Performance of Bilingual Speakers on the English and Spanish Versions of the Hearing in Noise Test (HINT)

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Abstract

This study compared the performance of bilingual participants on the English and Spanish versions of the Hearing in Noise Test (HINT). The participants were divided into an early bilingual (EB) group and a late bilingual (LB) group based on age of second-language acquisition. All participants acquired Spanish as their first language (L1) and English as a second language (L2). Care was taken to ensure that all participants demonstrated at least a "good competence level" for self-rated speaking, understanding, reading, and writing skills in both English and Spanish. Results revealed superior performance on the Spanish HINT versus the English HINT in both quiet and in noise for both groups of participants. Significant differences in performance were noted for the EB versus the LB participants. A number of possible explanations for superior performance in L1 are provided, and implications for educating students in their L2 are discussed.

Key Words: Bilingual, linguistic competence, speech recognition in noise, speech recognition in quiet

Abbreviations: BA = bilingual age; EB = early bilingual; HINT = Hearing in Noise Test; L1 = first language acquired; L2 = second language acquired; LB = late bilingual; MCR = message-to-competition ratio; SNR = signal-to-noise ratio

Sumario

Este estudio compara el desempeño de participantes bilingües en las versiones en inglés y en español de la Prueba de Audición en Ruido (HINT). Se dividieron los participantes en un grupo bilingüe temprano (EB) y un grupo bilingüe tardío, con base en la edad de adquisición de la segunda lengua. Todos los participantes adquirieron el español como su primera lengua (L1) y el inglés como su segunda lengua. Se tuvo cuidado que todos los participantes demostraran al menos un "buen nivel de aptitud" auto-calificado, en las habilidades para hablar, entender, leer y escribir tanto el inglés como el español. Los resultados revelaron desempeños superiores en el HINT en español versus el HINT en inglés, tanto en silencio como en ruido, para ambos grupos de participantes. Se observaron diferencias significativas en el desempeño para los participantes del EB versus el LB. Se aporta un número de posibles explicaciones para un desempeño superior en L1, y se discuten las implicaciones para educar estudiantes en su L2.

Palabras Clave: Bilingüe, aptitud lingüística, reconocimiento del lenguaje en ruido, reconocimiento del lenguaje en silencio

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Abreviaturas: BA = edad bilingüe; EB = bilingüe temprano; HINT = Prueba de Audición en Ruido; L1 = primera lengua adquirida; L2 = segunda lengua adquirida; LB = bilingüe tardío; MCR = tasa de mensaje/competencia; SNR = tasa de señal/ruido

BACKGROUND

Pure-tone testing, routinely used as a measure of peripheral hearing sensitivity, cannot indicate to what degree understanding of speech will be affected by degree of hearing loss. A speech audiometry test battery is used to determine ability to understand and recognize speech. Language proficiency can play a major part in performance on a traditional speech audiometric test battery. The score obtained from a bilingual speaker may be affected by the stimuli being in the participant's first language (L1) or second language (L2).

Relatively few tools exist in Spanish for clinical assessment of speech, language, and hearing skills. One speech perception test that is available in both English and Spanish is the Synthetic Sentence Identification (SSI) test (Jerger et al, 1968). The SSI is a closed-set speech recognition test in which sentences are presented in a background of single-talker competition.

It is commonly assumed that measurement of speech perception in English and Spanish with bilingual individuals should yield equivalent results; however, past studies (Lew and Jerger, 1991; Lopez et al, 1997) have found that bilingual subjects performed better on the Spanish version of the SSI than on the English version. Lew and Jerger (1991) compared the performance of 24 bilingual subjects on Spanish and English versions of the SSI. At a -30 dB message-to-competition ratio (MCR), in the ipsilateral competing message (ICM) mode, participants demonstrated superior performance on the Spanish version of the test. The authors explained the discrepancy as possibly due to the fact that the Spanish competing message had more silence, 31.28% of the time, compared to the English competing message, 22.93%. They also noted that the Spanish SSI sentences were longer, an average of 12 syllables compared to 9 syllables for English, potentially providing more acoustic information.

Lopez et al (1997) attempted to equalize the two versions of the test by adding speech noise to the competing messages in both the English and Spanish versions of the test based on a procedure used by Martin and Mussel (1979). However, even when the tests were "equalized," bilingual participants' scores remained significantly better on the Spanish SSI at the -10 dB MCR. The authors proposed several possible reasons for the difference: greater number of syllables in the Spanish SSI sentences, a factor previously mentioned by Lew and Jerger (1991), greater clarity or intelligibility in the Spanish version of the SSI, or structural differences between the English and Spanish languages.

