Cognitive Advantage in Bilinguals

The theoretical bilingual cognitive advantage has been conceptualized as the idea that bilingualism may enhance executive function control and possibly mediate cognitive decline and cognitive reserve. As previously mentioned, it is thought that bilinguals have enhanced executive function control as their expression of one language requires inhibition of the non-target language (Ong, Sewell, Weekes, McKague & Abutalebi, 2017). During discourse, joint activation of both languages occurs to process linguistic information, thus creating an attention demand (Bialystok, Craik & Luk, 2012). As language is processed, the individual is required to select the appropriate phonological, morphological, syntactic, semantic and pragmatic decisions which will result in the production of the correct language from the competing language/s (Bialystok, Craik & Luk, 2012).

The lifelong practice that bilinguals receive by managing two language systems has shown to reorganize the brain, such that it directly influences the cognitive decline that occurs at the presence of a pathology (Bialystok, Craik & Luk, 2012). Cognitive

decline has been investigated through different theories, one being the Cognitive Reserve (CR) Theory. The CR theory explores the idea that, at the presentation of a pathology, cognitive decline might be decelerated depending on different factors (e.g. education, intelligence, socioeconomic status (SES) and fitness). Research has shown that older bilinguals with more prominent cognitive atrophy due to the diagnosis of Alzheimer's, maintain higher levels of cognitive function, in comparison to older monolinguals (Bialystok, 2011). In fact, the development of the cognitive reserve might be in action throughout the lifespan of bilinguals, such that, faster response times (on the Simon Task) result in the activation of areas on the brain that govern the engagement of inhibitory processes, such as: the right temporal, left frontal and cingulate areas (Bialystok, Craik, Grady, Chau, Ishii, Gunji & Pantev, 2005). Not only are the areas of the brain in charge of inhibitory control being activated, but greater white matter density has been found in the corpus callosum and superior and inferior fasciculi, which results in stronger interconnections and more efficient subnetworks that are involved with executive function control (Luk, Bialystok, Craik & Grady, 2011). The cognitive benefits that result from bilingualism may contribute to the cognitive reserve, as it may delay the age of onset of symptoms of Alzheimer's disease (Bialystok, Craik & Freedman, 2007; Gold, 2015).

1.5 Visual Selective Attention

The presence of the bilingual cognitive advantage, as it is hypothesized to result in increased executive function control, has been assessed mainly using visual selective attention tasks. Such tasks (e.g. Simon Task, Ambiguous Figure Task, Attentional Network Task, etc.) require the participant to select or find the target stimuli while

ignoring interfering irrelevant information. For example, the study conducted by Bialystok, Martin & Viswanathan (2005), examined the effects of bilingualism (on young, middle aged, and older bilinguals and monolinguals) on visual selective attention using the Simon Task. During the task, the participant was presented with a blue or a red square on a computer, and was further instructed to press the right shift key for a red square and the left shift key for a blue square across two different conditions: congruent and incongruent trials. On a congruent trial, the stimulus item (e.g. red or blue square) appeared on the same side of the shift key the participant pressed. For example, a blue square was presented on the left side of the screen and the participant would have selected the left shift key to accurately respond to the trial. On the other hand, in an incongruent trial, the stimulus item was presented on the opposite side of the shift key that had to be pressed. For example, the blue square appeared on the right side of the screen and the left shift key had to be pressed to accurately respond to the trial item. No statistical differences were evidenced between the younger groups, however, bilinguals had more correct responses and faster latencies (across congruent and incongruent trials) than monolinguals in the middle aged and older adult groups (Bialystok, Martin & Viswanathan, 2005).

Consistent with the results stated previously, the study conducted by Salvatierra & Rosselli (2010) utilized the Simon Task on a sample of young (average age 25.88) and older (average age 63.40) bilinguals and monolinguals. The older bilinguals demonstrated an advantage as they were more efficient at inhibiting task irrelevant visual information during the Simon Task compared to their older counterparts. However, such advantage was not evidenced across the younger bilinguals as they performed similarly to the

younger monolinguals. Thus, suggesting the existence of the bilingual advantage might be dependent on age, as it was only prominent among older bilinguals (Bialystok, Martin & Viswanathan, 2005; Salvatierra & Rosselli, 2010).

Moreover, Costa, Hernández & Sebastián-Gallés (2008) found that young bilinguals outperformed young monolinguals on both congruent and incongruent conditions of the Attentional Network Task (ANT). In addition, the performance of the young bilingual group was not only better than the monolingual group, but it was similar across both conditions (congruent and incongruent), which indicates bilinguals are experiencing less interference than their younger counterparts (Costa, Hernández & Sebastián-Gallés, 2008; Chung-Fat-Yim, Sorge & Bialystok, 2017).

