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Degree of Bilingualism, Age, Income and Teacher Ratings of Giftedness as Potential Predictors of Dichotic Listening Performance

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DEGREE OF BILINGUALISM, AGE, INCOME, AND TEACHER RATINGS OF GIFTEDNESS AS POTENTIAL PREDICTORS OF DICHOTIC LISTENING PERFORMANCE

A Thesis

by

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ABSTRACT

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Bilinguals and gifted individuals have consistently shown distinctive patterns of performance on measures of brain laterality and auditory processing. The purpose of this study is to examine the relationship between bilingualism, teacher ratings of giftedness, and auditory divided attention by comparing children and adults with income partialed out. Child participants from first to fifth grade were included in addition to an adult comparison group. Assessment of bilingualism, auditory divided attention, and giftedness occurred via the Woodcock-Munoz Language Survey-III (WMLS-III), the Dichotic Test of Attention (DITA), and the Hispanic Bilingual Gifted Screening Instrument (HBGSI). The main hypothesis of this study is that both giftedness and bilingualism will lead to an increase in performance on the DITA after controlling for income. After controlling for age and income, bilingualism did not predict DITA performance in children, but it predicted DITA performance in adults.

DEDICATION

The completion of my graduate studies would have been impossible without the support of my family and loved ones. My mother, Marcela Isabel Garza, my father, Francisco Sierra, my girlfriend, Angela Farrah Gonzales, and my friends, gave me the motivation to move forward and complete my degree. Thank you for your love.

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CHAPTER I

INTRODUCTION

Statement of the Problem

Past research has focused on examining the performance of bilinguals on dichotic listening tests which measure selective attention and brain lateralization (e.g., Gresele, Vargas, Ortiz, dos Santos & Julio, 2013). Other studies have examined how the brain changes based on language learning and experience (Draganski et al., 2004). The very limited research in this area has left many questions unanswered about relations between giftedness and auditory processing in bilingual children. These are important processes to understand, as both are necessary for academic and social functioning.

Statement of the Purpose

The purpose of this study is to examine the relations between degree of bilingualism, age, income, and dichotic listening in samples of children and adults in the Rio Grande Valley, a bilingual region of the United States.

CHAPTER II

REVIEW OF THE LITERATURE

Dichotic Listening

Dichotic listening occurs when two auditory stimuli are simultaneously presented to each ear (Shinn, Baran, Moncrieff, Musiek, 2005). The stimuli can either be words, digits, syllables, or even sentences (Musiek & Chermak, 2015, p. 315). Participants can report both stimuli in what is called free recall or binaural integration mode (divided attention), involving the ability to process information presented to both ears simultaneously. Conversely, participants can report the stimuli in what is called directed report or binaural separation (directed attention), involving the ability to process information presented to one ear while ignoring the message presented to the other ear. The literature has consistently demonstrated a right-ear-left-hemisphere advantage for linguistic processing in typical, monolingual samples of the population (Musiek & Chermak, 2015). Kimura (1967) described the mechanisms by which this advantage occurs: The auditory nerves have both ipsilateral and contralateral connections to the auditory cortex. However, the contralateral connections have more nerve fibers than the ipsilateral connections, which in turn inhibit impulses arriving from the ipsilateral connections. The signals from the contralateral connections then arrive to the left hemisphere, where verbal stimuli are processed by the auditory cortex and associated areas. Thus, language processing has been demonstrated to be lateralized to the left hemisphere.

While this right-ear-left-hemisphere advantage for linguistic processing occurs in the general population, unique groups might demonstrate different patterns of ear advantage or lateralization, such as gifted (O'Boyle, 2005) or bilingual individuals (Hull & Vaid, 2007).

Giftedness

There are multiple theories that define giftedness. Some emphasize general intelligence, sometimes referred to as Spearman's *g,* while others take into account the influence of non-intellective factors such as motivation, appropriate cultural milieu, and historical period (Kaufman & Sternberg, 2008). Despite the profusion of different ideas, what they all share is the notion that giftedness has a biological basis. A review by Vaivre-Douret (2011) shows that intellectually gifted children develop sensory, locomotor, neuropsychological, and language skills earlier than average. Vaivre-Douret suggests that a higher degree of myelination and thus better processing speed are the cause of these differences. In the United States, an intelligence quotient (IQ) of 130 as measured by standardized intelligence assessments is typically considered the cut-off score for acceptance into school gifted programs (McIntosh, Dixon, & Pierson, 2012). Thus, there are many components of giftedness.

Giftedness and Underachievement

It is important to note that giftedness does not preclude underachievement at school (Vaivre-Douret, 2011). This might be because most gifted individuals demonstrate a set of characteristics known as overexcitabilities (Alias, Rahman, Majid & Mohd, 2013). The concept of overexcitabilities, which forms part of Dabrowski's formulation of positive disintegration theory, refers to the innate heightened intensity and sensitivity to stimuli in the intellectual, imaginational, emotional, psychomotor, and sensual domains (Piechowski, 1999). This means that gifted individuals might not experience the world in the same way that their non-gifted peers do, which can lead to misdiagnoses of Attention Deficit Hyperactivity Disorder (ADHD) and learning disabilities for the gifted individuals (Rinn & Reynolds, 2012). For example, individuals who are gifted and show signs of overexcitabilities might be misdiagnosed with ADHD, Autism Spectrum Disorder, Bipolar Disorder, and/or major depressive disorder. They are oftentimes medicated as well, with deleterious results (Webb, 2004). On the other hand, some gifted individuals are accurately diagnosed with ADHD and/or other learning disabilities such as dyslexia or non-verbal learning disability (NVLD). These individuals are denominated as twice-exceptional, or 2e. Understanding the relations between giftedness, learning disabilities, and academic achievement, especially among bilingual learners, is important as it can inform theories of brain development, but also has practical applications for educators and educational policymakers. An important first step in this area of research is to examine relations among giftedness, bilingualism, and dichotic processing.

Bilingualism involves parallel activation of both languages (Baum & Titone, 2014) which leads to interlanguage interference (Gasquoine, Weimer, & Amador, 2017). This interlanguage interference slows processing time (Green, 1998). Because of this slowed processing time in verbal tests, bilinguals who are gifted might be mistaken as average if given verbal intelligence tests for giftedness identification. Gifted bilingual children also can have learning disabilities, which can further prevent teachers from perceiving these students' strengths. Research is needed to understand how gifted bilinguals compare to others for this and many other reasons.

Giftedness and Lateralization

Past research using similar methodology has suggested that gifted individuals have a different pattern of laterality than that of average individuals. O'Boyle and Benbow (1990) used a dichotic test that presented different syllables to each ear, and a chimeric face task (which presents two different faces together in the same image), to determine the pattern of laterality exhibited by gifted youths compared to average ability youths. The participants included a group of gifted youth that had obtained an SAT score that placed them on the top .5% of the population and thus allowed them to be accepted in a gifted program at their school. The study also included youth of average abilities. The gifted and average ability groups consisted of 47 7th and 8th graders. Results demonstrated that the average ability youths showed the typical right-ear-left hemisphere advantage for processing linguistic stimuli. Gifted youths demonstrated a right-ear-left hemisphere advantage although this right-ear advantage was weaker when compared to that of the average ability youths, meaning that there was enhanced left-ear processing in the gifted youths. O'Boyle and Benbow interpreted these results as indicative of right hemisphere enhanced activity in gifted youth when compared to average ability youth in the processing of linguistic information.

Another study demonstrated that there were sex differences on a dichotic listening test, the Dean Lateral Preference Schedule (DLPS), and the Finger Tapping Test among gifted and average children (Lewandowski & Kohlbrenner, 1985). Participants consisted of 28 gifted and 28 average children. The mean ages for the gifted children and average children were 11.14 years and 11.59 years, respectively. The authors found no significant difference between all groups of participants on the Finger Tapping Test, but results with the dichotic listening test showed that control females (average ability females) demonstrated a significant right ear advantage compared to any subgroup (average ability males, gifted males and females), whereas gifted males and females performed similar to each other. Average males demonstrated less lateralization as well. Results obtained with the DLPS showed that control males demonstrated a significant right-side advantage, while gifted males performed similarly to both subgroups of females. Lewandowski and Kohlbrenner suggested that this pattern of performance is indicative of less hemispheric lateralization in gifted individuals when processing language.

O'Boyle (2005) demonstrated that mathematically gifted adolescents show an enhanced reliance on right-hemisphere processing and heightened interhemispheric communication compared to youths of average ability, as shown by using fMRI technology. It is important to note that the gifted participants in the studies discussed above still demonstrated a laterality pattern, but attenuation of the pattern was apparent when compared to that of average participants.

Bilinguals and Giftedness

Identifying gifted learners who are also bilingual or whose dominant language is not English poses challenges. Traditionally, white, upper-middle class students (Castellano, 1998) have dominated gifted and talented classrooms. Castellano identified some possible reasons that bilinguals are less likely to be subjects of identification for gifted and talented programs, such as the fact that many of these students have backgrounds that are linguistically and culturally distinct from those of the individuals who developed the measures to identify gifted students.