In exploring speech audiometry with bilingual participants, another factor to consider is the linguistic competence level of the participants in the language of test administration. In a review of 14 research articles, von Hapsburg and Peña (2002) found that limited information was provided about such important variables as whether or not participants were bilingual or monolingual, age of second-language acquisition in bilingual participants, language competency and stability, and demand for language use. Lew and Jerger (1991) attempted to control for linguistic level of their bilingual participants by requiring them to be able to read aloud all target sentences in both Spanish and English and requiring them to translate the sentences into English or Spanish. Lopez et al (1997) attempted to control for some degree of linguistic level of their bilingual participants by eliminating three participants who did not learn Spanish as their first language and by having all bilingual participants complete a self-rating scale of language proficiency.

Results of auditory function testing with timed tasks or noisy and/or degraded conditions have indicated that bilingual speakers of Spanish and English demonstrate inferior performance on English (L2) versus Spanish (L1) tests (Lopez et al, 1997; von Hapsburg and Peña, 2002). Further research has indicated that even "true" bilinguals, described as individuals who claim to use L1 and L2 equally, perform more poorly than monolingual participants on English speech perception testing under conditions of noise while they perform equally well under quiet conditions (von Hapsburg et al, 2004). A possible implication is that use of two languages comes at the cost of performance in one or both languages. Therefore, speech perception testing with bilingual individuals must be interpreted with caution.

The Hearing in Noise Test (HINT), which measures speech recognition thresholds in quiet and noise, is available in both English and Spanish versions (Nilsson et al, 1994; Soli et al, 2002). It consists of a series of sentences, presented in both quiet and in a background of noise that are six to eight syllables in length and are easily comprehended by average first graders. The HINT in quiet results are reported in dB HL whereas the HINT in noise results are reported in terms of dB signal-to-noise ratio (SNR). Noise is presented at a fixed level of 65 dB SPL while the level of speech is varied adaptively according to the responses of the individual being tested to achieve 50% sentence recognition. The results can then be compared to normative data in order to determine relative ability to hear in noise. The HINT has been developed for several other languages as well. The tests are designed so that they will be equivalent across the languages. Soli (2005), one of the test developers, stated that the norms across languages are "not entirely identical, but very similar." He also suggested that data can be pooled across languages.

The English version of the HINT has been studied for many years while the Spanish version of the HINT has only been commercially available since 2002. The purpose of this investigation was to compare the English and Spanish versions of the HINT. Based on the differences observed between English and Spanish versions of the SSI and the stated intent of equivalency across languages for the HINT, the major goal of this study was to determine whether the Spanish and English versions of this test would yield equivalent results in bilingual individuals. In addition, the impact of age at the initiation of L2 acquisition was investigated.

METHOD

Participants

In their review of a number of speech perception studies involving Spanish-English bilingual speakers, Von Hapsburg and Peña (2002) found that participant descriptors varied across studies and averaged only two out of 21 appropriate descriptors per study. Missing descriptors included critical information such as language status, that is, whether subjects were clearly bilingual; language history, such as when the second language was learned; proficiency of L1 and L2; and participant need for use of each language. Linguistic profile of the participants was often vague, making it difficult to compare information across studies and making it difficult to draw conclusions. In light of these previous shortcomings, efforts were made to carefully screen participants of this study and include as much relevant linguistic information as possible. A screening questionnaire including a self-rating scale (see Appendix) was designed for the study and was completed by all prospective participants. Participants selected for the study were required to have Spanish as L1 and English as L2 and have circumstantial reasons for L2 acquisition (i.e., relocation to an English-speaking country). Prospective participants with a history of any learning disability or speech problem were excluded since it was felt that these might negatively influence speech perception. Anyone with fluency in or exposure to a third language in addition to Spanish and English was also excluded from the study. Past studies have indicated that bilingual status has a negative influence on speech perception in noise for L2 (Mayo et al, 1997; von Hapsburg et al, 2004). It is not known whether the addition of a third language might have a confounding effect.

Two distinct groups were sought for this study, an early bilingual group (EB) and a late bilingual (LB) group. For inclusion in the EB and LB groups, participants had to begin learning English before the age of seven years or after the age of 11 years, respectively. These ages were chosen based on past similar studies that have utilized ranges of five to seven years of age as the upper level of inclusion in early bilingual groups and ranges of 10–14 years of age as the lower level of inclusion in late bilingual groups (Danhauer et al, 1984; Lopez et al, 1997; Mayo et al, 1997; von Hapsburg et al, 2004).

All participants were required to demonstrate normal hearing sensitivity. Puretone and immittance screenings were utilized to ensure that hearing sensitivity and function were within normal limits bilaterally. “Normal hearing” was defined as thresholds that were less than or equal to 25 dB HL at octave and interoctave frequencies between 250 and 4000 Hz. Normal (Type A) tympanograms were also required for participation. Any participant who did not meet the above standard was not included in the study.