In addition, Friesen, Latman, Calvo & Bialystok (2015) examined the performance of bilingual and monolingual young adults on a Visual Search Task. A total of 109 participants, 56 early bilinguals (mean age 20.9) and 53 monolinguals (mean age 21.2), were recruited for the study. Overall, participants performed better on feature searches than conjunction searches, as they responded faster and more accurately. However, during the conjunction searches both language groups performed slower and less accurately on discriminability and distractor conditions, but bilinguals outperformed the monolingual group in identifying the target stimulus faster. Thus, the results obtained in this study indicate the presence of a cognitive advantage, as bilinguals attended to relevant information and ignored irrelevant information to identify specific targets (Friesen, Latman, Calvo & Bialystok, 2015).

However, the presence of the cognitive advantage has not been evidenced across all studies. Luk, Anderson, Craik, Grady & Bialystok, (2010) assessed the performance

of younger bilinguals (mean age: 20) and monolinguals (mean age: 22) with highly similar backgrounds on the Flanker Task. The results revealed no differences in performance on accuracy and response latencies across both language groups. Thus, the results demonstrate language experience and exposure may not play a role on behavioral tasks that assess visual selective attention.

Ansaldo, Ghazi-Saidi & Adrover-Roig, (2015) assessed visual selective attention by using the Simon Task across older bilinguals (average age: 74.2) and monolinguals (average age: 74.5). Overall, no statistical differences were found between the older bilinguals and monolinguals on the congruent and incongruent conditions. Such that, accurate responses and reaction times were equivalent across both groups.

de Bruin, Bak & Della Sala (2015) examined the performance of older bilinguals and monolinguals that matched on lifestyle, socio-economic status, education, IQ, gender, and age on the Simon Task. The results showed bilinguals did not have an advantage in performance over their language counterparts on the Simon Task. Thus, counter indicating previous research supporting the presence of the bilingual cognitive advantage.

1.6 Auditory Selective Attention

Executive function control on bilinguals has primarily been assessed through the visual modality. If the bilingual cognitive advantage is a valid finding, it should generalize across modalities, namely auditory tasks that assess executive function control. Auditory selective attention has been measured using the dichotic listening task which uses a forced attention paradigm (Hugdahl & Andersson, 1986). During the Dichotic Listening Task, the participant is presented with a consonant-vowel (CV) syllable in both

ears, simultaneously, across three different attention conditions (non-forced, forced-right and forced-left) (Soveri, et al., 2011). The systematic set of instructions for each condition set up a cognitive conflict situation, such that the participant is required to selectively attend to the CV syllable presented in one ear while ignoring the auditory input presented in the opposite ear (Soveri, et al. 2011). The task instructions are modified according to the conditions that are presented to the participant; for instance, on the forced-right condition, the CV syllable presented in the right ear must be selected for a correct response, and vice versa for the forced-left condition, as only the CV syllable presented on the left ear can be selected. However, during the non-forced condition, no attentional instruction is provided, as the participant selects the syllable that was heard best (Soveri, et al. 2011).

Among the right-handed community, it is common to detect participants reporting more right ear responses than left ear responses on the non-forced condition. This occurrence is explained by the Right Ear Advantage (REA) theory, which entails speech sounds are processed faster in the right ear as there is a more direct pathway from the right ear to the left auditory cortex (Soveri, et al. 2011). In other words, the contralateral pathways suppress the ipsilateral pathways allowing for the input of the right ear to be directly processed in the language dominant hemisphere (left hemisphere) (Asbjornsen & Hugdahl, 1995). In terms of the dichotic listening task, the forced-right condition encourages the premise of the REA. However, the REA decreases during the forced-left condition, as attention must be modulated to the auditory input presented on the left ear. The forced-left condition increases cognitive demand, thus recruiting areas of the brain

that oversee attention, ignoring irrelevant stimuli and resolving a response conflict (Soveri, et al., 2011).

Soveri, et al. (2011) examined the effects of bilingualism on auditory selective attention by using the Dichotic Listening Task. The sample population of the study consisted of bilinguals and monolinguals between the ages of 30-50 and 60-74. Each participant was presented with CV syllables that were semantically meaningless, but phonologically relevant, such as /pa/, /ta/, /ka/, /ba/, /da/, /ga/. As previously mentioned, the dichotic listening task presents the auditory stimulus across three different conditions: the non-forced, forced-right and forced-left conditions. Results showed that early simultaneous bilinguals performed better across the forced-right and forced-left conditions, suggesting they are more effective at selectively attending to auditory information. Thus, bilinguals' ability to obtain more correct responses on the force right and force left condition lends support for the hypothesis that maintaining two languages enhances executive function abilities.

