Considerations in Speech Recognition Testing of Bilingual and Spanish-Speaking Patients, Part II: Young Children

Laura Gaeta, BHS, BA
University of Oklahoma Health Sciences Center, Oklahoma City, OK

Andrew B. John, PhD
University of Oklahoma Health Sciences Center, Oklahoma City, OK

The rapid growth of the Spanish-speaking population of the United States presents challenges for healthcare providers to develop linguistically- and culturally- appropriate best practices. An essential need for all audiologists is language-appropriate stimuli for speech recognition testing. Unfortunately, few well-validated tests exist for this purpose. We review the timeline of development of Spanish-language speech recognition test materials and address challenges facing the audiologist in evaluating accurately the speech-recognition abilities of young children who use Spanish as their primary or only language of communication, with emphasis on picture-pointing tests. Cultural, dialectical, and educational concerns for this population are discussed.

Introduction

Part I of this two-paper series reviews environmental, stimulus, and patient considerations in evaluating speech recognition abilities of older children and adults who are bilingual Spanish speakers or speakers of Spanish alone. In part II, we review similar issues for younger children and provide an overview of Spanish-language test materials developed for pediatric patients, particularly picture-pointing tests. We refer the reader to Gaeta and John (this issue) and to Shi (2014) for an extensive discussion of issues facing audiologists in conducting speech-recognition testing with Spanish-speaking patients.

Audiology and the Spanish-Speaking Pediatric Population

Pediatric hearing loss is an important public health concern. In 2008, Ross, Holstrum, Gaffney, Green, Oyler, and Gravel found that nearly three in 1,000 babies born in the United States are born with a permanent hearing loss. The prevalence of hearing loss in Hispanic children is higher than that in other children (Mehra, Eavey, & Keamy, 2009). As the resolution of diagnostic tools improve, more children are being identified early and enrolled in the appropriate intervention programs. A comparison of reports by the Gallaudet Research Institute's Survey of Deaf or Hard of Hearing Children (2002, 2011) reveals 21.9% of students surveyed in 2009-2010 reported Spanish as the spoken/written language in the home compared to 10.3% of students in 2000-2001. Despite these growing demographics, resources for speakers of Spanish have failed to keep pace, posing a challenge for audiologists who must administer, score, and interpret results from an audiologic evaluation and provide the ensuing recommendations.

In addition to the lack of testing materials available for the Spanish-speaking pediatric population, the Hispanic population encounters social and economic barriers and is more likely to be delayed timely and appropriate health care (Escarce & Kapur, 2006). Flores, Olson, and Tomany-Korman (2005) reported both racial and ethnic disparities among Hispanic children and insurance coverage, as 31% of Hispanic children are uninsured compared to 9% of Caucasian children. The inequality may result in Hispanic children being fit with lower-end technology for amplification and receiving limited speech and language therapy services. However, some organizations and hearing aid manufacturers donate or purchase hearing aids for low-income families to address this disparity (Morrison, 2008). The selection of hearing aids may be affected by the availability for distribution as some cities have more low-income families who require assistance. Flores and colleagues also noted that Hispanic parents made fewer phone calls to healthcare providers than did their Caucasian counterparts, probably due to language barriers rising from communication with the clinical staff. Providers also made fewer referrals to specialists for this population, compounding the disparity.

Cultural and Language Issues in the Assessment of Young Children

Cultural differences play a large role in the identification and intervention of hearing loss in bilingual children. A 2003 study by Steinberg, Bain, Li, Delgado, and Ruperto explored this role by interacting with Hispanic families living in the United States who had a child who had been identified with hearing loss. Steinberg and her colleagues found that many factors impacted the family's decision, including involvement of the parents and other healthcare professionals, language differences, language preference, choice of communication, decision-making roles, and religion. In the study, the authors learned that 100% of mothers were involved in the decision-making, compared to 64% of fathers. The parents also sought recommendations mostly from healthcare professionals (96%) and the child's school district (86%). Parents in the study stated that they felt the most influence from professionals who "listened to [their] concerns." Although language barriers are typical for Spanish speakers in English-only environments, only four families in the study considered it to be a factor limiting their

information. However, the majority were unable to share this experience due to the availability of interpreters, translators, and Spanish-speaking providers. Steinberg and her co-investigators reported that one parent in their study said that the material was a direct translation from English, disregarding nuances of the language and making the terminology difficult to understand. The authors reported that 63% of families hoped their child would be bilingual (Spanish/English) or trilingual (Spanish/English/sign language), with some parents stressing the need for their child to retain their Hispanic culture. In the study, 63% of families were only offered total communication by their school or school district and reported that other communication methods were not discussed. Total communication is a philosophy that involves choosing methods of communication (oral, signed/manual, written, and auditory language) that are appropriate for a child's communication needs. About half of the families interviewed described their decision-making in their child's intervention as "active," and 37% described themselves as "passive" (The authors were not able to classify three families). Lastly, 17 of the 27 families surveyed stated that religion influenced their decision-making, with four families crediting God for improvements in their child's hearing.