Language competency in both target languages is an important factor to consider when conducting studies with bilingual participants. Despite this, von Hapsburg and Peña (2002) found that researchers included this measure in only 36% of the 14 studies they reviewed. Accepted procedures for evaluating proficiency included language-competency measures, interviews, rating scales, reading or listening tests, translations, and questionnaires. As part of the screening questionnaire for the present study, participants self-rated their speaking, understanding, reading, and writing skills in Spanish and English on a five-point Likert scale ranging from 1 (“poor” competence level) to 5 (“excellent” competence level). All participants were required to self-score a 3 (“good” competence level) or better on speaking and understanding Spanish and English in order to be included in the study. This rating scale was an adaptation of one used by Lopez et al (1997). In their study, participants utilized a five-point Likert scale to rate themselves on comprehension, fluency, vocabulary, pronunciation, and grammar. According to von Hapsburg and Peña (2002), it is critical to obtain proficiency information on a bilingual participant’s ability to read, write, speak, and listen in both target languages when conducting speech audiometry studies so that results will be accurate and generalizable to similar populations. Therefore, these were the critical skills that were addressed in the rating scale for the current study. Since the sentences on the HINT are at a first-grade level, the questionnaire and self-rating scale utilized in this study in conjunction with the exclusionary criteria more than adequately ensure the necessary linguistic level to participate in the study.

The EB group was comprised of 18 participants, 12 females and six males, ranging in age from 18 to 41 years with a mean age of 22.7 years. L2 acquisition age ranged from one to seven years with an average L2 acquisition age of 4.0 years. A self-rating score for overall language competence for each language was obtained by averaging speaking, understanding, reading, and writing scores together. This yielded a significantly higher average of 4.7 for English versus 3.8 for Spanish (two-tailed t-test, $t = 6.21$, $p = .00001$). Combined Spanish scores for speaking plus understanding versus reading plus writing were significantly higher (one-tailed t-test, $t = 6.58$, $p = <.0001$) while the same combination of English scores was not significantly different (two-tailed t-test, $t = .437$, $p = 0.668$). The lower scores in Spanish reading and writing compared to speaking and understanding in this group were not surprising, given the fact that most early bilinguals are educated in their L2 and probably have limited formal education in their L1. Still, average scores of 3.3 and 3.0 on reading and writing in Spanish indicated that, on average, individuals in this group felt that their Spanish reading and writing skills were in the “good” range.

On average, participants in the EB group reported speaking English about 69% and Spanish about 31% in a typical day. Fourteen of the participants were born in the United States; two were born in Puerto Rico and two in Latin America. Those who were born in the United States reported learning English at an average age of 4.3 years (compared to the overall group average of 4.0 years). It is likely, however, that these individuals had some exposure to English through the environment prior to beginning formal education in English. Twelve of the 18 participants reported an equal comfort level in both languages; five reported being more comfortable speaking English; and one reported being more comfortable speaking Spanish. Ten individuals reported speaking primarily Spanish in the home; four reported speaking primarily English; and four reported an equal mixture of Spanish and English.

The LB group was comprised of seven participants, three females and four males, ranging in age from 19 to 33 years with a mean age of 24.3 years. L2 acquisition age ranged from 11 to 25 with an average L2 acquisition age of 15.8. A significantly higher average self-rating score of 4.5 for Spanish was obtained versus 3.8 for English (one-tailed t-test, t = 2.025, p = 0.0446). The lower scores in English are to be expected due to beginning the L2 at a much later age than L1. Still, an overall average English score of 3.8 indicated that individuals in this group felt that their overall English-language skills were close to the "very good" level. Combined Spanish scores for speaking plus understanding versus reading and writing and English scores for the same categories were not significantly different (two-tailed t-test, t = 1.987, p = 0.0941, and two-tailed t-test, t = 1.922, p = 0.1030, respectively).

On average, participants in the LB group reported speaking English and Spanish with nearly equal frequency in a typical day, 49% and 51%, respectively. Three of the participants were born in Puerto Rico while four were born in Latin America. Four participants reported an equal comfort level in both languages; three reported being more comfortable speaking Spanish. None of the participants was more comfortable speaking English. Six individuals reported speaking primarily Spanish at home while the remaining participant reported speaking primarily English.

Despite efforts to recruit a similar number of early and late bilingual participants, a disproportionate number of participants qualified for the EB group. Further, a number of recruited participants had to be eliminated because they did not meet the criteria for either group. The unequal group size has been controlled for statistically.

Stimuli

The stimuli were the sentences and speech-shaped noise included in the HINT for Windows Audiometric System, Version 6.2. The American English speech module and the Latin American Spanish HINT speech module (version 1.0) were utilized. Adult male native speakers of English and Spanish produced the sentences for the two versions of the test. The speech-shaped noise matched the long-term speech spectrum of the sentences.