The underrepresentation of bilinguals in gifted programs also might be due to the ambiguous identification methods used for bilingual students, narrow definitions of giftedness favoring English-only speakers, (noted exceptions being those that use non-verbal intelligence scales such as the Raven's Progressive Matrices, and the Naglieri Non-verbal Ability Test), and/or failure to identify stereotype threat as a possible effect on student performance on standardized tests (Dorn, Kanikeberg, Burke, & Harmon, 2009; Esquierdo & Arreguin-

Anderson, 2012). One study suggested teachers have little understanding of the characteristics of Hispanic bilingual gifted students, which can potentially influence their identification for admittance into gifted and talented programs (Lewis, Novak, & Coronado, 2015).

The belief that bilingualism leads to deficits, cultural misunderstandings, and the asynchronous development that comes with giftedness are also part of the problem of underrepresentation (de Wet, 2005). This suggests that some educators fail to notice the strengths that come with being bilingual and how these strengths become enhanced in those who are gifted learners. Given these issues, the present study seeks to examine the relationship between giftedness and dichotic processing, as language and cognitive processing are important in the classroom. The following section describes some of the differences in language processing found to be exhibited by bilinguals, as compared to monolinguals.

Lateralization and Bilingualism

Kovács and Mehler (2009) have demonstrated that bilingual babies have enhanced cognitive abilities when compared to monolingual babies. In three eye-tracking studies, Kovács and Mehler showed that only bilingual babies were successful at redirecting their anticipatory gaze when the cue for a reward changed location.

Some researchers have found positive influences of bilingualism on cognition. For example, one study of Scandinavian participants found that bilinguals outperformed monolinguals on a forced-attention dichotic listening task with syllabic stimuli (Sovieri, Laine, Hamalainen, & Hugdahl, 2011). Specifically the researchers tested Finnish monolinguals and early simultaneous Finnish-Swedish bilinguals from two adult age groups and found that bilinguals performed better than the monolinguals in the forced-right and forced-left attention conditions, in which they were required to direct their attention to either the right- or the left-ear stimulus and inhibit information coming to the other ear. These findings support the idea of a bilingual advantage in directing attention and inhibiting task-irrelevant stimuli.

Further, Gresele et al. (2013) examined the dichotic listening abilities of monolingual Portuguese speakers, bilingual Portuguese-German speakers and bilingual Portuguese-Italian speakers and demonstrated that bilingualism has a positive influence on dichotic listening tests. The researchers used the Dichotic Digits Test (DDT), and the Staggered Spondaic Words (SSW), which measure binaural integration, meaning that participants had to report the information presented simultaneously to both ears. Participants included monolingual speakers of Brazilian Portuguese, bilingual Portuguese-Italian speakers (who learned their second language after the age of six), and bilingual Brazilian Portuguese-German speakers (who learned their second language before the age of six). Gresele et al. demonstrated the following pattern: On the Dichotic Digits Test, Portuguese-German speakers showed significant differences in right ear and total scores compared to monolinguals, with better results for bilinguals. Results revealed that overall bilinguals outperformed monolinguals on tests of dichotic listening. Further, results also showed statistically significantly better results for bilinguals who acquired their second language after the age of six when compared to bilinguals who acquired their second language before the age of six (however, see Hull & Vaid, 2007).

Another study analyzed auditory behavior of Japanese descendants that spoke Japanese and Brazilian Portuguese (bilinguals), Japanese descendants that spoke Portuguese but not Japanese (monolinguals) and non-oriental descendants that spoke Brazilian Portuguese (monolinguals). Results showed that the bilingual group performed significantly better on a dichotic listening test (Staggered Spondaic Words/SSW; Onoda, Pereira & Guilherme, 2006).

Similarly, Anderson (2012) examined the effects of bilinguals who learned Spanish as a second language. Anderson examined whether participants would have a greater deficit in selective attention when a target was in the second language and a distractor in the first language. Anderson found that bilinguals who were highly proficient in their second language were better at attending to their second-language target while ignoring their native-language distractor when compared to bilinguals who were less proficient in their second language.

Other studies have demonstrated that bilingual adults show increased bilateral hemispheric processing as compared to monolinguals (Hull & Vaid, 2007; Jafari, Esmaili, Toufan, & Aghamollaei, 2014). Specifically, Hull and Vaid conducted a meta-analysis concluding that early bilinguals demonstrated more bilateral hemispheric involvement, as compared to monolinguals. Jafari et al. used a dichotic listening test presenting syllables consisting of the six top consonants /b/, /d/, /g/, /k/, /t/, and /p/. These consonants were then combined with the vowel /a/ to create syllables. Degree of bilingualism was measured with the Bilingual Proficiency (BP) Score, which was obtained from the sum of correctly identified Persian words minus the sum of correctly identified English words, divided by the sum of correctly identified Persian words plus the sum of correctly identified English words. A score of zero indicates that a participant had a perfect balance between the two languages, while a positive or a negative score indicates that either the first language is dominant or the second language is dominant, respectively. The researchers found that a significant right-ear advantage was observed in the non-forced (free recall) condition just as in the forced right condition and decreased in the forced left condition. A Pearson correlation demonstrated a significant positive correlation between degree of bilingualism and the right ear accuracy in the non-forced, forced right, and forced left conditions. This means that less bilingual people demonstrate a higher right-ear advantage. A significant negative correlation was found between degree of bilingualism and the left ear accuracy for all three conditions. Thus, degree of bilingualism was associated with a higher left ear accuracy. The results of these studies demonstrate that more bilingualism is associated with higher bilateral hemispheric processing among adults.

Age-related Changes in Dichotic Listening

When studying dichotic listening in bilingual children as in the present study, it is important to consider the possibility of age-related changes in performance. One study demonstrated a trend towards decreased lateralization in older children (Moncrieff, 2011). Moncrieff examined children aged five through 12 years of age. They were tested using a dichotic digits test and a dichotic word listening test. The majority of children produced a right ear advantage. Males in the oldest child group (11 through 12 years of age) produced the highest left ear advantage. Overall, there was a trend towards smaller ear advantages as children aged. For older adults, there is an increased preference for reporting stimuli presented to the right ear due to decreased performance for left ear stimuli as age increases (Westerhausen, Bless, & Kompus, 2015). Musiek and Chermak (2015, p. 316) stated that there is a left ear disadvantage in children under the age of 12, as the corpus callosum has not attained the full myelin complement. Another study (Westerhausen et al., 2011) utilized a dichotic listening task presenting consonant-vowel syllables. They also used magnetic resonance imaging to measure the corpus callosum thickness in 20 children aged six through eight years of age and in a control group of 17 healthy adults (mean age of 25.9 years). The results demonstrated that children whose corpus callosum isthmus increased in thickness over the course of 2 years demonstrated diminished interhemispheric communication. However, those children demonstrating a decrease in callosal isthmus thickness showed an increase in interhemispheric communication transfer. In the adult control group, interhemispheric communication was positively correlated with isthmus thickness. Researchers must consider the effects that age has on laterality as measured by dichotic paradigms in both childhood and adulthood as there are clear developmental trends (Westerhausen et al., 2011).

Functional and Structural Aspects of Language Learning

Other researchers have examined how experience shapes different areas of the brain (Draganski et al., 2004), and more specifically, areas associated with the auditory cortex (Golestani, Price & Scott, 2011). Along these lines, researchers have found the following: Bilinguals use the dorsal anterior cingulate cortex (a structure involved in executive control functions), more efficiently than monolinguals, bilinguals might possess larger Heschl's gyri when compared to monolinguals, and that learning a second language increases the gray matter density of the left inferior parietal cortex (Abutalebi et al., 2012; Ressel et al., 2012; Mechelli et al., 2004).

Purpose

Collectively these studies indicate is that bilinguals, drawn from different geographic areas, have enhanced cognitive abilities, including auditory processing as measured by dichotic listening tests, and enhanced bilateral hemispheric involvement when compared to monolinguals. Yet, more comprehensive testing of auditory processing in bilingual individuals is needed to investigate the possibility of age differences. Research also has shown that gifted individuals demonstrate differences in lateralization as measured by dichotic listening tests and other related measures (O'Boyle & Benbow, 1990; O'Boyle, 2005). To date, studies have not examined the relationship between bilingualism, auditory processing, and giftedness among English-Spanish bilingual children. Studies examining dichotic listening and bilingualism have not included both children and adults. With respect to bilingualism and giftedness, the belief that bilingualism brings with it deficits (Bialystok, 2010) might be a hindrance for admittance into gifted and talented programs at schools. This is true even though the research presented above has consistently demonstrated that bilinguals from other parts of the world present better auditory processing skills, and that gifted individuals demonstrate enhanced right hemispheric involvement in linguistic processing as measured by dichotic listening tests.

This study addresses other gaps in the literature. Most studies involving dichotic listening and bilingualism measure bilingualism as a categorical variable. That is, one is either a bilingual or a monolingual. This way of operationalizing bilingualism does not capture variability in bilingual's degree of proficiency across their two languages (Takakuwa, 2005). Furthermore, most studies have not addressed how bilingualism relates to and predicts dichotic listening in a child sample. It is important to investigate these factors in a child sample as the literature suggests there are significant developmental changes in hemispheric involvement (Moncrieff, 2011). Giftedness in adults has been demonstrated to be associated with dichotic listening as a measure of divided attention (i.e., binaural integration), but much is unknown about these relations in a child bilingual sample. Other problems with dichotic studies involving bilinguals are the lack of control for the cognate facilitatory effect (Costa, Santesteban, & Cano, 2005). Cognate words are those which are similar to words in the other language of comparison. The cognate facilitatory effect occurs when cognate words are more efficiently processed than non-cognate words. Furthermore, the literature regarding bilingual cognitive advantages has been riddled with problems, such as the lack of matched groups in terms of socio-economic status (Paap, Johnson, & Sawi, 2015).