Similarly, Guiberson (2014) conducted a survey of parents who had children who are deaf or hard of hearing in Spain. Seventy-one parents took the online survey, which included questions about influences and inclinations of parents for a mode of communication and bilingualism for their children. Although Guiberson noted that these cultural variables are different in Spain, the results mirrored those of Steinberg and her co-investigators (2003). Guiberson found that family involvement was a major factor in the decision of a communication mode, and that the parents and grandparents were the most involved. However, unlike the Hispanic families in Steinberg and colleagues' study, Spanish families were more likely to seek advice from professionals in speech and hearing, rather than from physicians. Guiberson attributed this difference to higher parental education levels in Spanish parents of which 48% of mothers and 49% of fathers earned at least a bachelor's degree, compared to 3% of mothers in the Steinberg and colleagues group. This family support has a strong influence on the decision of a communication modality and bilingualism in children with hearing loss. Further research is needed on the role parental education has on the decision making process for children who are deaf or hard of hearing.

The results of Guiberson's 2014 study are important because they highlight the many intricate factors that can have a large impact on the decision-making process in this population. Foremost, cultural competence and sensitivity are paramount in providing services to Hispanic families to ensure satisfaction, gain trust and confidence, and ensure future involvement from both sides. Steinberg and her co-investigators emphasized the need for a "shared language", similar to that of the Deaf culture. Lastly, the authors stressed the need for Hispanic professionals who can support and advocate for this growing population.

Peyton, Ranaard, and McGinnis (2001) reported that one in four children speak a non-English language when they enter school, and eventually lose the first language as they are exposed to and learn English in school. Language can become a concern for the audiologist working with the child and his or her family when there is no common language. After a child is identified with hearing loss, it is imperative intervention occurs as soon as possible. However, the initial assessment and further assessments of progress are impeded when the audiologist does not speak the native language of the child and if the appropriate measures are not used. The U.S. Department of Education's Individuals with Disabilities Education Act (2004) requires that evaluations and assessments be "administered in the child's native language or other mode of communication and in the form most likely to yield accurate information on what the child knows and can do academically, developmentally, and functionally, unless it is clearly not feasible to provide or administer." It can be challenging for audiologists who must choose the most appropriate test for a non-English speaking child, decide the language to use for testing, and to score the child's responses. Although there are speech perception materials available in Spanish, not all of the measures have been validated and used outside of research. Additionally, there has been limited research with bilingual children. Therefore, the primary purpose of this paper is to review the current literature for speech perception measures available for assessing Spanish/English bilingual children. This review will provide additional considerations facing this growing pediatric population.

Speech Audiometry and Monolingual Children

As described in the Part I paper, clear speech has been shown to improve intelligibility of speech. Bradlow, Kraus, and Hayes (2003) examined speech perception in noise abilities in children with learning disabilities (with and without a diagnosis) and children without learning disabilities. The subjects were 63 school-age children with learning disabilities and 36 children for the control group. The children underwent testing similar to that of Bradlow and Bent (2002) (see Part I), including the Revised Bamford-Kowal-Bench (BKB) (Bench, Kowal, & Bamford, 1979) sentences spoken by a male and female speaker in both conversational and clear speech styles in varying signal-to-noise ratios (SNR). Bradlow, Kraus, and Hayes concluded that speech perception in noise highlights deficits in children with learning disabilities. These children performed worse than the control group and experienced greater adverse effects when the SNR was increased. The study results also reveal additional factors such as background noise, reverberation, and hearing loss can increase difficulties with speech perception. However, clear speech was shown to benefit both groups of children in spite of the decreasing SNR. This discovery, Bradlow and colleagues suggested, is the basis for encouraging clear speech for these children. As seen in the 2002 study by Bradlow and Bent, the observed clear speech effect was greater for the female talker, leading to an increase in benefit for the female talker. Bradlow and her colleagues recommended that parents, clinicians, and teachers use clear speech to speak to children in environments with poor SNR.

The adverse effects in noise are exacerbated as hearing loss increases. Blamey and colleagues (2001) studied the relation between speech perception and hearing loss, along with speech production, spoken language, and age. The researchers also explored differences in these skills for children with hearing aids

and cochlear implants. Using the information from this study, Blamey and his co-investigators designed a model of language acquisition and speech perception for children with hearing loss, and considered the development of these skills when they enter secondary school. For the study, the researchers enrolled 78 children (4-12 years old) who had hearing loss of at least 40 dB HL and a cochlear implant and/or hearing aid. All of the children were enrolled in classes with normal hearing children and participated in an aural/oral rehabilitation program. The children underwent a series of measures to assess their abilities in the aforementioned areas. Speech perception ability was measured with the Consonant-Nucleus-Consonant (CNC) test (Peterson & Lehiste, 1962) and Bench-Kowal-Bamford (BKB) test. Two lists from both measures were presented in an auditory-visual condition and two lists in an auditory-only condition. Blamey and his colleagues found that speech production and language level had a large impact on speech perception. Speech perception scores declined 5% for every 10 dB of the child's hearing loss for the auditory-only conditions. However, the researchers concluded that when the child's language scores reach that of a seven-year-old with normal hearing, his or her sentence recognition scores are expected to exceed 90% in an auditory-visual condition, which the authors identify as representative of the child's daily communication modes.

As the numbers of bilingual children continue to increase, concerns have risen about introducing a second language to children with hearing loss. These arise from concerns that the child will become confused and will be unable to separate the two languages, in spite of research demonstrating otherwise. A 2013 study by Bunta and Douglas explored this notion by comparing language abilities in bilingual and monolingual children with hearing loss and assessing the bilingual children's language scores in both English and Spanish. The study involved 40 children who wore a cochlear implant and/or hearing aids before the age of five and who had been enrolled in oral communication classes for at least one year. The children underwent a test battery consisting of auditory comprehension, expressive communication, and total language scores from the Preschool Language Scale (PLS-4) (Zimmerman, Steiner, & Pond, 2002). Based on the results of their study, Bunta and Douglas concluded that learning two languages, in this case, English and Spanish, had no adverse effects on language development. The bilingual children performed comparably to their monolingual peers. Banta and Douglas supported these findings by underscoring the role of the audiologist, speech-language pathologist, and educator to enable this dual-language use and proficiency. It is also noteworthy that the children in the study received language support in Spanish and English. The authors of this study underscored the role of a home language as well as speech and language development in both languages.