The experimental setup was consistent with the manufacturer's operating instructions for the HINT for Windows Audiometric System, Version 6.2 (House Ear Institute, 2003). The participants were seated in a double-walled, IAC audiometric test booth, equidistant from two loudspeakers. The loudspeakers were located one meter from the center of the participant's head at a 90° angle to each other. The center of the speaker cabinet was located 45 in from the floor. The stimuli were delivered through the automated protocol provided by the HINT for Windows Audiometric System, Version 6.2, and were presented through a GSI 61, two-channel audiometer. The output of the audiometer was connected to the two loudspeakers. It was possible to present both the speech and the noise through a single loudspeaker (0° azimuth) or separately through loudspeakers at 90° azimuth. The talkback system of the GSI 61 was used to monitor both the stimuli and the participant responses.

The loudspeakers were calibrated according to the protocol of the HINT system. A sound level meter was placed in a test position corresponding with the center of the participant's head. This calibration procedure ensured the accuracy of the level of the speech stimuli and verified that the speech-shaped noise was presented at a constant level of 65 dB(A). Calibration was checked at regular intervals throughout the investigation.

Conditions

The four test conditions of the HINT battery were utilized. The test conditions included (1) sentences with no competing noise, (2) sentences with competing noise presented directly in front of the participant (0° azimuth), (3) noise presented at 90° to the right of the participant, and (4) noise presented at 90° to the left of the participant. Under all test conditions, the speech was presented from directly in front of the participant (0° azimuth).

Procedure

Participants were instructed to repeat the sentences they heard. Instructions were presented in the language of test administration, English for the English HINT (E-HINT) and Spanish for the Spanish HINT (S-HINT). The order of test presentation was alternated so that half the participants completed the S-HINT first and half the E-HINT first. The four conditions for the S-HINT and the E-HINT were presented in random order. A sentence was scored as correct if all key words were repeated correctly. Four variations of the presentation conditions were analyzed:

1. E-HINT-Q—English sentences presented in quiet at 0° azimuth;
2. S-HINT-Q—Spanish sentences presented in quiet at 0° azimuth;
3. E-HINT-N—English sentences presented with background noise. A composite score was created by averaging the following three conditions: competing noise directly in front of the participant (noise and signal at 0° azimuth), noise presented at 90° to the right of the participant (signal 0° azimuth, noise 90° azimuth), and noise presented at 90° to the left of the participants (signal 0° azimuth, noise 90° azimuth).
4. S-HINT-N—Spanish sentences presented with background noise. A composite score was created by averaging the following three conditions: competing noise directly in front of the participant (noise and signal at 0° azimuth), noise presented at 90° to the right of the participant (signal 0° azimuth, noise 90° azimuth), and noise presented at 90° to the left of the participants (signal 0° azimuth, noise 90° azimuth).

RESULTS

In order to verify that participant gender did not exert a significant effect on the data, a two-tailed t-test was performed with data collapsed for the four test conditions. No significant difference was found between males and females for test condition ($t = .957$, $p = .348$).

The average scores in dB HL of the early and late bilingual groups under quiet conditions for the Spanish and English versions of the HINT are presented in Figure 1. Both the EB and LB groups performed significantly better on the Spanish HINT test when compared to the English HINT (EB, $t = -6.942$, $p = <0.0001$; LB, $t = -4.627$, $p = 0.004$). Early bilinguals had an average threshold score of 15.1 dB on the S-HINT compared to a threshold of 18.0 dB on the E-HINT. Late bilinguals had an average threshold score of 11.0 dB on the S-HINT compared to a threshold of 15.2 dB on the E-HINT.

The average scores in dB SNR of the early and late bilingual groups for sentence presentation with noise for the Spanish and English versions of the HINT are presented in Figure 2. Both the EB and LB groups performed significantly better on the Spanish HINT test when compared to the

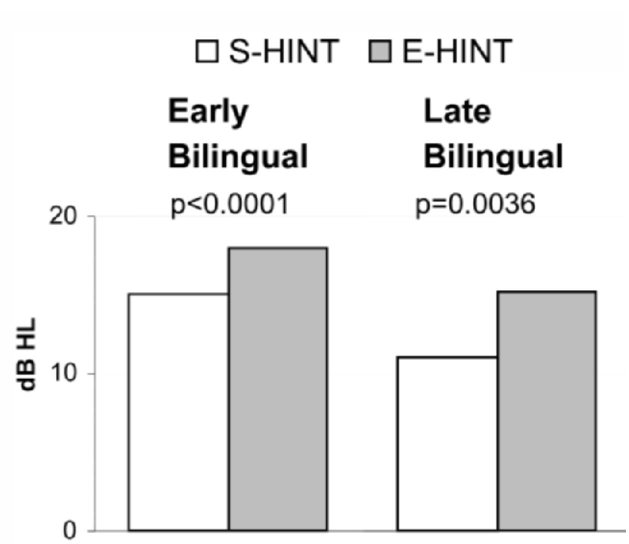

Figure 1. Comparison of Spanish and English HINT in quiet. Mean scores in dB HL and significance levels for early bilingual and late bilingual participants on the Spanish and English HINT tests under quiet condition.