Similarly, Bak, Vega-Mendoza & Sorace, (2014) examined performance differences on the Test of Everyday Attention (TEA) in young monolinguals and bilinguals. Participants included early childhood bilinguals (ECB) (learned both languages before the age of 4), late childhood bilinguals (LCB) (learned their language between the age of 4-15) (average age of ECB: 21.3 and LCB: 23.6) and monolinguals (average age: 22.2). Results revealed the bilingual group performed significantly better than the monolingual group on the TEA, thus indicating the presence of the bilingual cognitive advantage across the auditory modality.

Recently, Desjardins & Fernandez (2018), examined visual and auditory selective attention using the Simon Task and a Dichotic Listening task, respectively. Participants included 20 monolinguals and 19 early Spanish-English bilinguals between the ages of 18-30. Results on the Simon Task indicated that the bilinguals and monolinguals performed similarly to each other on both the congruent and incongruent conditions. Similarly, the performance of the bilinguals did not differ from that of the monolinguals on the Dichotic Listening Task. This suggests that bilinguals are not more effective than monolinguals at inhibiting task irrelevant information through the auditory and visual modalities. The dearth of statistically significant differences found across young bilinguals and monolinguals could be attributed to their age, such that the bilingual cognitive advantage may only be evidenced across individuals who have experienced natural cognitive decline due to age. Thus, enhanced executive function control may be most prominent across the older population of bilinguals- which will be examined in the current study.

1.7 Purpose

The purpose of the current study was to examine the effect of bilingualism on visual and auditory tasks of selective attention in younger and older adults. The specific aims of the study were to (1) determine if selective attention performance differs between bilinguals and monolinguals on auditory and visual selective attention tasks, and (2) determine how selective attention performance changes with age in bilingual adults. We hypothesized that older bilingual speakers would show an advantage in performance on the forced-attention dichotic listening task and non-verbal visual inhibition task compared

to older monolingual speakers, but that no differences would be observed between the two younger groups of participants.

Chapter 2: Methods and Procedures

2.1 Participants

The Institutional Review Board for human subjects at the University of Texas at El Paso approved this study. All participants were recruited from the El Paso area with the use of posters, referral from students, and through social media. Upon completion of the study, all participants received a 25-dollar gift card.

The participants in this study consisted of a total of sixty-one adults divided into four groups according to their age and linguistic proficiency. The four groups were: 15 younger Spanish-English bilinguals, 15 younger monolinguals, 16 older Spanish-English bilinguals and 15 older monolinguals. Younger participants were between 18-25 years of age and older participants were between 47-62 years of age. See Table 1 for participants' demographic information.

Table 2.1: Participant Demographics

	YM	OM	YB	OB
Age	21.1 (1.9)	55.8 (5.2)	21.4 (1.9)	55.9 (4.0)
Gender (%)				
Male (%)	7 (46.7%)	7 (46.7%)	7 (46.7%)	7 (43.8%)
Female (%)	8 (53.3%)	8 (53.3%)	8 (53.3%)	9 (56.3%)
Handedness (%)				
Right	15(100%)	15 (100%)	15(100%)	16 (100%)
Handed	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Left Handed				
Digit Span Total	20.1 (3.7)	18.28 (4.4)	17.7 (2.5)	16.8 (3.3)
Minimental		29.2 (1.0)		28.43 (1.5)
Non-Hispanic	5 (33.3%)	13 (86.7%)	0 (0%)	0 (0%)
Hispanic	10(66.7%)	2 (13.3%)	15(100%)	16 (100%)
Years of School	15.4(1.45)	15.2 (2.3)	14.8 (1.3)	15.6 (3.3)
Country of Origin (%)				
Mexico	0 (0%)	0 (0%)	1 (6.7%)	1 (6.3%)
US	13(86.7%)	14 (93.3%)	14(93.3%)	14(87.5%)
Other	2(13.3%)	1 (6.7%)	0 (0%)	1 (6.3%)

The abbreviations are as follows: For Age, Digit Span, and Minimental: Mean (SD), for Gender and Handedness is number of participants (%).