Speech Audiometry and Bilingual Children

Although there exists a selection of speech perception materials in Spanish for adults and older children, a review of the literature for speech perception measures for bilingual children does not yield many results (see Gaeta and John, this issue). Adolescents and older children may be tested with speech perception measures designed for adults. However, these measures are not appropriate for use with younger children or those with developmental delays. There have been many attempts to create measures for the pediatric population (see Table 1); however, some have been not validated and/or have not had their clinical use and feasibility reported. Five major picture-pointing tests for evaluating speech recognition of Spanish-speaking children were identified in our review and are summarized below.

Table 1. Picture-Pointing Word-Recognition Tests for Spanish-Speaking Pediatric Patients

Author	Stimulus Type	Number of Lists / Stimuli	Example Stimuli
Martin and Hart (1978)	nouns chosen based on stress pattern, simplicity, and ease of representation	12 lists (English), 12 lists (Spanish)	carro, casa, leche, libro, llave
Spitzer (1980)	words chosen from lists of common Spanish words (objects, animals, body parts, etc)	51 bisyllabic words	niño, toro, perro, suéter, sofá
Comstock and Martin (1984)	bisyllabic CVCV words within the vocabulary of Spanish-speaking preschool children	4 lists of 25 words	mala, boca, lloro, ocho, cama
Mendel et al (2013)	bisyllabic trochaic words without definite article	4 lists of 25 words	mano, ojo, puerta, cama,libro
Calandruccio et al (2014)	bisyllabic words (in both English and Spanish) from Dolch word list (1948) and common words expected to be part of a five-year-old child's vocabulary	30 words	papel, pollo, agua, mesa, niños

Picture Identification Tests

Bilingual children and audiologists may encounter a language barrier when administering speech audiometry materials (see Gaeta and John, this issue). Martin and Hart (1978) explored the use of a recorded speech reception threshold test in the form of a picture-pointing task for use with Spanish-speaking children. The use of the picture-pointing task was to allow a non-Spanish-speaking practitioner to administer the closed-set test without any knowledge of Spanish. The words for the English recordings were selected from the most familiar words for testing by Conn, Dancer, and Ventry (1975), and the Spanish words were chosen based on simplicity, stress pattern, and ease of representation in picture form (see Figure 1). Twelve phonetically-dissimilar words were selected and preceded by the carrier phrase, "¿Dónde está…" (In English, "Where is ...?"), for the task. Martin and Hart evaluated the resulting test stimuli with 16 normal hearing Spanish/English bilingual adults and 16 normal hearing Spanish/English bilingual children from Texas (age 3-6). Test stimuli were found to have good homogeneity in terms of audibility, equivalent to that of English spondees. In addition, good agreement was found between the Spanish speech threshold and the pure-tone average, with the mean of the Spanish speech threshold and the pure-tone average differing by 4 dB. Based on these findings, the authors recommended the use of the test with older patients who speak Spanish but have little to no knowledge of English. The picture-pointing task can also be easily developed and/or modified into other languages and regions.

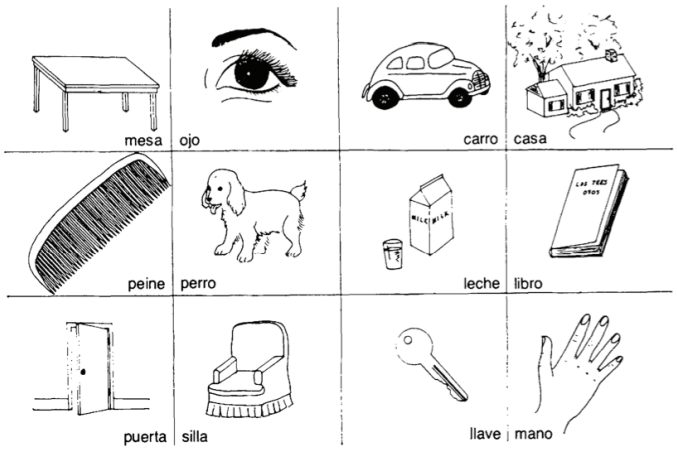

Figure 1. Sample response card for Martin and Hart picture-pointing test (from Martin and Hart, 1978)

In 1980, Spitzer sought to develop a Spanish word picture-pointing task, designed for use with Spanish speakers from diverse backgrounds. Similar to Martin and Hart (1978), the test was intended for use by non-Spanish-speaking clinicians. Spitzer cited the speech reception threshold (SRT) and picture-pointing task by Martin and Hart (1978) as having Spanish vocabulary that was "insufficient" for clinical purposes. The test items were chosen from a frequently used list of Spanish words, consisting of body parts, animals, common objects, food, clothing, and people. The carrier phrase "Muéstrame…" (In English, "Show me…") was presented before the word. No definite articles preceded the word, such as "Muéstrame niño" instead of "Muéstrame el niño," in order to avoid unintentional information (i.e. gender) influencing the word choices. The child would then point to a picture on the card, which was marked with numbers corresponding to the word's location (see Figure 2). To determine the SRT, stimuli were presented in descending 5-dB steps with three correct responses needed to proceed. Although not validated in a laboratory setting, Spitzer stated that audiologists using the test reported good agreement between the SRT and the pure-tone average without any difficulty.