The purposes of this study are to: 1) examine the relations between degree of bilingualism and dichotic listening (divided attention) in adults and children; 2) examine the relations between teacher ratings of the Hispanic Bilingual Gifted Screening Instrument (HBGSI), dichotic listening, and degree of bilingualism in children; and 3) examine if there are age-related differences in dichotic listening by comparing English-Spanish bilingual children and adults. To this end, the variable of bilingualism was measured in a continuous manner. To control for the cognate facilitatory effect, half of the word pairs in the dichotic listening task were cognate, and the other half were not. Furthermore, income was controlled for in the analyses. Pearson's *r* correlations and multiple linear regression were the analyses performed on the Statistical Package for the Social Sciences (SPSS). Multi-level modelling was performed using R statistical analysis package.

The following hypotheses were tested in the present study:

1) Degree of bilingualism will be a significant predictor of dichotic listening accuracy in children and in adults, even after controlling for income: The more bilingual a participant is, the higher the dichotic listening accuracy.
2) Teacher-ratings of the Hispanic Bilingual Gifted Screening Instrument (HBGSI) in children will also be a significant predictor of dichotic listening: The higher the teacher-rating for a participant is, the higher dichotic listening accuracy there will be.
3) A Multi-Level Modeling analysis will demonstrate differences in dichotic listening between adults and children. Children will demonstrate a wider gap between the left and the right ears while this gap will be narrower in adults, as adults demonstrate higher callosal isthmus thickness which is associated with higher interhemispheric communication.

CHAPTER III

METHODOLOGY AND FINDINGS

Participants

Participants consisted of 59 children aged six through 11, (*M* = 7.86, *SD* = 1.80, Males: 25, Females: 34) from first to 5th grade, who were recruited from Cesar Chavez Elementary, from the Pharr-San Juan-Alamo Independent School District in the Rio Grande Valley, Texas, United States. More specifically, participants were recruited via contacting local school district staff. School staff, including teachers and principals, were informed about the research and its possible implications. Parent consent forms, along with the Hispanic Bilingual Gifted Screening Instrument (HBGSI), school permission forms, and the demographics survey, were sent on a sealed envelope to the schools. It was assumed the sample was bilingual as Cesar Chavez Elementary had a bilingual program where students were expected to speak in English or in Spanish on different days. The demographics survey asked parents about the child's age, father's and mother's income, years of education for both parents, and the otological background and hearing complaints of the child. The latter element is important so that those who have diagnosed or apparent hearing problems are excluded in order to prevent that confounding factor. Neither teachers, nor parents, nor child participants, were told about the hypothesis of this study. In addition, 61 adult participants aged 18 through 83 (M = 34.02, *SD* = 15.70, Males: 25, Females: 36) were recruited from the Rio Grande Valley community, including from the student population of the University of Texas Rio Grande Valley (UTRGV). This adult sample served as a comparison group for the child group. Thus, a total of 120 participants were recruited to participate in this study.

Measures

Demographics Survey

Socioeconomic status was determined using parental reports of maternal and paternal education and yearly total household income. Parents also were asked to report about the frequency of their child's use of English and Spanish, their child's ethnicity, age, etc. Adults reported their total household income, ethnicity, age, and language use.

Dichotic Test of Attention (DITA)

The DITA was administered through the software E-Prime 2.0 (Schneider, Eschman, & Zuccolotto, 2012), a software commonly used in psychological research. The DITA consists of 2 practice items and 64 word-pair trials, 32 of which are cognate word pairs and the other 32 non-cognate word pairs (see appendix A for the list of words). This is in order to control for the cognate facilitatory effect that occurs in bilinguals (Costa, Santesteban, & Cano, 2005). There was a total of 128 words. The DITA words vary by length and word frequency and each word in a pair was matched accordingly (Techentin & Voyer, 2011). Furthermore, the volume and sound onset of each word on a pair was matched (Musiek & Chermak, 2015), meaning that words had the same loudness and began at the same time. Words were also not matched with other semantically similar words. Before each pair of words was presented, a blank screen appeared for 1000 milliseconds. The presentation for each word pair lasted for 4000 milliseconds, and participants had unlimited time to provide their answers before the next 1000 millisecond blank screen appeared, and the cycle was repeated for all the 64 word-pairs. Scores for the right ear, left ear, and the combined scores for both ears, were treated as separate variables. There was the same number of left ear words as right ear words. One point was awarded for each correctly reproduced left- or right-ear word, so that separate scores for the left and the right ears were obtained. A score of 64 on each ear was a perfect score. Additionally, there was a "both ears" measure (i.e., both words were correctly recalled) where one point was awarded for each correctly recalled word-pair. A score of 64 was also a perfect score in the "both-ears" measure. For cognate accuracy and non-cognate accuracy, a score of 32 was a perfect score. One point was awarded for each cognate or non-cognate word pair that was correctly recalled. To measure degree of laterality, the left ear score was subtracted from the right ear score, and then transformed into absolute values. All of the DITA stimuli consisted of common English and Spanish words selected from a list of cognate and non-cognate words compiled by Schwartz, Kroll & Diaz (2007). The word-pair trials were all presented in random order for all participants, and each participant had a new random order of presentation. Adult participants typed the words they heard as soon as the instructions indicated they might do so, and participants were not penalized for misspellings provided the word typed was recognizable as a presented word. Adult participants also rated their typing ability and speed on a Likert scale. Child participant responses were typed by the research assistant. The DITA measures divided attention in participants, as they must listen to both right and left auditory channels and must report both words. It is also a measure of language cerebral laterality, due to the verbal nature of the stimuli and the contralateral connections between the ears and the left and right brain hemispheres.

Language proficiency and dominance

Participants were administered English and Spanish versions of the Picture Vocabulary subtest of the Woodcock-Muñoz Language Survey-III (WMLS-III; Woodcock, Alvarado, Ruef,

& Schrank, 2017). This allowed a calculation of picture vocabulary in both languages, with age-corrected norms (*M* = 100, SD =15). To determine the participant's language dominance, difference scores were created for each participant. This was done by subtracting the English from the Spanish language picture vocabulary score. Bilingual participants have traditionally been divided into two groups based on the overall difference scores established a priori: Spanish-dominant (>10), English-dominant (< –10) and balanced bilinguals (–10 to +10). These cutoffs have been used successfully to form groups that differed significantly on language-based tests (e.g., Weimer & Gasquoine, 2016), though there is no consensus among researchers about which values should be used for separating balanced bilingual vs. language dominant groupings (Takakuwa, 2005). To address this issue in the literature, a Degree of Bilingualism score was calculated: The difference between Spanish and English was calculated, and then the result was transformed to a variable consisting of absolute values, which were then transformed by multiplying by minus one. This provides a variable in which the highest value, i.e., zero, indicates higher degree of bilingualism. Lower negative values evidenced decreasing degrees of bilingualism.

Teacher Rating of the Hispanic Bilingual Gifted Screening Instrument (HBGSI)

A short version of the Hispanic Bilingual Gifted Screening Instrument (HBGSI) checklist to be completed by classroom teachers based on work by Irby and Lara-Alecio (1996) was used to assess gifted traits in child participants (see appendix B). This instrument is preferred as each school uses different criterion for giftedness, and a uniform criterion is preferred for this study. The HBGSI has a high split-half reliability when the items were halved on an even-odd number basis. The obtained coefficients ranged from .79 to .94 (Fultz, Lara-Alecio, Irby, & Tong, 2013). The split-half reliability was also high when half of the items were randomly selected and correlated with the remaining items, with coefficients ranging from .93 to .97. Fultz et al. (2013) also found that the HBGSI had concurrent validity when correlated with the Bilingual Verbal Ability Test (BVAT). The BVAT measures vocabulary and oral academic proficiency. The correlation between the HBGSI and the BVAT was moderate, $r = .39$, $p = .01$. Fultz et al. further stated that a short form of the HBGSI may be used for further research. The HBGSI also highly correlates with the Naglieri Nonverbal Ability Test (NNAT), with correlations as high as .50 with a $p < .01$ (Irby, Lara-Alecio, & Rodriguez, 1999). The HBGSI was selected instead of more traditional measures of giftedness as those traditional measures tend not to favor bilingual speakers (Irby & Lara-Alecio, 1996).

Procedure

Child assent was sought both by the teachers and the research assistants involved in this study after parental consent was obtained. Teachers completed the HBGSI for each child participant. Two research assistants, who were also naïve as to the hypotheses of this study, asked the child for assent to participate in either English or Spanish. This was done based on the child's preferred language. In order to know what the child's preferred language was, he or she was asked by the research assistant to provide the preferred language. The research assistants also built rapport with the child participant using the preferred language through small talk as the child was taken to the testing room.