All participants in this study had hearing thresholds of <25 dBHL from 250 Hz to 4000 Hz bilaterally (ANSI, 2007) and were right handed according to the Edinburgh Handedness Inventory-Short Form (Veale, 2014). Participants completed the Digit Span Subtest, forward and backward, from the Wechsler Adult Intelligence Scale- Third Edition (Wechsler, 1997) to estimate working memory abilities. There were no significant differences in performance on the Digit Span test between any of the participant groups [F (3, 58) =2.204; p=.09]. The older participants in this study completed the Minimental State Examination (MMSE) (Folstein, Robins & Helzer, 1983), a test of cognitive impairment. Participants' scores were greater or equal to 26, which is interpreted as having no cognitive impairment.

Participants were administered the Language Experience and Proficiency Questionnaire (LEAP-Q) (Marian, Blumenfeld & Kaushanskaya, 2007) to obtain a linguistic profile of each individual. All monolingual speakers reported knowing only English and no other language. The bilingual participants reported learning their second language before the age of 7 and using both of their languages on a daily basis. On average, younger bilinguals reported using English 62.7% and Spanish 37.3% of the time, while older bilinguals reported using English 69.6% and Spanish 30.4%. See to Table 2 for results from the LEAP-Q.

Table 2.2: LEAP-Questionnaire Results

	YM	OM	YB	OB
Language Dominance (%)				
Spanish	0 (0%)	0 (0%)	4 (26.7%)	3 (18.8%)
English	15 (100%)	15 (100%)	11 (73.3%)	13 (81.3%)
Language Acquisition (%)				
Spanish	0 (0%)	0 (0%)	10 (66.7%)	7 (43.8%)
English	15 (100%)	15 (100%)	5 (33.3%)	9 (56.3%)
Spanish Age Acquisition			1.4 (1.6)	4.4 (10.4)
English Age Acquisition	.8 (1.59)	.3 (.89)	4.1 (3.6)	2.3 (2.2)
L1 Speaking	9.6 (.63)	9.4 (.82)	8.6 (1.2)	8.8 (1.2)
L1 Understanding	9.6 (.63)	9.4 (.73)	9.1 (1.1)	9.0 (1.1)
L1 Reading	9.5 (.7)	9.3 (1.7)	8.4 (1.4)	8.6 (2.1)
L2 Speaking			7.4 (2.2)	7.0 (2.8)
L2 Understanding			8.8 (.9)	7.3 (2.6)
L2 Reading			7.8 (2.0)	6.3 (3.1)
English Use (%)	100 (.0)	100 (.0)	62.7 (20.0)	69.6 (17.8)
Spanish Use (%)	0 (0)	0 (0)	37.2 (20.0)	30.3 (17.8)

The abbreviations are as follows: For Language Dominance and Acquisition: number of participants (%); For Age acquisition, Spanish and English Use, L1 and L2 Speaking, Reading and Understanding: Mean (SD)

2.2 Test Measures

Simon Task of Visual Selective Attention

The Simon Task was used in the current study to assess non-verbal visual selective attention performance (Millisecond, 2012). Participants were presented with circles that varied in color (red or blue) and location (right side or left side of the screen) via a Dell computer monitor. All participants were instructed to press the right shift key at the presentation of a red circle and the left shift key for a blue circle, regardless of its position on the screen. The visual stimuli (circles) were presented across two experimental conditions: congruent and incongruent trials. During a congruent trial, the visual stimuli was presented on the same side of the screen as the shift key that was pressed (for example: a red circle appeared on the right side of the screen which corresponds to the right shift key). On an incongruent trial, the circle appeared on the opposite side of the screen as the shift key (for example: a blue circle appeared on the right side of the screen). The participants began the task with a set of 8 practice items, however, practice items were extended by 8 until the participant responded correctly to all test items. After completing the practice session, the participant was then presented with 14 congruent and 14 incongruent trials in a randomized order. Percent correct and latency (in ms) were obtained for both congruent and incongruent trials.

Dichotic Listening Task

An English forced-attention dichotic listening task was used to measure inhibition of irrelevant auditory information following the protocol outlined by Hugdahl et. al. (2009). This test was chosen for use in the current study because it has been shown to be

sensitive to differences in inhibition performance between monolingual and bilingual adults (Soveri et. al., 2011). The task included four lists of 30 consonant-vowel (CV) stimuli consisting of six different syllables of a consonant (i.e., /b, p, t, d, g, k/) followed by the /a/ vowel sound recited by a male talker with constant intonation and intensity (Audiotec, St Louis, MO). Each syllable was presented at a length of 350 milliseconds (ms) with an inter-trial interval of 4 seconds. The CVs were presented dichotically in three different attention conditions; (1) forced right, (2) forced left, and (3) non-forced. In the forced right and forced left conditions, participants were instructed to listen to the CVs and report the CV that was presented in either the right or left ear, respectively. In the non-forced condition, participants were instructed to listen to the CVs presented to both ears and report the CV they heard 'best' or 'most clearly'. The test was scored as the percentage of syllables reported for the right and left ears for the three test conditions.