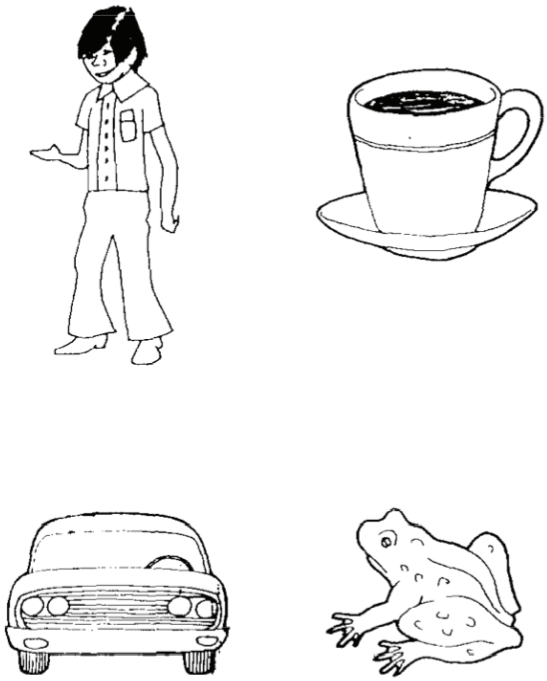

Figure 2. Sample response card for Spitzer picture-pointing test (from Spitzer, 1980)

Comstock and Martin (1984) developed a picture-pointing word discrimination test that could be administered to Spanish-speaking children by English-speaking clinicians who had no knowledge of Spanish. The authors compiled four lists of 25 words, which were recorded by a native speaker from Texas who was also fluent in Spanish. A carrier phrase, "Apunta con el dedo…" (In English "Point with your finger"), was presented prior to the stimulus. The words were illustrated by black and white drawings on six tiles on an 8 x 11 plate (see Figure 3). The pictures included four stimuli words and two foils. Comstock and Martin included two experiments within this study. The first experiment involved 15 adults with normal hearing who were native Spanish speakers and who grew up in Texas. The second experiment was comprised of 20 children (between the ages of three and eight) who lived in central Texas and who identified Spanish as their dominant language. The first experiment revealed equivalent word lists and a performance-intensity (PI) function slope of 2.9%/dB. The average PI function for the PB-50 lists is 2.5%/dB. Experiment 2 showed an increase in discrimination score as age increased. Most of the words that the children missed were due to limited vocabulary, which, Comstock and Martin noted, should be assessed for any speech discrimination measure. Results from experiment 2 demonstrated that the test was useful in assessing word discrimination. Because the carrier phrase does not require the audiologist to review any instructions in Spanish, it may also be an effective assessment for English-speaking clinicians. At the time of publication, the authors were investigating the effect of hearing loss on word discrimination ability. However, a recent review of the literature returned no results of a follow-up study.

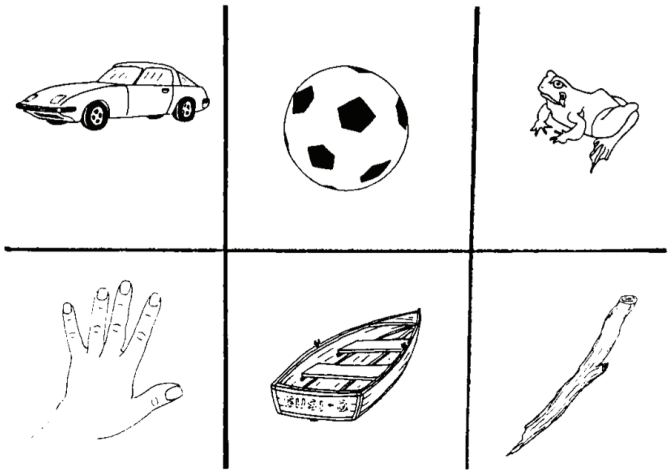

Figure 3. Sample response card for Comstock and Martin picture-pointing test (from Comstock and Martin, 1984)

In a 2013, Mendel, Elkins, McNiece, Lane, Carter, and Taylor developed and validated a Spanish SRT test that used picture pointing for Spanish-speaking children between the ages of two and five. This test included bisyllabic trochaic words and did not include an article, which in Spanish, provides information about a word's gender. The words were easily illustrated and were considered very familiar to Spanish speakers (see Figure 4). The first part of their study consisted of two sections. The first section involved 12 adult Spanish speakers in order to determine the most familiar words to young children. The second section included 25 Spanish-speaking children who were between the ages of three and eleven. The child was asked to point to the picture that matched the stimulus heard. Mendel and colleagues found that the children responded more accurately (95%) to illustrations of the words rather than photos. The second part of the study reported the initial normative data obtained from Spanish-speaking children with normal hearing. At the time of presentation, the validation process was noted as ongoing, but the authors have expanded the test to include quiet and competing message conditions.