The child was assessed in a quiet room. The WMLS-III was administered after some rapport-building questions were asked regarding the language currently being spoken. The WMLS-III was administered in the language that had been used thus far. Then the WMLS-III was administered in the other language. The WMLS-III was administered in either English or

Spanish. Responses had to be in either language. When administration was in English, the child had to reply in English, and the same applied to Spanish. If a child spoke in the language formerly assessed, the research assistant in charge of administering the assessment politely asked the child to proceed through the assessment in the corresponding language being used. After the WMLS-III was administered, the other research assistant who was in charge of record keeping compared results from both languages. The researcher administered the DITA in the dominant language. This measure ensured optimal results by avoiding the confounding factor of language barriers, since the items on the DITA consist of words.

The child was asked to place the stereo headphones on his or her ears. The child was instructed to repeat both words in the order in which they were heard. The words were presented simultaneously, one on each ear. Clarification on the assessment was provided to the children as requested. Once the assessment began, the research assistant typed the words that the child was able to hear and repeat back. The child was given the chance to prepare for the next item by being asked if he or she was ready to proceed. After the DITA was finished, the researcher thanked the child for his or her participation and handed a book to the child. The researcher then asked the child to go back to his or her classroom.

Adult participants were recruited through word of mouth throughout the Rio Grande Valley, a bilingual region of the United States. Adult participants were asked to read the consent form and to sign it if they agree to participate. Then they were asked to complete the demographics survey. The rest of the procedures were virtually the same as those for the child participants: They completed the WMLS-III in English and Spanish, and they also completed the DITA in the dominant language as determined by the WMLS-III. Adult participants were asked to read the instructions from the DITA displayed on the screen, and to type in the words that they heard from the DITA in the order in which they were heard. As with child participants, the words were presented simultaneously, and adult participants had to pay attention to both auditory channels before providing a response. Adults were also asked to type into the computer the two words in the order in which they were heard. After the session was over, the participant was thanked for his or her participation by the researcher.

Results

Table 1. Means, Standard Deviations, and Ranges for age, income, vocabulary, degree of bilingualism, dichotic listening, and HBGSI Score

	Age Groups	N	Mean	Standard Deviation	Range
Age**	Children	59	7.86	1.80	6 – 11
	Adults	61	34.02	15.70	18 – 83
Income (factor of 1,000)	Children	44	30.71	27.78	0 – 118.80
	Adults	51	26.35	39.4	0 – 200
Spanish Vocabulary	Children	59	71.37	13.45	37 – 94
	Adults	59	72.27	11.53	33 – 88
English Vocabulary	Children	58	81.17	22.33	27 – 117
	Adults	59	89.22	9.86	71 – 118
Degree of Bilingualism**	Children	58	-27.56	17.44	-76 – -2
	Adults	59	-17.59	16.1	-64 – 0
Left Ear Accuracy**	Children	59	22.45	11.84	1 – 44
	Adults	61	38.31	15.18	6 – 63
Right Ear Accuracy**	Children	59	29.91	12.77	4 – 55
	Adults	61	39.13	14.83	4 – 61
Both Ears Accuracy**	Children	59	11.93	10.45	0 – 40
	Adults	61	26.03	17.77	0 – 60
Cognate Accuracy**	Children	59	4.67	4.92	0 – 19
	Adults	61	11.93	8.37	0 – 29
Non-cognate Accuracy**	Children	59	7.27	5.95	0 – 21
	Adults	61	14.09	9.77	0 – 32
Laterality**	Children	59	11.32	9.38	1 - 39
	Adults	61	7.08	7.15	0 - 36
HBGSI Score***	Children	54	3.77	1.15	1.41 – 5

* $p < .05$.
** $p < .01$.
*** Hispanic Bilingual Gifted Screening Instrument score.

Initially, descriptive analyses were computed for all variables. Table 1 provides the means, standard deviations, and ranges for age, income, vocabulary, degree of bilingualism, dichotic listening, and teacher rated HBGSI score for children and adults. Then, the child and adult groups were compared on age, income, vocabulary, degree of bilingualism, and dichotic listening. Next, the intercorrelations among age, income, vocabulary, degree of bilingualism, left, right, and both ears accuracy, cognate, and non-cognate accuracy, laterality, and giftedness (for children only). These are shown in Tables 2 and 3. A one-dollar difference is likely to not have an influence on any analysis of the relationship between income and any other variable. To that end, the variable of income was modified through the "compute variable" feature of SPSS. This modification involved dividing income by 1,000 so that differences in income were measured by a factor of a thousand.

Table 2. Intercorrelations among age, income (factor of 1,000), vocabulary, degree of bilingualism, left, right, and both ears accuracy, cognate, and non-cognate accuracy, laterality, and HBGSI Score for children

	1	2	3	4	5	6	7	8	9	10	11	12
1.Age	-											
2. Income	-.19	-										
3. Spanish Vocabulary	-.30*	-.30*	-									
4. English Vocabulary	-.03	.52**	-.49**	-								
5. Degree of Bilingualism	.23	-.32*	.57**	-.27*	-							
6. Left Ear Accuracy	.50**	-.35*	.02	-.11	.11	-						
7. Right Ear Accuracy	.47**	-.09	.01	-.21	.03	.47**	-					
8. Both Ears Accuracy	.48**	-.38**	.16	-.30*	.13	.87**	.76**	-				
9. Cognate Accuracy	.45**	-.37*	.20	-.38**	.14	.80**	.68**	.95**	-			
10. Non-cognate Accuracy	.48**	-.36*	.12	-.22	.11	.86**	.77**	.97**	.85**	-		
11. Laterality	.06	.38*	-.15	.00	-.11	-.37**	.41**	-.14	-.18	-.10	-	
12. HBGSI Score	-.12	.21	-.14	.26	-.10	.07	-.05	.06	.00	.10	-.15	-

* $p < .05$.

** $p < .01$.

Table 3. Intercorrelations among age, income (factor of 1,000), vocabulary, degree of bilingualism, left, right, and both ears accuracy, cognate and non-cognate accuracy, and laterality for adults

	1	2	3	4	5	6	7	8	9	10	11
1. Age	-										
2. Income	.21	-									
3. Spanish Vocabulary	.68**	-.17	-								
4. English Vocabulary	-.07	.10	-.23	-							
5. Degree of Bilingualism	.52**	-.17	.82**	-.72**	-						
6. Left Ear Accuracy	-.03	.01	.06	-.27*	.23	-					
7. Right Ear Accuracy	-.07	.18	.00	-.17	.10	.77**	-				
8. Both Ears Accuracy	.06	.10	.15	-.28*	.29*	.91**	.90**	-			
9. Cognate Accuracy	.04	.07	.15	-.26*	.27*	.89**	.89**	.98**	-		
10. Non-cognate Accuracy	.08	.11	.15	-.28*	.30*	.90**	.88**	.98**	.92**	-	
11. Laterality	-.04	.15	-.20	.14	-.25	-.31*	-.06	-.30*	-.26*	-.32*	-

* $p < .05$.

** $p < .01$.

Testing Hypotheses

To test Hypothesis 1 (if degree of bilingualism significantly predicts dichotic listening accuracy in children and adults, after controlling for income, see Paap, Johnson, & Sawi, 2015) and Hypothesis 2 (if teacher rated HBGSI score predicts dichotic listening in children), six linear regression analyses were conducted to examine the six unique dependent variables (left ear accuracy, right ear accuracy, both ears accuracy, cognate accuracy, non-cognate accuracy, and laterality), beginning with the child sample, then proceeding with the adult sample. All the models included the following predictors: age, income (as a factor of 1,000), degree of bilingualism, and the teacher rated HBGSI score (children only).

Results of Analyses of Children's Dichotic Listening Performance

The first analysis examined left ear accuracy, the second right ear accuracy, the third both ears accuracy, the fourth cognate accuracy, the fifth non-cognate accuracy, and the sixth laterality. All analyses included the same predictors: age, income (factor of 1,000), degree of bilingualism, and teacher rated HBGSI score.

The overall left ear analysis result was significant, $F(4, 40) = 4.95$, $p = .00$, with an R^2 of .35. Of all predictors, only age was a significant predictor of accuracy for the left ear. The left ear analysis result showed that the following is the coefficient for each predictor (the first number is the intercept) -3.72 + 3.28 (Age) - .11 (Income) + .02 (Degree of Bilingualism) + 1.39 (teacher rated HBGSI score). Thus, children's performance accuracy for the left ear words increased by 3.28 words for every year of increase in age (significant), decreased by 0.11 words for every increase of a thousand dollars (insignificant), increased by .02 words for every unit increase of degree of bilingualism (insignificant), and increased by 1.39 words for every unit increase of teacher rated HBGSI score (insignificant).

The overall right ear analysis was significant, $F(4, 40) = 3.57$, $p = .01$, with an R^2 of .28. Of all predictors, only age was a significant predictor of accuracy for the right ear. The right ear analysis result showed that the following is the coefficient for each predictor (the first number is the intercept) .28 + 3.71 (Age) + .00 (Income) + .01 (Degree of Bilingualism) + .26 (teacher rated HBGSI score). Thus, children's performance accuracy for the right ear words increased by 3.71 words for every year of increase in age (significant), by 0.00 words for every increase of a thousand dollars (insignificant), by .01 words for every unit increase of degree of bilingualism (insignificant), and by .26 words for every unit increase of teacher rated HBGSI score (insignificant).