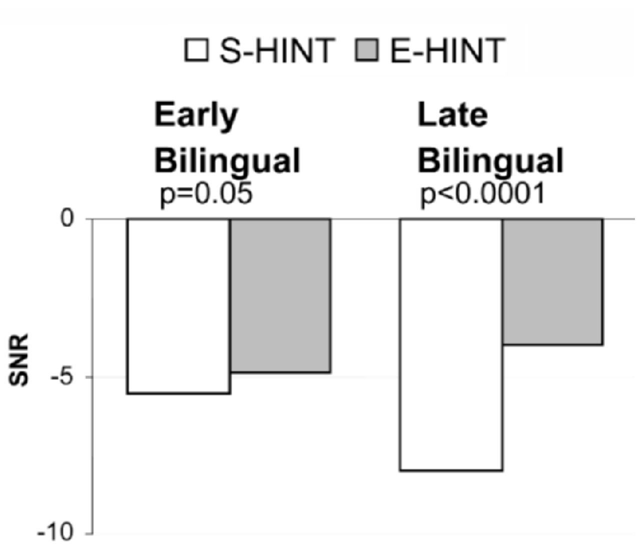

Figure 2. Comparison of Spanish and English HINT in noise. Mean scores in SNR and significance levels for early bilingual and late bilingual participants on the Spanish and English HINT tests in noise.

English HINT (EB, t = -2.107, p = <0.05; LB, t = -9.584, p = <0.0001). Early bilinguals had an average signal-to-noise ratio (SNR) of -5.6 dB on the S-HINT compared to an average SNR of -4.9 dB on the E-HINT. Late bilinguals had an average signal-to-noise ratio (SNR) of -8.0 dB on the S-HINT compared to an average SNR of -4.0 dB on the E-HINT.

Under all conditions, a significant difference was found between the early and late bilingual groups. Three of these four findings were expected; one was not. As expected, on both conditions of the S-HINT, the LB group demonstrated superior performance compared with the EB group. Average threshold for the S-HINT quiet condition was 11.0 dB for the LB group as opposed to 15.1 dB for the EB group (t = 2.984, p = .007). The average SNR for the S-HINT condition with noise was -8.0 for the LB group and -5.6 for the EB group (t = 5.353, p < 0.0001). On the E-HINT, it was expected that the EB group would show superior performance compared with the LB group. This was the case for the E-HINT condition with noise in which the EB group had an average SNR of -4.9 compared to 4.0 for the LB group (t = -2.225, p = .04). However, for the E-HINT in quiet condition, the LB group had an average threshold of 15.2 dB compared with an average threshold of 18.0 dB for the EB group (t = 2.349, p = .03), which was not expected. Post hoc comparisons were computed to eliminate the possibility of family wise error rate. Since the sample group numbers were unequal, the Tukey-Kramer test (a modification of Tukey's HSD test) was used for the follow-up evaluation. All results were significant at the alpha level of 0.05 (StatView 5.0.1 [SAS Institute, 2002]).

Post hoc regressions were computed in an effort to determine the participant characteristic that might explain the significantly better scores observed on the L1 test (S-HINT) under presentations in quiet and noise. For this purpose, the bilingual groups were collapsed into one bilingual group (BG). An independent variable, bilingual age (BA), was created to represent each participant's level of L2 experience. BA was calculated as the number of years speaking L2 divided by chronological age. Thus, if a 20-year-old individual spoke L2 for a total of 10 years, the BA would be 10 divided by 20 for a BA of .5 versus a 30-year-old individual who spoke L2 for 10 years, whose BA would be calculated as 10 divided by 30, resulting in a BA of .33. This calculation incorporates both the total and the relative number of years speaking L2, rather than just the total years as is commonly considered.

The results of regression analyses between BA and the various conditions of the HINT are displayed in Figures 3–6. The regression between BA and S-HINT in