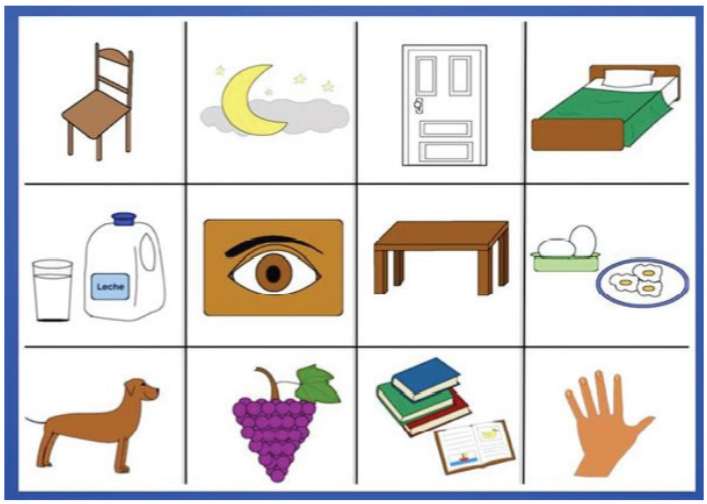

Figure 4. Sample response card for Mendel picture-pointing test (from Mendel et al, 2013)

Most recently, in 2014, Calandruccio, Gomez, Buss, and Leibold developed a speech perception task for use with bilingual Spanish/English children. The authors chose to use a four-alternative forced-choice picture identification format based on a study by Jerger, Speaks, and Trammell (1968) that found that since closed set formats have limited possible answer choices, they are appropriate for non-native speakers of English. The picture-pointing format allows the audiologist to accurately score the responses without knowledge of the Spanish language, and is commonly used with other clinical measures such as the Word Intelligibility by Picture Identification (WIPI) (Ross & Lerman, 1970) and Northwestern University- Children's Perception of Speech (NU-CHIPS) (Elliot & Katz, 1980). The speech perception task was designed for use with three main pediatric populations: monolingual English speakers, monolingual Spanish speakers, and bilingual Spanish/English speakers. This permits flexibility for the audiologist to choose the most appropriate task depending

on the L1 (first language) and L2 (second/foreign language) of the child. Calandruccio and her co-investigators chose to develop the task to be conducted in the presence of a masker or noise as most speech perception measures available for the pediatric population are conducted in quiet conditions. The authors selected 30 words from the Dolch word list (Dolch, 1948) and common words in children's literature that are expected to be part of the vocabulary of a typically developing five-year-old. Words selected were bisyllabic in both English and Spanish (e.g., feath-er and plu-ma) and easily illustrated for clear identification (see Figure 5). The target words and speech used in the masker were recorded from bilingual Spanish/English speakers to minimize any potential for temporal and spectral differences. The masker was passages from the English and Spanish versions of Jack and the Beanstalk and Juan y los Frijoles Mágicos, respectively. For the study, 16 children between the ages of 4.9 and 16.4, consisting of eight bilingual Spanish/English speakers and eight monolingual English speakers, were selected. Six children were considered simultaneous bilinguals and two children acquired English after learning Spanish. The bilingual Spanish/English children performed better in English than Spanish in the presence of competing speech, but performed similarly in a competing noise condition. Calandruccio and colleagues concluded the pediatric speech perception measures were easy to administer and addressed the need for a test available in English or Spanish.

Figure 5. Sample response card for Calandruccio picture-pointing test (from Calandruccio et al, 2014)

Considerations when Testing Speech Recognition of Spanish-Speaking Monolingual or Bilingual Children

The following review studies the impact of various factors on speech perception in bilingual children. Though the studies involved children with normal hearing, the effects are exacerbated by a hearing loss. These effects of hearing loss result in a compromise of speech perception compared to children with normal hearing, requiring additional considerations.

It is important to evaluate (or examine previous evaluations of) the language comprehension and production capabilities of a child in the language to be used for speech recognition testing. Carrow (1972) compared auditory comprehension of English in bilingual and monolingual children. Two groups of 30 Mexican-American children were given the Auditory Test for Language Comprehension (Carrow, 1968), which assesses oral language comprehension for both English and Spanish. The test includes black and white drawings of various parts of speech such as nouns, verbs, adjectives, demonstratives, pronouns, etc. The child was instructed to point to the picture for each word. Carrow found that the children might first experience a language delay around preschool ages, which progresses as they become older. The bilingual children made more errors than their monolingual counterparts on adjectives, nouns, pronouns, and noun phrases that had adjective modifiers. Carrow attributed this to the challenge that bilingual listeners may encounter with nouns and not with syntax and functional words. The results of the study support the position of adequate assessment of a bilingual child's language ability as it may be delayed. This delay can be further intensified as the child enters school learning two languages, leading to academic difficulties.

Ferullo (1983) used a case illustration to provide guidelines for the use of assessing pre-school bilingual Spanish/English children. Ferullo explained the process of assessing "Wanda," a three year old who was seen because she was not responding and talking in neither Spanish nor English, raising concerns for her mother. Based on behavioral measures (Wanda's behavior prevented objective measures from being obtained), the clinician diagnosed Wanda as having a severe-to-profound hearing loss. The recommendation was to follow Wanda for future audiologic evaluations and to enroll her in speech-language therapy in English. Subsequent audiologic evaluations supported the initial diagnosis of a severe-to-profound bilateral hearing loss. Wanda was enrolled in a public school program for preschool children who had hearing loss. Later, Wanda was making unsatisfactory progress with her speech and language therapy, likely due to the 76 absences from preschool she logged. After psychological testing, Wanda obtained a score of 98 on the Wechsler Preschool and Primary Scale of Intelligence and Performance Scale at 4;3. Later evaluations deemed oral-auditory communication was not appropriate for Wanda's communication needs and that it be supplemented with a total communication program.