The overall analysis for both ears combined was significant, $F(4, 40) = 5.67$, $p = .00$, with an R^2 of .39. Age and income were the only significant predictors of accuracy for both ears combined. The results of the analysis for both ears combined showed the following is the coefficient for each predictor (the first number is the intercept) -8.93 + 2.66 (Age) - .10 (Income) + .04 (Degree of Bilingualism) + 1.19 (teacher rated HBGSI score). Thus, children's performance accuracy for both ears combined increased by 2.66 words for every year of increase in age (significant), decreased by 0.10 words for every increase of a thousand dollars (significant), increased by .04 words for every unit increase of degree of bilingualism (insignificant), and increased by 1.19 words for every unit increase of teacher rated HBGSI score (insignificant).

The overall cognate analysis was significant, $F(4, 40) = 4.30$, $p = .00$, with an R^2 of .32. Of all predictors, only age was a significant predictor of cognate accuracy. The results of the cognate analysis showed the following is the coefficient for each predictor (the first number is the intercept) -2.90 + 1.08 (Age) - .05 (Income) + .03 (Degree of Bilingualism) + .31 (teacher rated HBGSI score). Thus, children's performance accuracy for cognate words increased by 1.08 words for every year of increase in age (significant), decreased by .05 words for every increase of a thousand dollars (insignificant), increased by .03 words for every unit increase of degree of bilingualism (insignificant), and increased by .31 for every unit increase of teacher rated HBGSI score (insignificant).

The overall non-cognate analysis was significant, $F(4, 40) = 5.42$, $p = .00$, with an R^2 of .38. Of all the predictors, only age was a significant predictor of non-cognate accuracy. The results of the non-cognate analysis showed the following is the coefficient for each predictor (the first number is the intercept) -5.86 + 1.58 (Age) - .06 (Income) + .02 (Degree of Bilingualism) + .83 (teacher rated HBGSI score). Thus, children's performance accuracy for non-cognate words increased by 1.58 words for every year of increase in age (significant), decreased by 0.06 words for every increase of a thousand dollars (insignificant), increased by .02 words for every unit increase of degree of bilingualism (insignificant), and increased by .83 words for every unit increase of teacher rated HBGSI score (insignificant).

The overall laterality analysis was insignificant, $F(4, 40) = 1.19$, $p = .13$, with an R^2 of .17. Of all the predictors, only income was a significant predictor of laterality. The results of the laterality analysis showed the following is the coefficient for each predictor (the first number is the intercept) 7.70 + .50 (Age) + .15 (Income) + .01 (Degree of Bilingualism) – 1.21 (teacher rated HBGSI score). Thus, children's laterality increased by .50 words for every year of increase in age (insignificant), increased by .15 words for every increase of a thousand dollars (significant), increased by .01 words for every unit increase of degree of bilingualism (insignificant), and decreased by 1.21 words for every unit increase of teacher rated HBGSI score (insignificant).

Results of Analyses of Adults' Dichotic Listening Performance

A series of six linear regression analyses was conducted for adults' data on dichotic left ear accuracy, right ear accuracy, both ears accuracy, cognate accuracy, non-cognate accuracy, and laterality. Age, income (factor of 1,000), and degree of bilingualism were predictors for all the analyses. The overall left ear-word analysis result was not significant, $F(3, 48) = 2.37$, $p = .08$, with an R^2 of .14. Age and degree of bilingualism were significant predictors, with degree of bilingualism being more significant. The results of the left ear analysis showed the following is the coefficient for each predictor (the first number is the intercept) 55.50 - .35 (Age) + .06 (Income) + .41 (Degree of Bilingualism). Thus, adults' left ear accuracy decreased by .35 words for every year of increase in age (significant), increased by .06 words for every increase of a thousand dollars (insignificant), and increased by .41 words for every unit increase of degree of bilingualism (significant).

The right ear analysis was significant, $F(3, 48) = 3.29$, $p = .03$, with an R^2 of .18. Age, income, and degree of bilingualism were significant predictors of right ear accuracy, with age being the most significant, followed by degree of bilingualism and by income. The results of the right ear analysis showed the following is the coefficient for each predictor (the first number is the intercept) 55.56 - .42 (Age) + .13 (Income) + .41 (Degree of Bilingualism). Thus, adults' right ear accuracy decreased by .42 words for every year of increase in age (significant), increased by .13 words for every increase of a thousand dollars (significant), and increased by .41 words for every unit increase of degree of bilingualism (significant).

The analysis for both ears combined was significant, $F(3, 48) = 3.00$, $p = .04$, with an R^2 of .17. Of all predictors, only degree of bilingualism was a significant predictor of both ears accuracy. The results of the analysis for both ears combined showed the following is the coefficient for each predictor (the first number is the intercept) 43.39 - .34 (Age) + .11 (Income) + .55 (Degree of Bilingualism). Thus, adults' accuracy for both ears combined decreased by .34 words for every year of increase in age (insignificant), increased by 0.11 words for every increase of a thousand dollars (insignificant), and increased by .55 words for every unit increase of degree of bilingualism (significant).

The cognate analysis was significant, $F(3, 48) = 2.90$, $p = .04$, with an R^2 of .16. Of all predictors, only degree of bilingualism was a significant predictor of cognate accuracy. The results of the cognate analysis showed the following is the coefficient for each predictor (the first number is the intercept) 20.24 - .17 (Age) + .05 (Income) + .26 (Degree of Bilingualism). Thus, adults' cognate accuracy decreased by .17 words for every year of increase in age (insignificant), increased by 0.05 words for every increase of a thousand dollars (insignificant), and increased by .26 words for every unit increase of degree of bilingualism (significant).

The non-cognate analysis was significant, $F(3, 48) = 2.83$, $p = .04$, with an R^2 of .16. Of all predictors, only degree of bilingualism predicted non-cognate accuracy. The results of the cognate analysis showed the following is the coefficient for each predictor (the first number is the intercept) 23.02 - .17 (Age) + .06 (Income) + .29 (Degree of Bilingualism). Thus, adults' non-cognate accuracy decreased by .17 words for every year of increase in age (insignificant), increased by 0.06 words for every increase of a thousand dollars (insignificant), and increased by .29 words for every unit increase of degree of bilingualism (significant). The laterality analysis was not significant, $F(3, 48) = .73$, $p = .53$, with an R^2 of .05.

Age Group Differences in Dichotic Listening

Hypothesis 1, that degree of bilingualism was going to predict higher accuracy in dichotic listening, was supported only for adults, but not for children alone. Given that these two groups differ in dichotic listening as was demonstrated in the multiple linear regression analyses, a Multivariate Analysis of Covariance (MANCOVA) was conducted to examine age group related differences in accuracy for each ear, for both combined, for the cognate and non-cognate accuracy, and for laterality, after controlling for degree of bilingualism (see figure 1, and Table 4). Furthermore, a multilevel modeling analysis was conducted to examine on an item-by-item basis whether children and adults differed in dichotic listening after controlling for degree of bilingualism.

Multivariate Analysis of Co-variance (MANCOVA): Effects of age groups and degree of bilingualism on dichotic listening