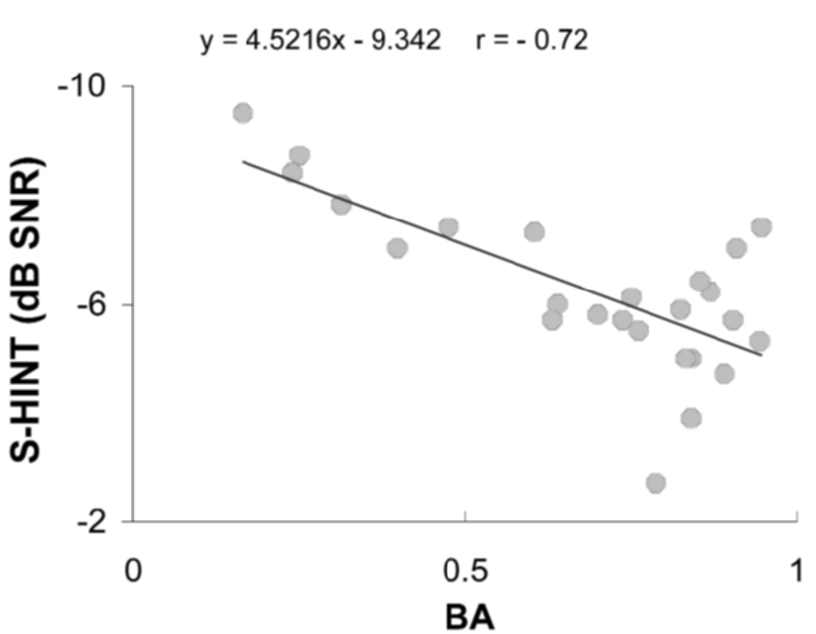

Figure 3. Regression between bilingual age (BA) and S-HINT in noise (SNR). The solid line shows the regression.

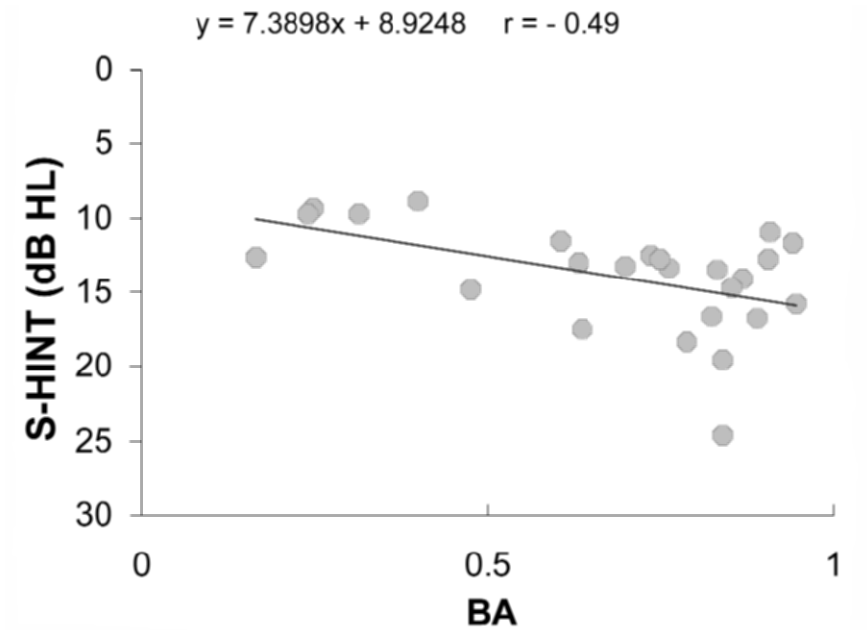

Figure 4. Regression between bilingual age (BA) and S-HINT in quiet (dB HL). The solid line shows the regression.

noise (dB SNR) is shown in Figure 3. This figure reveals that BA and performance on the S-HINT in noise were highly negatively correlated (r = -.72, p < .0001). As BA increased, the performance based on SNR became poorer. Figure 4 reveals a moderate negative correlation between BA and S-HINT in quiet (dB HL) (r = -.49, p = .0120). No significant correlation was found between BA and E-HINT in quiet (Figure 5) or in noise (Figure 6).

DISCUSSION

Results of this study indicated that all bilingual participants scored better on the Spanish HINT than the English HINT for presentations in quiet and in noise. Although there were differences in the number of participants between the EB and LB groups due to difficulty recruiting LB participants, differences in group performance were statistically significant. Those in the LB group scored significantly higher

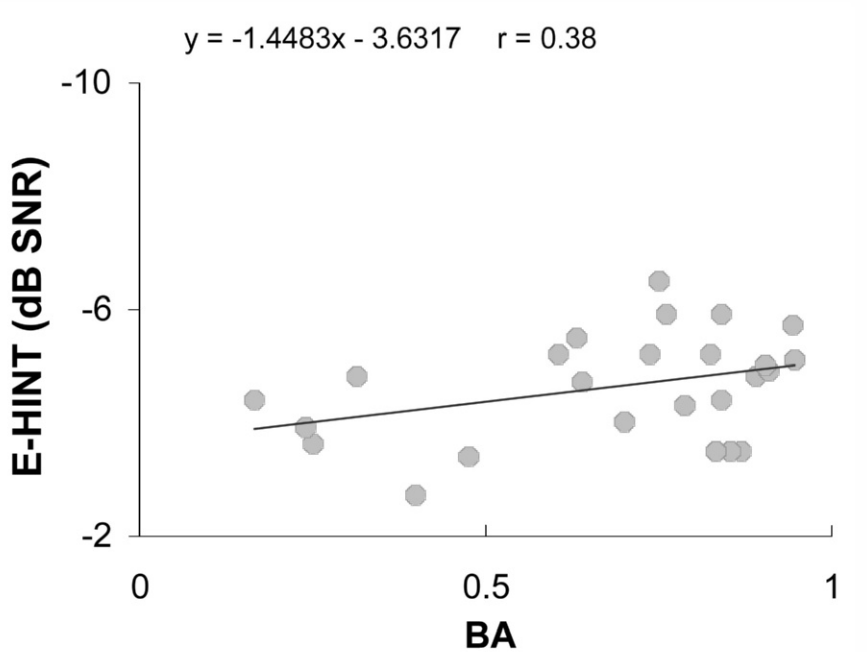

Figure 5. Regression between bilingual age (BA) and E-HINT in noise (SNR). The solid line shows the regression.