Ferullo used the case of Wanda to create guidelines for preschool bilingual children, citing the family environment, Hispanic culture, Wanda's mother's overbearingness, inconsistent language exposure, and variation of recommendations as sources of Wanda's identification and intervention. Based on these

"mis-steps" as Ferullo refers to them, the following guidelines were developed: 1. Avoiding "premature, monoprofessional recommendations" favoring the involvement of a team of clinicians, 2. Avoiding "the defense of a specific philosophy" as each family and child is different, 3. Avoiding "transgressing from the professional role" as rapport between clinician and family is important in determining the next step, and 4. Being "aware of the impact of a child's hearing impairment, not only on the child, but on the family" as the hearing loss is only one aspect and other areas like the child's academic performance and social interaction should not be overlooked. Ferullo concluded that these guidelines allow for objectivity in evaluating non-native English-speaking children.

An evaluation conducted in the child's non-native language may yield inaccurate test results. Smyk, Restrepo, Gorin, and Gray (2013) sought to address this concern by developing and validating an oral language proficiency scale for Spanish/English sequential children between the ages of four and eight years old to assess L2 proficiency. Using the above definition of language proficiency, Smyk and colleagues designed the Spanish-English Language Proficiency Scale (SELPS) as a criterion-reference rating scale to be used with a story-retelling task that would provide a language sample. The authors chose to use a story-retell task as previous studies have shown that sequential bilinguals produce longer utterances and more complex syntactical structures than other tasks like spontaneous conversation. Two stories were used for the retell task to avoid memory effects and allow for test-retest within the assessment. The study consisted of two parts: evaluating the reliability of the new scale and determining its suitability for measuring language proficiency in English. For the first part, Smyk and colleagues found that the SELPS yielded similar results on the story-retelling task in bilingual children. However, the authors cautioned that all of the participants had experience with storytelling, an awareness that could affect results for children who did not. For the second part, the authors used the SELPS to assess sequential bilingual children who identified English as their L2 in English-only schools in Arizona, as well as teacher ratings of the child's language proficiency in English. Results showed significant correlation between the score on the SELPS and language sample, indicating comparable assessment of language ability between the two scores. It should be noted that the SELPS provides an overall view of language proficiency in the L2 and should, therefore, be utilized as a screener. Teacher ratings and scores on the SELPS were significantly moderately correlated, meaning higher scores on the SELPS correlated to higher ratings on the teacher's scales. Smyk and colleagues cautioned that the measure should not be used to identify language impairments as it was developed based on the milestones normally achieved by children. Based on these findings, the SELPS may be a valid measure for assessing L2 proficiency in sequential bilingual children.

In addition to evaluating a child in his or her non-native language, there are other factors that influence a bilingual child's word recognition ability, including maternal education, socioeconomic status, and other environmental factors. In 2007, Hurtado, Marchman, and Fernald studied children learning Spanish as their first language and how low socioeconomic status affected speech recognition and processing. The study involved 49 children between 1;3 and 3;6 years who had recently immigrated to the United States from Mexico. The majority of the children were born in the United States, but 92% of their parents were born in Mexico. None of the parents reported developmental delays or hearing loss for their children. In a satellite laboratory, the children underwent assessments of their expressive vocabulary and eye-movements during a listening task. Hurtado and her co-investigators learned that there was a positive correlation between speech processing ability and age, as older children were quicker to respond than younger children, and that their spoken language ability was also correlated to the size of their vocabulary. Other associations include maternal education and socioeconomic status. The authors attributed these associations to mothers who contribute to their child's language abilities by using labeling (e.g., "the naming game") and their level of talking to their children. The families in the study were in the bottom 20% of the education and income levels of the United States population, which may explain the poorer performance in children of low socioeconomic backgrounds who required more time and scored more poorly on the tasks. Hurtado and her co-investigators concluded vocabulary size and speech processing efficiency are adversely affected by the child's socioeconomic status. The results from this study are crucial in the assessment of speech perception in bilingual children from low socioeconomic backgrounds as they may experience lower understanding of spoken language and have limited vocabulary, especially younger children. Familiarization for speech recognition threshold measures is, therefore, imperative to ensure the score obtained is accurate.

Challenges for Assessment and Treatment of Bilingual Children in Educational Settings

The implications of speech perception testing are especially important for children as classrooms tend to be noisy and reverberant environments. Background noise has greater adverse effects on speech perception for children than adults (Nelson, Kohnert, Sabur, & Shaw, 2005).

Speech testing in noise is of particular interest to audiologists working with children to estimate how the child performs in a classroom, an environment where noise and reverberation occur naturally and can negatively affect speech perception, even for children with normal hearing. The American National Standards Institute (ANSI), U.S. Access Board, and the Acoustical Society of America sought to formulate guidelines for creating an optimal environment for speech understanding in the classroom (ANSI S12.60-2010). ANSI S12.60-2010 is endorsed by the American Academy of Audiology and the American Speech-Language-Hearing Association. This standard has recommended criteria for permanent school buildings (ANSI S12.60-2010/Part 1) and portable classrooms (ANSI S12.60-2009/Part 2). These criteria include recommendations for background noise and reverberation time, dependent on the size of the room and the type of classroom. Portable classrooms have higher allowances for background noise compared to permanent classrooms, 41 dBA and 35 dBA, respectively, for rooms less than 10,000 cubic feet and rooms between 10,000 and 20,000 cubic feet. Background noise levels of 40 dBA are permissible in both permanent and portable