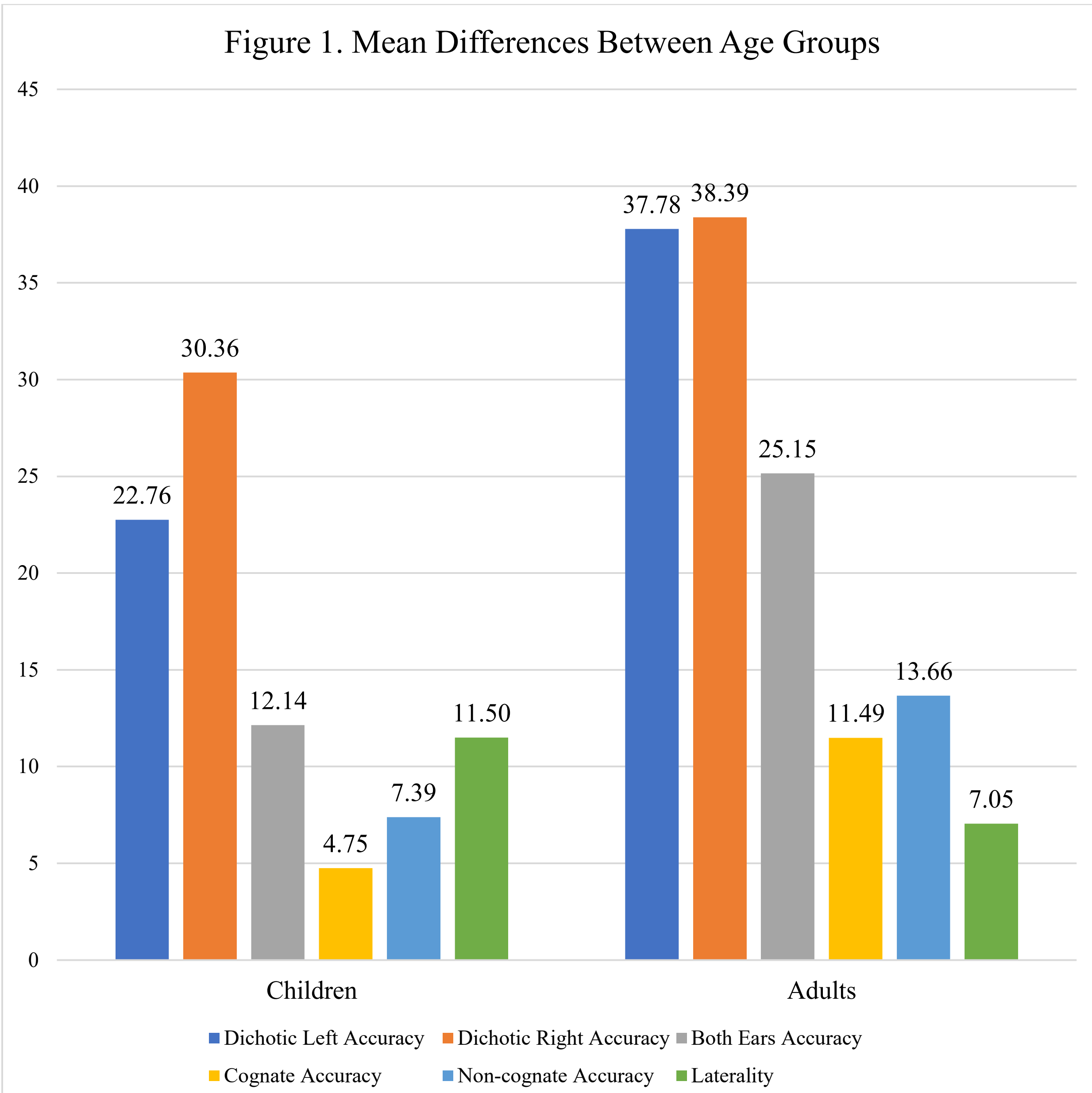

Table 4. Multivariate Analysis of Dichotic Listening

Source	Dependent Variables	Sum of Squares	df	Mean Square	F	Partial Eta Squared
Age Groups	Left Ear Accuracy	4980.48	1	4980.48	27.85**	.19
	Right Ear Accuracy	1508.84	1	1508.84	8.22**	.06
	Both Ears Accuracy	3334.35	1	3334.35	16.87**	.13
	Cognate Accuracy	931.62	1	931.62	21.27**	.15
	Non-cognate Accuracy	734.19	1	734.19	11.94**	.09
	Laterality	351.08	1	351.08	5.17*	.04
Degree of Bilingualism	Left Ear Accuracy	636.68	1	636.68	3.56	.03
	Right Ear Accuracy	91.35	1	91.35	.49	.00
	Both Ears Accuracy	1136.54	1	1136.54	5.75*	.04
	Cognate Accuracy	230.35	1	230.35	5.26*	.04
	Non-cognate Accuracy	348.21	1	348.21	5.66*	.04
	Laterality	225.57	1	225.57	3.32	.03
Error	Left Ear Accuracy	20386.07	114	178.82		
	Right Ear Accuracy	20908.07	114	183.40		
	Both Ears Accuracy	22519.97	114	197.54		
	Cognate Accuracy	4993.00	114	43.79		
	Non-cognate Accuracy	7008.88	114	61.48		
	Laterality	7737.77	114	67.87		

* $p < 0.05$.

** $p < 0.01$.

There was a statistically significant difference between children and adults in word reproduction accuracy for left, right, both ears combined, and for cognate and non-cognate accuracy, and laterality after controlling for degree of bilingualism, F (1, 114) = 27.85, $p < .01$ (left ear accuracy), F (1, 114) = 8.22, $p < .01$ (right ear accuracy), F (1, 114) = 16.87, $p < .01$ (both ears combined), F (1, 114) = 21.27, $p < .01$ (cognate accuracy), F (1, 114) = 11.94, $p < .01$ (non-cognate accuracy), F (1, 114) = 5.17, $p < .05$ (laterality). Given these differences between children and adults, a multilevel modeling analysis was conducted to test differences in accuracy between the left and the right ear for both children and adults.

Multilevel Modeling: Subject and Words as random factors to examine the effect of age group on dichotic listening accuracy

In this analysis, subject and words were treated as random factors. Age groups and ears were treated as fixed factors (see Table 5). The dependent variable was the dichotic-listening accuracy. Statistical significance was determined by calculating p values from a z distribution. There was a significant main effect of ear, (estimate = 0.27, SE = 0.02, $z = 12.54$, $p < .01$), with the right ear having higher accuracy than the left ear. Furthermore, there was a significant main effect of age groups, (estimate = -0.60, SE = 0.11, $z = -5.39$, $p < .01$), with adults having a higher accuracy than children. There also was a significant interaction between ear and age groups, (estimate = 0.12, SE = 0.02, $z = 5.77$, $p < .01$). Children demonstrated a higher gap between the two ears in dichotic listening accuracy than adults, although both groups scored higher for the right ear words than the left ear words (see Table 6).

Table 5. Descriptive Statistics from Linear Mixed Model

Ear	Age Groups	N	Mean	Standard Deviation	Range
Left	Children	3776	.35	.48	0-1
Right	Children	3776	.47	.50	0-1
Left	Adults	3904	.60	.49	0-1
Right	Adults	3904	.61	.49	0-1

Table 6. Linear Mixed Model

Fixed Effects	Estimate	Standard Error	*z*-value	*p*
Ear	.27	.02	12.54	< .01
Age Groups	-.60	.11	-5.39	< .01
Interaction: Ear by Age Groups	.12	.02	5.77	< .01

CHAPTER IV

SUMMARY AND CONCLUSION

Results from the present study indicate that teacher rated HBGSI score is not a significant predictor of dichotic listening accuracy, failing to replicate previous findings by O'Boyle & Benbow (1990), and by O'Boyle (2005). Furthermore, degree of bilingualism in children is not a predictor of dichotic listening accuracy, either. This finding is different from what other researchers demonstrate with adults. This finding also highlights the importance of including a broad age range of participants in studies of dichotic listening differences. Results suggest that bilingualism is not the only factor influencing hemispheric processing differences in the general population. Moncrieff (2011), and Westerhausen et al. (2015) also illustrate how children and adults differ in dichotic listening performance.

For children, only age was a significant predictor of dichotic listening performance for the left and the right ears and also for cognate and non-cognate word accuracy. Age and income were significant predictors of accuracy for the both ears combined, with age being a better predictor as indicated in the regression equation. Thus, age was always a significant predictor of dichotic accuracy for children. Hypotheses 1 (that degree of bilingualism would predict dichotic listening accuracy after controlling for income) and 2 (that the HBGSI score would predict dichotic listening accuracy) were not supported with respect to children.

The results with adults are markedly different from those obtained with children. With respect to adults, results corroborate the findings in the literature with respect to bilingual differences in hemispheric information processing (Hull & Vaid, 2007; Jafari, Esmaili, Toufan, & Aghamollaei, 2014). There was a marginally significant correlation (p = .058) between degree of bilingualism and laterality. Additionally, the more bilingual an adult is, meaning that there is a smaller difference between Spanish and English proficiency, the higher the accuracy for trials where both words were correctly recalled and repeated, and this is true regardless of whether the word pairs were cognate or non-cognate. The results also indicate that the dichotic word recall accuracy difference in bilingual adults exists regardless of income status. The first analysis result, which predicted left ear accuracy, was not significant. The second analysis result, predicting the right ear accuracy, was significant, and age was the most significant predictor followed by degree of bilingualism and then income. The third analysis result, predicting accuracy for both ears combined, was significant. In the both ears combined analysis, degree of bilingualism was the only significant predictor. The sixth analysis, predicting laterality, was not significant, meaning that degree of bilingualism does not predict laterality after controlling for age and income. Thus, hypothesis 1 (that degree of bilingualism would predict dichotic listening accuracy after controlling for income) was supported with respect to adults.

The results from the MANCOVA and from the MLM analyses demonstrate that children have a wider gap between the left and right ear accuracies than adults. These findings support the reports in the literature which demonstrate how corpus callosum development leads to a general decrease in laterality (Westerhausen et al., 2011). Furthermore, these findings are significant as they included a bilingual sample and the comparisons were done between adults and children as opposed to within a group of children or a group of adults.

Based on the findings of this study, it appears that degree of bilingualism increases in importance as a person ages. Degree of bilingualism did not predict any of the dichotic listening performance in children. However, degree of bilingualism was a significant predictor in the adult sample, particularly when the accuracy for both ears was measured. One possible explanation for the lack of support for hypothesis 1 in the child sample is the relatively small sample size. However, the age factor in the child sample remained significant, challenging the viability of this explanation. If degree of bilingualism was not significant in the child sample because of low power, then one must answer this question: why was age a significant predictor but not degree of bilingualism? The low power explanation for children is further weakened by the fact that income remained significant when the accuracy for both ears combined was the dependent measure. Thus, it appears that there is an age-related effect when the effects of age, income, and degree of bilingualism are used as the predictors.

This age-related change in dichotic listening performance led to examining the effects of age groups in dichotic listening accuracy in a more direct fashion through the MLM analysis. The accuracy gap between the left and the right ears narrows in adults relative to children, as indicated by the significant interaction between age groups and ears. This is remarkable considering that subject and words were each treated as random effects.