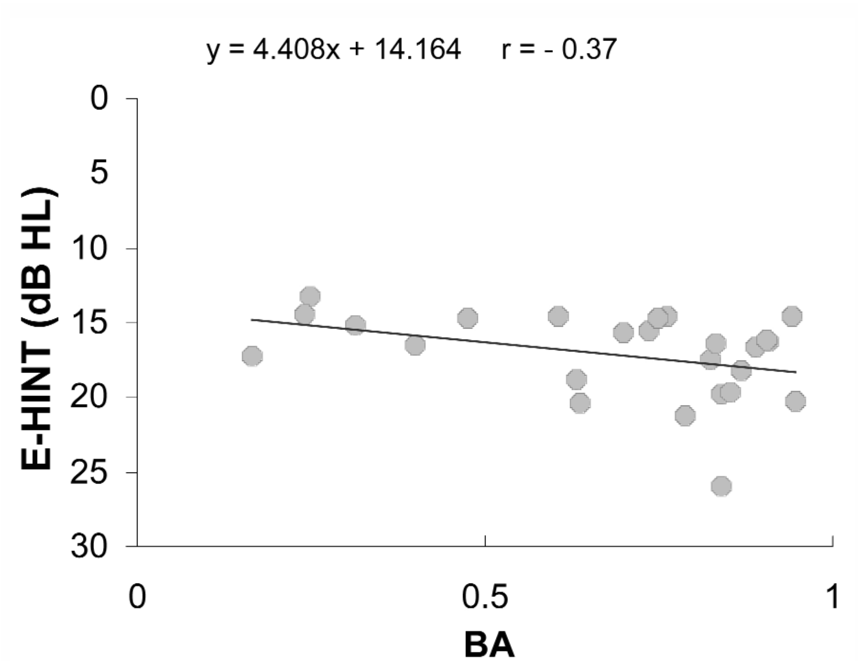

Figure 6. Regression between bilingual age (BA) and E-HINT in quiet (dB HL). The solid line shows the regression.

than those in the EB group. Results of this study corroborate results reported by Lew and Jerger (1991) and Lopez et al (1997) that showed superior results on the Spanish compared to the English version of the SSI, and results by von Hapsburg et al (2004) that showed superior results on the Spanish versus the English HINT by late bilinguals. Clinical implications are important to consider. Soli and Nilsson (1994) suggest that a difference of 1 dB in SNR is approximately equivalent to an improvement of 9% in sentence intelligibility. Therefore, the advantage for the EB group in Spanish over English was approximately 6.2% in noise, while the advantage for the LB group was approximately 36%.

While the overall results of the LB group were not surprising given results of past studies that have demonstrated that bilingual individuals score higher on comparable tests in L1 than L2, results of the EB group were more surprising. It has been speculated that the differences reported in previous studies may be due, at least in part, to a lack of careful control of participant variability. It is difficult in many studies to determine status of the bilingual participants due to a lack of reported detail (von Hapsburg and Peña, 2002). The assumption has been that there has been a mixture of early and late bilinguals in some of the participant pools, with the late bilinguals positively influencing the Spanish test scores.

In the present study, early and late bilingual groups were carefully controlled and their performance compared on the English and Spanish versions of the HINT, which are normed for equivalence across the languages. Given a number of facts regarding the EB group, it was remarkable that they scored significantly better on the Spanish HINT compared with the English HINT. On average, participants in this group reported that they began to learn English at the age of four. Most were born in the United States, however, and it is therefore likely that they had some exposure to English beforehand either through the environment outside the home or through the media. They reported speaking significantly more English than Spanish in a typical day. Their self-rated score on language competence, averaged for speaking, understanding, reading, and writing was 4.7 for English versus 3.8 for Spanish, a significant difference, which indicated that they felt that they have a much higher linguistic competence level in English. Finally, 15 out of 16 were either more comfortable speaking English than Spanish or felt equally comfortable speaking both languages. Given all of the above, it is notable that the EB participants scored significantly better on the Spanish versus the English HINT.