classrooms with room volumes greater than 20,000 cubic feet. Reverberation time in portable classrooms should not exceed 0.5 seconds and 0.6 seconds for rooms less than 10,000 cubic feet and rooms between 10,000 and 20,000 cubic feet, respectively. This allowance is slightly higher for permanent classrooms that have recommended reverberation times of 0.6 seconds and 0.7 seconds for rooms less than 10,000 cubic feet and rooms between 10,000 to 20,000 cubic feet. In 1996, Crandell and Smaldino sought to investigate the speech perception ability in bilingual Spanish/English children. The subjects were 20 children who were native speakers of English and 20 children who were learning English as a second language. Crandell and Smaldino used the Bamford-Kowal-Bench (BKB) sentence test presented in the presence of 12-speaker babble from Auditec (Etymotic Research, 2005). To simulate a typical classroom environment, Crandell and Smaldino presented the stimuli at varying signal-to-noise-ratios (SNR) of +6, +3, 0, -3, and -6 dB. The authors found that the children learning English as a second language had poorer speech perception scores in noise than the native English speakers. The differences between groups became more evident as the SNR decreased. However, in quiet conditions, both groups obtained similar scores. The results of this study are two-fold. Firstly, academic difficulties typically encountered by children learning English as a second language may be attributed to the poor classroom acoustic environment. Secondly, classroom acoustics, both noise and reverberation, can create an unfavorable environment for listening, especially for children whose first language is not English. Crandell and Smaldino suggested the use of assistive technology such as a personal FM (frequency modulation) or sound-field FM system to improve the SNR to observe any improvements by children learning English as a second language in a classroom setting.

In 2005, Nelson, Kohnert, Sabur, and Shaw explored the effects that classroom noise had on bilingual children's attention and speech perception compared to monolingual children. This involved the observation of behavioral changes prior to and following the addition of amplification in the classroom. Then, a word recognition measure, similar to that of Crandell and Smaldino (1996), was used. The majority of the 22 second-grade students who participated in the study spoke Spanish at home. The school chosen by Nelson and colleagues had a bilingual education program, which allowed students to spend half of the school day learning in English and the second half of the day in Spanish. The teachers and speech-language pathologist at the school reported high levels of noise from a busy street outside of the classroom in spite of renovations. These noise levels were found to range between 54 and 67 dBA. Nelson and her co-investigators found no differences when observing behavior before and after adding amplification. However, the authors reported a decline in word recognition scores for both monolingual and bilingual children when the test was presented in the noise condition. This decline was greater for the bilingual children. The results from this study supported the findings of Crandell and Smaldino. Nelson and colleagues recommended that those working in the school first recognize any noise and try to remove it. Examples of this include turning off computers, adding tennis balls to the legs of chairs, and closing open doors and windows. The authors also suggested that educational audiologists work with teachers to identify these noise sources and work to increase the signal's level. Results of this study further support the concept of increasing the signal over the noise, especially for those learning a second language, as research has shown they experience greater deficits in speech perception in poor SNR environments.

Reverberation and noise can cause bilingual listeners to experience deficits in speech perception. Tabri, Chacra, and Pring (2010) noted that these deficits are especially important to address in children who are multilingual and are learning in classrooms with poor acoustics. In the study, Tabri and colleagues recruited monolingual, bilingual, and trilingual adult listeners who were "highly fluent" in English and had normal hearing. Participants underwent the Speech Perception in Noise (SPIN) test (Kalikow, Stevens, & Elliott, 1977) with varying levels of noise. The results of the study supported the indication that although monolingual speakers and bilingual speakers may perform similarly in quiet conditions, bilingual speakers have declines in their speech perception abilities when the SNR is poor. Trilingual listeners' performance was similar to that of bilingual listeners. Tabri and her co-investigators extended these results to non-native children in classrooms who may struggle with speech perception. The authors recommended that teachers and school administrators focus on improving the listening environment in classrooms for these students.

Synthesized speech is utilized by electronic communication devices, such as augmentative and alternative communication (AAC) systems, for the purpose of providing individuals with severe communicative disabilities with a means to express themselves (Axmear, Reichle, Alamsaputra, Kohnert, Drager, & Sellnow, 2005). Children from diverse linguistic backgrounds may benefit from increased use of synthesized speech devices (Harrison-Harris, 2002). Because it is electronically created, synthesized speech is considered less intelligible than natural speech and is generated by a computer. Digitized speech uses pre-recorded human speech, so the voice output is more natural. Given the growing number of linguistically diverse children who now use devices with synthesized speech and the disadvantages they can pose, Axmear and her co-investigators sought to compare synthesized speech and live speech with monolingual and bilingual children. In the study, 10 monolingual children and 10 sequentially bilingual children underwent testing with the SPIN test, which was presented twice, once by a female speaker from the Midwest United States, and then via Perfect Paul, an application that uses text-to-speech for synthesis. Axmear and colleagues found that both groups of children performed comparably when the stimuli were presented with live speech. However, the monolingual group (84%) outperformed the bilingual group (61%) when the Perfect Paul application was used. Previous research has shown that exposure to synthetic speech like that produced by the Perfect Paul led to improved performance with speech intelligibility in monolingual children (McNaughton, Fallon, Tod, Weiner, & Neisworth, 1994). Based on these findings, Axmear and her colleagues concluded that although bilingual children may need synthesized speech in noisy classroom environments, they are likely to encounter difficulties with understanding. Therefore, audiologists and interventionists

in the schools may have to implement external speakers and find ways to decrease classroom noise levels.