2.3 Procedure

All testing was conducted in one 2-hour session. All participants completed Edinburgh Handedness Inventory-Short Form (Veale, 2014) and the general demographic questionnaire. Audiometric Testing was then conducted per the American Speech Language Hearing Association (ASHA) Standards, which entailed measuring octave frequencies from 250 Hz to 8000 Hz in the left and right ears (ASHA, 2003). After obtaining hearing thresholds, the LEAP-Q (Marian, Blumenfeld & Kaushanskaya, 2007) and Digit Span (Wechsler, 1997) were administered. The Mini-Mental State Examination (Folstein, Robins & Helzer, 1983) was administered only to the older participants.

The order of presentation of the two experimental tasks, the Dichotic Listening Task and Simon Task, was randomized for each participant using a computerized

program. The Dichotic Listening task was administered across three experimental conditions: The non-forced, forced-right and forced-left condition. The first attentional condition presented is always the non-forced condition, but the presentation of the forced-right and forced-left was counterbalanced between participants. Each participant was presented with 240 trials that were equally divided over the three instruction conditions (80 trials for the NF, 80 for the FR and 80 for the FL). All responses were recorded on the PC via the click of the computer mouse. In addition, the Simon Task was administered across the incongruent and congruent trials, which were presented in a randomized order.

2.3 Data Analysis

Statistical analysis of the data was performed using the IBM SPSS v22 (SPSS Inc., Chicago Ill.) software. The Dichotic Listening was analyzed using a Repeated Measures Analysis of Variance (RMANOVA) across linguistic proficiency (bilingual and monolingual), age (younger and older), ear (right and left) and condition (non-forced, forced-left, and forced right). A separate RMANOVA was utilized to analyze the Simon Task across age (older and younger), linguistic proficiency (bilinguals and monolinguals) and condition (congruent and incongruent). A significance level of .05 was used for all statistical analyses. All post hoc multiple comparisons were performed using a Bonferroni adjusted critical alpha level

Chapter 3: Results

3.1 Dichotic Listening Task

Figure 2 shows participants' mean performance on the dichotic listening task across the non-forced, forced-right and forced-left condition, respectively, for the right and left ears. A 3x2x2x2 (condition, linguistic proficiency, age, ear) RMANOVA was performed. Results showed a significant main effect for attention condition [$F(2,90) = 7.75$; $p=.001$]. Such that, all participants reported more correct responses on the Forced-right condition than the other attention conditions. The results also showed a significant main effect of ear [$F(1,45) = 37.09$; $p<.001$], meaning the participants had more correct right ear responses overall compared to left ear responses. There was a significant 4- way interaction of condition x ear x age x linguistic proficiency [$F(2,90) = 3.89$; $p=.024$]. That is, the older monolingual groups had more right ear responses on the Forced-left condition than the other participant groups, suggesting the monolingual group may have less flexibility modulating attention on the Forced-Left condition.