This leads to the question why bilinguals and, especially in this case, early bilinguals who appear to have clear advantages in English perform better in Spanish than in English. In some previous studies, performance under quiet conditions in L1 and L2 were equivalent; however, results of this study indicated that even under quiet conditions, performance was superior in Spanish compared to English. Possible explanations for these results include structural differences between English and Spanish (Lopez et al, 1997), lack of test equivalency between Spanish and English tests (Lew and Jerger, 1991), and processing differences among bilinguals compared to monolinguals (Soares and Grosjean, 1984). Given the simplicity of the sentences on the HINT (first-grade level), there should be little in the way of linguistic complexity in either the Spanish or English version of the test that would affect the outcome. Further, since the two tests are normed for equivalence with monolingual speakers for each test, the HINT demonstrates built-in equivalency.

Therefore, possible differences in the way bilingual individuals perceive or process speech, especially under noisy or deteriorated listening conditions, deserves consideration as an explanation for the present results. In this study, there was a high negative correlation between bilingual age (BA), defined as the percentage of lifetime years speaking L2, and SNR for speech perception on the S-HINT in noise, and a moderate negative correlation for the S-HINT in quiet. In other words, the less experience with L2, the better the individual was able to perceive speech in L1, especially under noisy conditions. Since all the bilingual participants spoke Spanish since birth as their L1, it appears that longer exposure to L2 resulted in either deterioration of speech perception in Spanish or failure to develop speech perception in Spanish to its fullest.

Given the results of this study in conjunction with results of previous studies, the issue of implications for classroom settings is an important one. Magiste (1985, 1992) found that in timed tasks, bilingual individuals needed more time than monolingual participants to process verbal materials in both languages. Other studies have demonstrated that bilingual individuals perform more poorly than monolingual participants on measures of speech perception under noisy or degraded conditions (Bergman, 1980; Crandell and Smaldino, 1996; Mayo et al, 1997; von Hapsburg et al; 2004). Knecht et al (2001) found that the background noise levels in 28 out of 32 unoccupied classrooms they tested in eight schools exceeded the recommended ASHA (1995) level of 35 dB. Current educational trends that promote interactive collaboration among students further increase the noise level in typical classrooms. It stands to reason that the combined effects of timed tasks in conjunction with noisy or degraded conditions would result in further reduction of performance by bilingual individuals. The current study and others have found that bilingual individuals are more successful on speech perception tasks in L1 compared to L2.

Synthesizing the results of these studies would suggest that the optimal learning environment for bilingual children would be a classroom with minimal background noise, reduced emphasis on timed testing, and instruction in both L1 and L2. Currently, in the United States, there is a high level of controversy surrounding the issue of short-term immersion education versus longer-term bilingual education. The implications of the findings of this study and others with similar results suggest that a shorter exposure time to bilingual education may result in degraded classroom input to bilingual students and possible subsequent learning deficiencies.

Although the reasons for the superior performance of bilingual individuals in L1 speech perception tests are complex and inconclusive, the fact that this is the case despite high levels of L2 proficiency indicates that caution is needed when interpreting testing results as well as in the consideration of language when selecting versions of tests. Further, this factor, in conjunction with the others discussed above, may partially explain the educational deficits that are often reported in the bilingual population.

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Appendix

Screening Questionnaire for Prospective Study Participants

1) Name: ____________________

2) Date of birth: __________ Age: ________

3) Telephone: ______________ E-mail: ______________

4) Where were you born? ____________________

5) Where were your parents born? Mother __________ Father __________

6) Are you proficient in, or have you had prolonged exposure to, a language other than Spanish and English?
 ❑ No
 ❑ Yes
 Please elaborate ____________________

7) Parents' level of education:
 ❑ Did not graduate high school
 ❑ High school education
 ❑ Some college
 ❑ Graduated from college

8) Have you ever been identified as having a learning disability or a speech problem?
 ❑ No
 ❑ Yes
 Please elaborate ____________________

9) Indicate which of the following languages you speak *fluently*:
 ❑ Spanish
 ❑ English

10) Which language did you learn first?
 ❑ Spanish
 ❑ English
 ❑ I learned both at the same time

11) How old were you when you began to learn English?
 Age __________

12) Why did you learn English?
 ❑ I relocated to the United States from a country in which Spanish was the primary language spoken.
 ❑ I was born in the United States and grew up speaking Spanish at home. I didn't begin to learn English until I started school.
 ❑ Other (please be specific) ____________________

13) Currently I am most comfortable speaking in:
 ❑ Spanish
 ❑ English
 ❑ I am equally comfortable in both languages

14) During a typical day I speak ______% English and ______% Spanish.

15) Currently, what language do you *primarily* speak at home?
- ❑ Spanish
- ❑ English

16) Indicate your level of competence in the following areas with the appropriate number:

Speaking in Spanish:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Understanding spoken Spanish:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Reading adult-level material in Spanish:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Writing adult-level material in Spanish:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Speaking in English:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Understanding spoken English:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Reading adult-level material in English:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent

Writing adult-level material in English:
1__________2__________3__________4__________5
Poor Fair Good Very Good Excellent