There are limitations to this study. The first limitation is that while the entire child sample might not be of low power, the portion of the child sample that had a complete HBGSI survey was of low power, accounting for the lack of effect of teacher rated HBGSI score. Furthermore, while the HBGSI has been validated after being correlated with well-known assessments of intelligence and language (Irby, Lara-Alecio, & Rodriguez, 1999; Fultz et al., 2013), the nature of the HBGSI is markedly different from the kinds of assessments that O'Boyle and Benbow

(1990) used. O'Boyle & Benbow used the SAT as their basis for measuring giftedness. The SAT is a standardized assessment which measures verbal and mathematical reasoning skills. The HBGSI is a checklist completed by teachers and the answers are based on their perceptions of the child. Thus, the lack of replication of the effects of giftedness on lateralization reported by O'Boyle and Benbow could be due to the different natures of these two measures. However, the O'Boyle & Benbow study involved adult participants, whereas this study involved children. Despite the differences in how giftedness was measured, this study adds to the literature on lateralization and giftedness by examining a sample of children. Giftedness as measured by the teacher rated HBGSI is not associated with dichotic listening accuracy performance, and thus, is not associated with bilateral hemispheric involvement.

Another limitation was the lack of an adolescent sample. An adolescent sample would provide with information on what happens between childhood and adulthood in terms of dichotic listening and would provide a stronger basis for comparing the age groups. The adult sample also lacked more elderly participants. This is crucial as important changes in lateralization occur in this group as well (Westerhausen, Bless, & Kompus, 2015).

A further limitation was the lack of a reaction time measure. In this case, measuring reaction time could enable researchers to examine laterality in terms of how quickly a participant responds to stimuli first entering each brain hemisphere. The reason this measure was not included was because the procedure of the recording for the dichotic listening responses differed between children and adults: children had the words typed for them by the experimenter, while adults typed the words themselves.

Future studies should include an adolescent sample, and each group (child, adolescent, and adult) should have a higher number of participants. This will enable researchers to further subdivide these three larger groups into smaller subgroups and examine how laterality develops across these various age groups. Future researchers should also examine reaction time and have a consistent method of recording dichotic listening responses so that reaction time can be accurately measured. Furthermore, a measure of giftedness appropriate for each age group should be used in those future studies. Each of those measures for giftedness should be equivalent to ensure consistency.

Finally, future studies should also measure how accurately and how quickly participants respond to words from the left and right ears based on their cognate status. This study had both left and right words matched according to their cognate status. However, this does not tell us whether the cognate facilitatory effect occurs depending on which ear is receiving cognate words. Because the study did not find a cognate facilitatory effect (although cognate and non-cognate status were predicted by degree of bilingualism), researchers should have a dichotic assessment where the left ear is presented with one type of word and the right ear with another, and another where the words are matched according to their word status as in the present study. This will enable researchers to examine whether laterality and cognate word status interact.

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APENDIX A

APENDIX A

DICHOTIC LISTENING WORD LISTS

Table 7. DITA English Words

Left	Right	Left Word Type	Right Word Type	Left Frequency	Right Frequency	Left Length	Right Length	Left Condition*	Right Condition
Actor	Metal	Cognate	Cognate	26.3	19.45	5	5	+O+P	+O+P
Band	Final	Cognate	Cognate	53.41	49.66	4	5	+O+P	+O+P
Canal	Terror	Cognate	Cognate	6.39	9	5	6	+O+P	+O+P
Cereal	Formal	Cognate	Cognate	6.35	8.31	6	6	+O+P	+O+P
Director	Romantic	Cognate	Cognate	35.96	35.17	8	8	+O+P	+O+P
Hospital	Perfect	Cognate	Cognate	124.19	158.64	8	7	+O+P	+O+P
Crystal	Superior	Cognate	Cognate	16.13	13	7	8	+O+P	+O+P
Error	Triple	Cognate	Cognate	9.27	9.39	5	6	+O+P	+O+P
Benign	Vacant	Cognate	Cognate	1.13	2.64	6	6	+O-P	+O-P
Diet	Palm	Cognate	Cognate	15.37	13.23	4	4	+O-P	+O-P
Base	Grave	Cognate	Cognate	35.37	26.27	4	5	+O-P	+O-P
Real	Air	Cognate	Cognate	442.8	139.01	4	3	+O-P	+O-P
Tiger	Cable	Cognate	Cognate	18.52	21.72	5	5	+O-P	+O-P
Triangle	Eligible	Cognate	Cognate	4.27	3.31	8	8	+O-P	+O-P
Severe	Debate	Cognate	Cognate	9.41	9.29	6	6	+O-P	+O-P
Image	Motor	Cognate	Cognate	22.62	13.15	5	5	+O-P	+O-P
Credit	Victim	Cognate	Cognate	45.82	47.72	6	6	-O+P	-O+P
Notion	Violin	Cognate	Cognate	6.58	4.74	6	6	-O+P	-O+P
Dollar	Fruit	Cognate	Cognate	27.64	21.72	6	5	-O+P	-O+P
Guitar	Version	Cognate	Cognate	15.58	16.23	6	7	-O+P	-O+P
Plastic	Sweater	Cognate	Cognate	18.76	13.8	7	7	-O+P	-O+P
Compass	Deficit	Cognate	Cognate	4.05	1.07	7	7	-O+P	-O+P
Train	Camera	Cognate	Cognate	95.05	57	5	6	-O+P	-O+P
Panic	Solid	Cognate	Cognate	21.84	19.56	5	5	-O+P	-O+P
Bank	Mark	Cognate	Cognate	84.98	82.01	4	4	-O-P	-O-P
false	circle	Cognate	Cognate	21.13	21.5	5	6	-O-P	-O-P
Evasion	Pension	Cognate	Cognate	1.15	4.84	7	7	-O-P	-O-P
Mission	Terrific	Cognate	Cognate	47.05	41.92	7	8	-O-P	-O-P
Machine	Angel	Cognate	Cognate	70.25	78.27	7	5	-O-P	-O-P
Logic	Vivid	Cognate	Cognate	6.7	2.03	5	5	-O-P	-O-P
Ultimate	Ignition	Cognate	Cognate	9.01	4.15	8	8	-O-P	-O-P
Oxygen	Guide	Cognate	Cognate	13.88	17.84	6	5	-O-P	-O-P
Kitchen	Address	Non-cognate	Non-cognate	58.31	52.27	7	7		
Advice	Desk	Non-cognate	Non-cognate	47.98	43.9	6	4		
Avocado	Insight	Non-cognate	Non-cognate	1.21	2.8	7	7		
Arrival	Madness	Non-cognate	Non-cognate	8.27	8.45	7	7		
Highway	Attempt	Non-cognate	Non-cognate	17.86	19.11	7	7		
Beauty	Danger	Non-cognate	Non-cognate	48.23	43.66	6	6		
Blanket	Loyalty	Non-cognate	Non-cognate	12.98	11.66	7	7		
Brick	Skirt	Non-cognate	Non-cognate	10.17	9.96	5	5		
Bullet	Horses	Non-cognate	Non-cognate	38.23	40.92	6	6		
Butter	Flower	Non-cognate	Non-cognate	20.43	22.76	6	6		
Dinner	Inside	Non-cognate	Non-cognate	202.66	211.27	6	6		
Devil	Shirt	Non-cognate	Non-cognate	41.33	46.37	5	5		
Elevator	Mistakes	Non-cognate	Non-cognate	24.41	21.88	8	8		
Factory	Remnant	Non-cognate	Non-cognate	16.8	36.245	7	7		
Threat	Rabbit	Non-cognate	Non-cognate	20.76	20.94	6	6		
Grass	Youth	Non-cognate	Non-cognate	16.78	16.82	5	5		
School	Watch	Non-cognate	Non-cognate	333.11	330.01	6	5		
Shame	Stone	Non-cognate	Non-cognate	41.56	40.62	5	5		
Umbrella	Weakness	Non-cognate	Non-cognate	7.49	8.9	8	8		
Window	Middle	Non-cognate	Non-cognate	86	89.19	6	6		
Mouse	Prize	Non-cognate	Non-cognate	19.11	22.39	5	5		
Pencil	Repair	Non-cognate	Non-cognate	9.86	8.82	6	6		
Mayor	Noise	Non-cognate	Non-cognate	31.27	34.88	5	5		
Lawyer	Needle	Non-cognate	Non-cognate	79.5	11.92	6	6		

Pumpkins	Wrinkle	Non-cognate	Non-cognate	0.64	1.88	8	7
Truck	South	Non-cognate	Non-cognate	72.86	64.47	5	5
Farmer	Spider	Non-cognate	Non-cognate	11.84	10.09	6	6
Thread	Warmth	Non-cognate	Non-cognate	5.15	4.45	6	6
Square	Throat	Non-cognate	Non-cognate	31.76	36.01	6	6
Sugar	Pride	Non-cognate	Non-cognate	37.76	27.66	5	5
Forest	Mercy	non-cognate	non-cognate	18.88	25.31	6	5
Shoulder	Nonsense	Non-cognate	Non-cognate	26.19	28.47	8	8