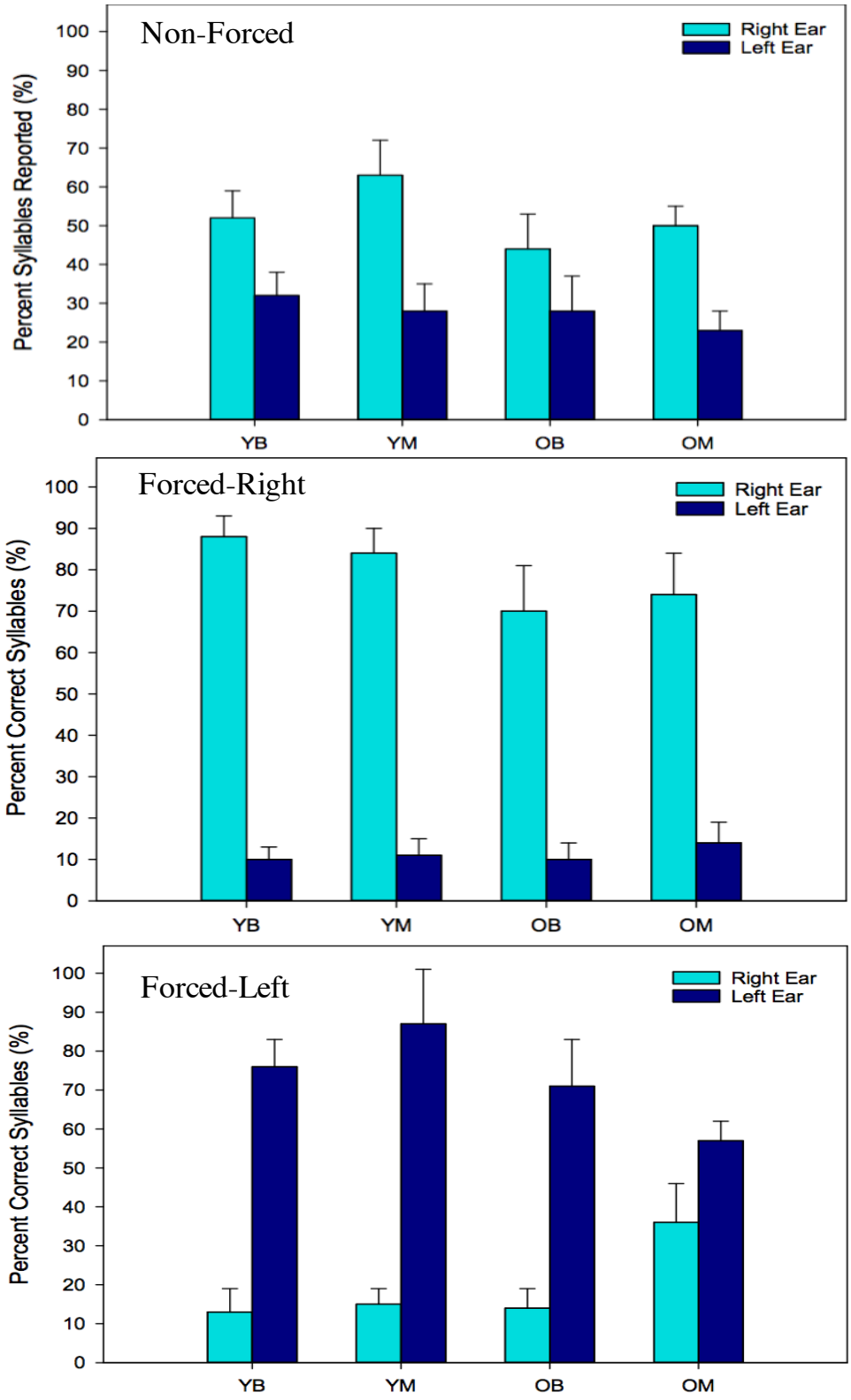

Figure 3.1: Percent syllables reported on a) Non-Forced Condition and percent correct on b) Forced-Right and c) Forced-Left Conditions

3.2 Simon Task

Figure 3 shows participants' mean performance on the Simon Task on the congruent and incongruent conditions for the younger and older monolinguals and bilinguals. A 2x2x2 (condition, age, linguistic proficiency) RMANOVA showed a significant main effect for condition [$F(1, 57) = 15.52$; $p<.001$]. That is, participants had more correct responses on the congruent condition than the incongruent condition. There was a significant 2-way interaction between condition x age [$F(1, 57) = 6.93$; $p=.011$]. Such that, younger participants scored significantly better on the incongruent condition compared to the older adults. There were no other significant ($p>.05$) main effects or interactions. Thus, there were no differences in performance scores between monolinguals and bilinguals.