Table 8. DITA Spanish Words

Left	Right	Left Word Type	Right Word Type	Left Frequency	Right Frequency	Left Length	Right Length	Left Condition	Right Condition
actor	canal	cognate	cognate	29.61	33.58	5	5	+O+P	+O+P
banda	local	cognate	cognate	59.83	40.52	5	5	+O+P	+O+P
cereal	triple	cognate	cognate	9.25	8.43	6	6	+O+P	+O+P
correcto	hospital	cognate	cognate	169.73	165.93	8	8	+O+P	+O+P
tractor	reforma	cognate	cognate	3.6	2.81	7	7	+O+P	+O+P
metal	piano	cognate	cognate	20	21.44	5	5	+O+P	+O+P
cristal	mortal	cognate	cognate	16.82	19.15	7	6	+O+P	+O+P
terror	formal	cognate	cognate	15.4	9.03	6	6	+O+P	+O+P
aire	base	cognate	cognate	111.85	83.34	4	4	+O-P	+O-P
benigno	gradual	cognate	cognate	1.27	1.05	7	7	+O-P	+O-P
cable	grave	cognate	cognate	30.16	43.05	5	5	+O-P	+O-P
canoa	severo	cognate	cognate	2.21	4.37	5	6	+O-P	+O-P
genuino	vacante	cognate	cognate	2.88	3.79	7	7	+O-P	+O-P
audible	notable	cognate	cognate	45.125	4.78	7	7	+O-P	+O-P
visible	casual	cognate	cognate	3.84	4.47	7	6	+O-P	+O-P
radio	imagen	cognate	cognate	74.51	50.48	5	6	+O-P	+O-P
ácido	dólar	cognate	cognate	10.19	18.17	5	5	-O+P	-O+P
fruta	pánico	cognate	cognate	13.7	24.13	5	6	-O+P	-O+P
víctima	crédito	cognate	cognate	63.53	45.5	7	7	-O+P	-O+P
guitarra	símbolo	cognate	cognate	17.59	14.2	8	7	-O+P	-O+P
mérito	noción	cognate	cognate	5.36	6.51	6	6	-O+P	-O+P
violín	compás	cognate	cognate	4.51	1.73	6	6	-O+P	-O+P
tren	cámara	cognate	cognate	70.98	101.12	4	6	-O+P	-O+P
plástico	versión	cognate	cognate	20.24	25.52	8	7	-O+P	-O+P
círculo	oxígeno	cognate	cognate	21.63	17.33	7	7	-O-P	-O-P
evasión	vívido	cognate	cognate	1.89	0.96	7	6	-O-P	-O-P
justo	último	cognate	cognate	245.19	180.07	5	6	-O-P	-O-P
lógica	pensión	cognate	cognate	13.34	11.61	6	7	-O-P	-O-P
banco	héroe	cognate	cognate	76.89	53.67	5	5	-O-P	-O-P
helicóptero	naturaleza	cognate	cognate	30.62	48.82	11	10	-O-P	-O-P
ángel	marca	cognate	cognate	31.17	40.93	5	5	-O-P	-O-P
guía	puro	cognate	cognate	27.37	19.35	4	4	-O-P	-O-P
ventana	consejo	non-cognate	non-cognate	73.22	77.23	7	7		
aguacate	ladrillo	non-cognate	non-cognate	0.81	5.43	8	8		
llegada	muebles	non-cognate	non-cognate	15.26	14.2	7	7		
belleza	amenaza	non-cognate	non-cognate	43.46	45.5	7	7		
cerveza	peligro	non-cognate	non-cognate	79.61	83.79	7	7		
manta	oveja	non-cognate	non-cognate	8.58	6.32	5	5		
zanahoria	proyectil	non-cognate	non-cognate	3.26	2.01	9	9		
sillas	piedad	non-cognate	non-cognate	10.4	14.06	6	6		

diablo	hambre	non-cognate	non-cognate	91.92	103.77	6	6
escuela	alcalde	non-cognate	non-cognate	235.07	39.49	7	7
odio	cielo	non-cognate	non-cognate	148.14	144.92	4	5
carretera	diversión	non-cognate	non-cognate	32.11	33.7	9	9
ascensor	garganta	non-cognate	non-cognate	20.12	24.59	8	8
milagro	fábrica	non-cognate	non-cognate	30.21	26.49	7	7
cuadrado	granjero	non-cognate	non-cognate	5.55	7.9	8	8
flor	vela	non-cognate	non-cognate	16.63	10.55	4	4
bosque	camisa	non-cognate	non-cognate	54.18	46.27	6	6
hierba	hombro	non-cognate	non-cognate	26.37	21.85	6	6
adivina	arreglo	non-cognate	non-cognate	33.75	20	7	7
lápiz	aldea	non-cognate	non-cognate	14.83	16.08	5	5
ratón	falda	non-cognate	non-cognate	14.75	9.71	5	5
juventud	prestamo	non-cognate	non-cognate	12.37	13.96	8	8
aguja	sudor	non-cognate	non-cognate	11.22	7.59	5	5
reloj	lucha	non-cognate	non-cognate	51.53	41.1	5	5
debilidad	cerradura	non-cognate	non-cognate	14.11	8.24	9	9
calabazas	bienestar	non-cognate	non-cognate	1.61	7.06	9	9
legumbre	paraguas	non-cognate	non-cognate	45.125	3.58	8	8
calor	apoyo	non-cognate	non-cognate	60.04	51	5	5
abogado	película	non-cognate	non-cognate	119.9	153.48	7	8
medio	resto	non-cognate	non-cognate	198.55	150.48	5	5
caballos	vergüenza	non-cognate	non-cognate	32.25	42.16	8	9
adentro	locura	non-cognate	non-cognate	132.78	94.83	7	6

*+O+P are cognates that are orthographically and phonologically similar to their equivalents in the other language. +O-P are cognates that are orthographically (but not phonologically) similar to their equivalents in the other language. -O+P are cognates that are phonologically (but not orthographically) similar to their equivalents in the other language. -O-P are cognates with distinct orthographic and phonological codes to those of the other language (Schwartz, Kroll, & Diaz, 2007).

APPENDIX B

APENDIX B

HISPANIC BILINGUAL GIFTED SCREENING INSTRUMENT (HBGSI)

1	Likes to read in native language; is a proficient reader in native language
2	Likes to write in native language; is a proficient writer in native language
3	Likes to speak in native language; is a proficient speaker in native language
4	Values education; sees education as a way to improve status
5	Is motivated to learn; exhibits a desire for learning
6	Possesses leadership qualities in relation to working in the peer group; works well with others
7	Has appropriate social adjustment; well accepted by peers; sensitive to personal relationships
8	Demonstrates ability for giving advice and judgements in disputes and in planning strategies
9	Effective at setting goals
10	Is aware of justice and quickly observes injustices
11	Is able to evaluate events and people
12	Has a special sensitivity to the needs of society; has a world perspective on humanity
13	Participates in school activities and in class discussions
14	Exhibits language (speaking) rich in imagery
15	Is imaginative in story telling
16	Exhibits language (writing) rich in imagery
17	Has ability to generalize learning to other areas and show relationships among apparently unrelated ideas
18	Has the ability to use stored knowledge to solve problems
19	Reasons by analogy or contrast
20	Talents demonstrated through various projects and interests at home or in the community
21	The relationship between learning and language is consistent in the areas of math and science; level of competency is equal in all of those areas
22	Performs at or above grade level in math; has high math abilities; likes to do math problems
23	Perceives cause and effect relationships
24	Is self-directed in activities and is methodological

25 Has an entrepreneurial ability/spirit
26 Has a working command of Spanish as well as English
27 Uses intuition
28 Exhibits high nonverbal fluency and originality
29 Shows interest in primarily one academic area
30 Needs minimal support in second language acquisition
31 Exhibits steadfast self-concept and self-confidence
32 Reasons in a more step-by-step process rather than in a spontaneous process
33 Has effective test-taking skills
34 Is trustworthy

NOTE: The HBGSI was rated by teachers using the following Likert scale: 1 = never exhibits behavior/characteristics; 2 = seldom exhibits behavior/characteristics; 3 = sometimes exhibits behavior/characteristics; 4 = often exhibits behavior/characteristics; 5 = always exhibits behavior/characteristics.

BIOGRAPHICAL SKETCH

Francisco J. Sierra completed his Bachelor of Science in psychology on December 2015 with a minor in art. He began his Masters in experimental psychology on August 2016 and finished on December 2019. Francisco has worked as an evaluator and data analyst for two and a half years at The Office of Engaged Scholarship & Learning, and for another year at The Office of Student Success, and at The Office for Victim Advocacy & Violence Prevention.

Francisco obtained research experience at the Center for Bilingual Studies, the Basic Memory and Cognitive Processes lab, and at the Cognitive Science of Language & Education lab. Francisco developed an independent research project investigating whether degree of bilingualism has any relation to and predicts the number of source monitoring errors in a divided attention condition. Through his research, he has provided mentorship and research opportunities to undergraduate and graduate students and presented at local, regional, and national conferences. Francisco was the founder and first president of the Cognitive Research Society, a student organization devoted to the promotion of cognitive science research in the Rio Grande Valley. Through the organization, Francisco's research team was able to accrue enough funds to travel to Washington D.C. and present at the Association for Psychological Science on May 2019.

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