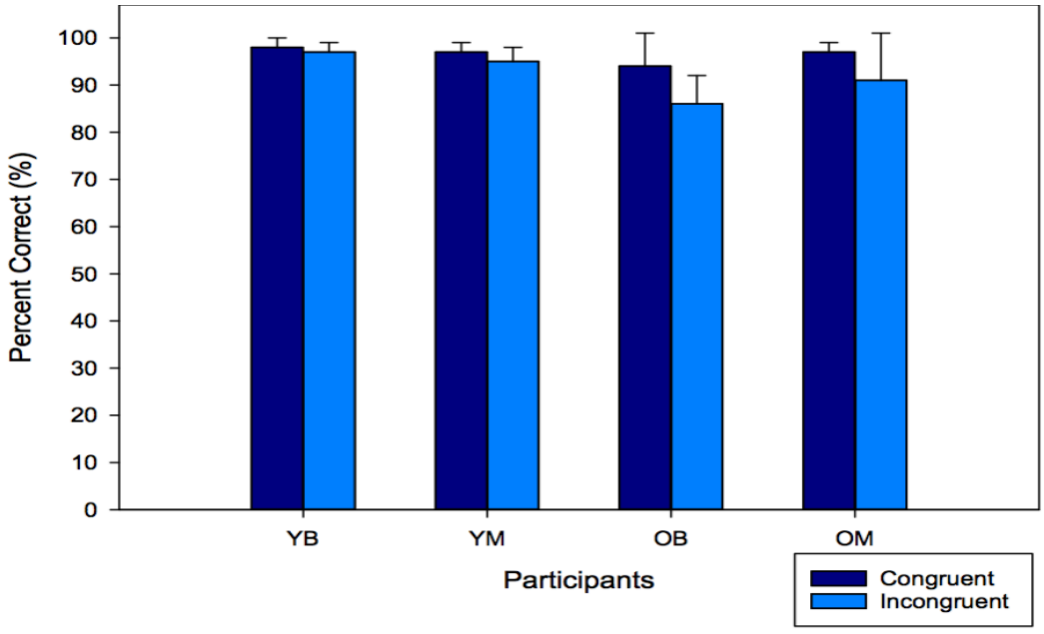

Figure 3.2: Percent correct on Congruent and Incongruent conditions

3.3 Simon Task Latency Response Times

Figure 4 shows participants' mean response latencies, in milliseconds, on the Simon Task on the congruent and incongruent conditions for the younger and older monolinguals and bilinguals. A 2x2x2 (condition, age, linguistic proficiency) RMANOVA showed there was a significant main effect for condition [$F(1, 57) = 91.15$; $p<.001$]. Such that, both groups performed faster during the congruent condition compared to the incongruent condition. There was a significant interaction between condition x age [$F(1, 57) = 8.70$; $p=.005$]. That is, the younger groups demonstrated faster response times on the congruent and incongruent conditions compared to the older participants. There was a main effect of language between subjects [$F(1,57) =4.25$; $p=.04$]. Such that, older bilinguals performed significantly slower than the older monolinguals across the congruent and incongruent condition. There were no other significant ($p>.05$) main effects or interactions. Thus, there were no other significant ($p>.05$) differences in response latencies between monolinguals and bilinguals.

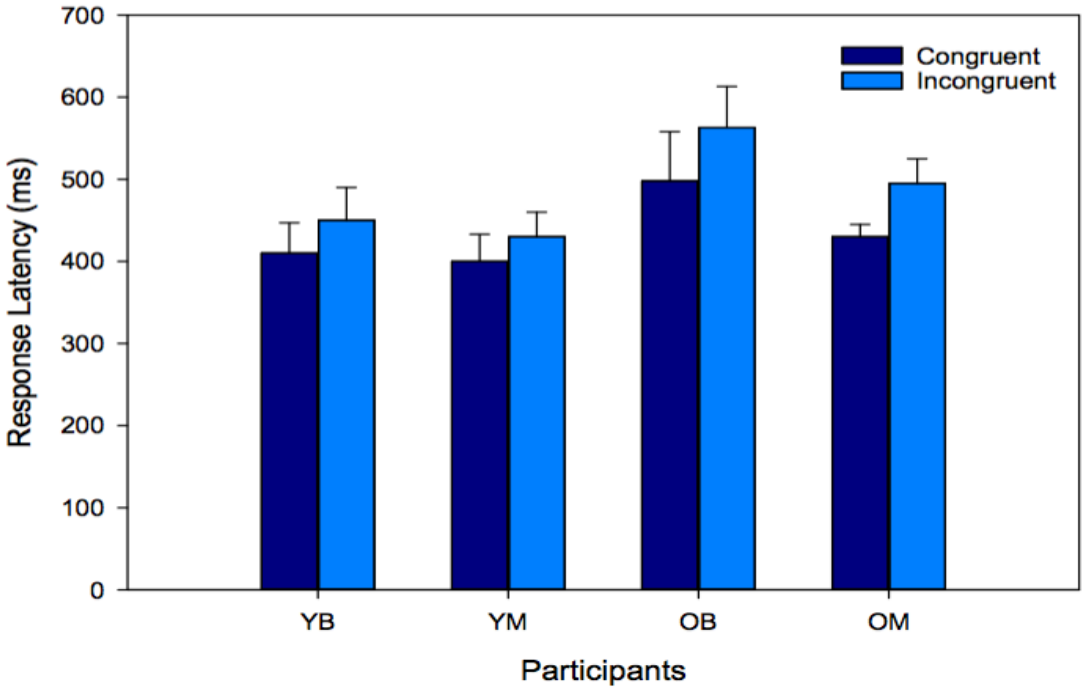

Figure 3.3: Latency Response Times (in ms) on Congruent and Incongruent conditions

Chapter 4: Discussion

The purpose of the study was to examine the effects of bilingualism on selective attention across the auditory and visual modalities. More specifically, the Dichotic Listening Task and Simon Task were used to assess auditory selective attention and visual selective attention, respectively, across younger and older bilinguals and monolinguals. The Dichotic Listening Task required the participant to ignore irrelevant auditory stimuli across the non-forced, forced-right and forced-left condition conditions. The Simon Task required the participant to attend to relevant visual information while ignoring competing stimuli.

The results from the Dichotic Listening Task indicated that all groups performed significantly better on the forced-right compared to the forced-left condition. Recent research has suggested that the forced-right and forced-left conditions, of the forced-attention Dichotic Listening Task, require different attentional control (Hugdahl, et al., 2009). That is, brain areas associated with cognitive load have been shown to be activated during the Force-Left condition but not the forced-right condition, suggesting that the forced-right condition may be less cognitively taxing (Hugdahl, et al., 2009). Therefore, in the current study, it was not surprising that the participants performed better on the forced-right condition because it is assumed to be easier than the forced-left condition.

The younger groups of participants performed better on the forced-right condition than the older group. This is consistent with previous literature showing that younger individuals have increased focused attention on the forced-right condition compared to older participants on the Dichotic Listening Task (Hugdahl, Carlsson & Eichele, 2001). Considering the forced-right condition may be less cognitively demanding, it is not

surprising the younger groups of participants, who have intact cognitive abilities (Bialystok, Martin & Viswanathan, 2005), perform better than the older groups, who may be experiencing normal age-related changes in cognition.

All participants in the current study reported overall more right ear responses than left ear responses. This result is largely consistent with the Right Ear Advantage theory (Soveri, et al., 2011). The premise of the Right Ear Advantage contends that speech sounds are processed more efficiently through the right ear, which is contralateral to the hemisphere where language is processed (Asbjornsen & Hugdahl, 1995). Our result is consistent with several studies which have also shown a Right Ear Advantage for processing speech (Asbjornsen & Hugdahl, 1995; Desjardins & Fernandez, 2018; Soveri, et al., 2011).

Older bilinguals outperformed the older monolinguals on the forced-left condition. Not only are older bilinguals able to ignore task irrelevant auditory information more efficiently, but their performance matched that of the younger bilinguals in the current study. Considering the Forced-Left condition is more cognitively demanding, this finding suggest older bilinguals may have enhanced executive function control across the auditory modality. The presence of a cognitive advantage in older bilinguals is consistent with the findings by Bialystok, Martin & Viswanathan (2005). Such that, older bilinguals performed better than older monolinguals on the selective attention task.

All participants in the current study performed better on the congruent condition compared to the incongruent condition on the Simon Task. The congruent and

incongruent conditions vary in complexity as different cognitive demands are required to complete each trial. That is, during the congruent trial, the shift key pressed matched the side of the stimulus presented. On the other hand, during the incongruent trial, the shift key pressed was contralateral to the side of the stimulus presentation, making it a more difficult task. Therefore, these findings are not surprising as individuals are expected to perform better on trials that are less cognitively demanding.

The findings from the current study showed that the older participants obtained less accurate responses on the incongruent condition compared to their younger counterparts. Also, overall, the younger and older groups demonstrated faster response times on the congruent condition than the incongruent condition. Considering the congruent condition is easier than the incongruent condition, it was expected that both age groups performed better on the former. Accurate performance on the incongruent condition requires the use of working memory to recall task instructions and inhibition to control the execution of the automatic response (Bialystok, Martin & Viswanathan, 2005). The additional recruitment of cognitive skills needed to complete the incongruent condition require additional time, thus explaining the slower response times of all groups (Ansaldo, Ghazi-Saidi & Adrover-Roig, 2015; Bialystok, Martin & Viswanathan, 2005).

Lastly, the results showed the younger group responded faster than the older group on the incongruent condition. Research has shown variations in the performance of individuals on the Simon Task across the lifespan. Such that, while no statistically significant differences on response times were found across young bilinguals and monolinguals on the Simon Task, research demonstrates older participants are slower in all conditions (Bialystok, Martin & Viswanathan, 2005). Most interestingly, the older

bilinguals had longer latencies on the congruent and incongruent trials compared to older monolinguals despite their overall similar performance on the Simon Task.

Chapter 5: Conclusion

Results from the current study suggest that bilingualism may influence selective attention. However, this advantage was only evidenced by the older bilinguals during the forced-left condition on the Dichotic Listening Task. The outperformance of the older bilinguals suggest language experience plays a role on executive function control, such that the more experience bilinguals gain managing two language systems can result in enhanced selective attention (Soveri, et al., 2011).

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Vita

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