In order to rectify the challenges bilingual children with hearing loss face in the classrooms, Walker-Vann (1998) proposed a model for educational systems that include Hispanic students with hearing loss. After collecting demographic information from Hispanic and non-Hispanic students at the Texas School for the Deaf, Walker-Vann learned of some differences between the groups. First, 27% of the Hispanic students surveyed had a hearing loss attributable to genetics, compared to 35% of non-Hispanic students. Secondly, although the ratio of males to females with hearing loss is higher for the former, Walker-Vann found that 64% of the Hispanic students were male and 58% of the non-Hispanic students were female. The author attributed this discrepancy to research by Schildroth and Hotto (1993) that found that "males… *are reported* [emphasis in original] to have significantly higher rates of emotional/behavioral problems and learning disabilities than females." In Walker-Vann's study, about half (44%) of the students reported Spanish as the preferred language in the home. Similarly, 52% of the households used a form of signed language for communication, even if the parents were hearing. In this case, the child is introduced to trilingualism, which includes signed language, English, and Spanish. Walker-Vann commented that this can be "frustrating and stressful" and that the educational system should work with these students to alleviate these feelings. Using the results from this study combined with results from a 1985 study by Christensen, Walker-Vann proposed the use of videotaped lessons for families to receive instruction or who are unable to attend sign language classes. Lastly, the author noted that these lessons would allow children and their parents to participate actively in language learning at home.

Finally, when screening for hearing loss, an accurate case history can provide the pediatric/educational audiologist with essential information for diagnosis and treatment of children who speak Spanish primarily. A literature review by Muñoz, Caballero, and White (2014) examined studies published between 1980 and 2013 in either English or Spanish for the use of questionnaires. The authors found seven studies that used parent or teacher-completed questionnaires as a means of identifying children who may require additional hearing evaluations. Of those seven studies, only one was deemed effective in screening for permanent hearing loss. Based on these results, Muñoz and colleagues recommended that further research needs to be performed on questionnaires to ensure that they are effective tools for screening hearing. The findings of this study are especially important for audiologists working with culturally diverse populations. Morrison (2008) suggested the inclusion of small-talk prior to obtaining a case history in order to build rapport and impart confidence. In addition to showing respect, Morrison advised that the audiologist allow the family to ask questions and to explain any new terminology. This also includes being aware of the family's cultural and belief system and any influences they may have on hearing loss (Talamantes, Lindeman, & Mouton, 2001; Warda, 2000 as cited in Morrison, 2008).

Future Research and Clinical Implications

After a review of the literature, it is evident that more research with bilingual children is needed. Goldstein and Kohnert (2005) direct future research to include interactions with the Hispanic family and culture, given its influence within the population. As the Hispanic population continues to grow, the fields of audiology and speech-language pathology will require materials that have been validated and have had normative values obtained in order to ensure that bilingual children with hearing loss are receiving appropriate services and to address any hearing healthcare disparities. In addition to the development of additional test materials appropriate for Spanish-speaking pediatric patients, considerable work is needed to assess the validity and reliability of these tests that are already available and in use.

References

American Speech-Language-Hearing Association's Working Group on Classroom Acoustics. (2004). Retrieved from http://www.asha.org/public/hearing/American-National-Standard-on-Classroom-Acoustics/

ANSI (2009). ANSI/ASA S12.60-2009 Acoustical performance criteria, design requirements and guidelines for schools, part 2: Relocatable classroom factors. New York: American National Standards Institute.

ANSI (2010). ANSI/ASA S12.60-2010 Acoustical performance criteria, design requirements and guidelines for schools, part 1: Permanent schools. New York: American National Standards Institute.

Axmear, E., Reichle, J., Alamsaputra, M., Kohnert, K., Drager, K., & Sellnow, K. (2005). Synthesized speech intelligibility in sentences: A comparison of monolingual English-speaking and bilingual children. *Language, Speech, and Hearing Services in Schools, 36*, 244-250.

Bench, J., Kowal, A., & Bamford, J. (1979). The BKB (Bamford-Kowal-Bench) sentence lists for partially-hearing children. *The British Journal of Audiology, 13*(3), 108-112.

Blamey, P.J., Sarant, J.Z., Paatsch, L.E., Barry, J.G., Bow, C.P., Wales, R.J.,…Tooher, R. (2001). Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. *Journal of Speech, Language, and Hearing Research, 44*, 264-285.

Bradlow, A.R., & Bent, T. (2002). The clear speech effect for non-native listeners. *Journal of the Acoustical Society of America, 112*(1), 272-284.

Bradlow, A.R., Kraus, N., & Hayes, E. (2003). Speaking clearly for children with learning disabilities: Sentence perception in noise. *Journal of Speech, Language, and Hearing Research, 46*, 80-97.

Bunta, F., & Douglas, M. (2013). The effects of dual-language support on the language skills of bilingual children with hearing loss who use listening devices relative to their monolingual peers. *Language, Speech, and Hearing Services in Schools, 44*, 281-290.

Calandruccio, L., Gomez, B., Buss, E., & Leibold, L.J. (2014). Development and preliminary evaluation of a pediatric Spanish-English speech perception task. *American Journal of Audiology, 23*, 158-172.

Carrow, E. (1968). The development of auditory comprehension of language structure in children. *Journal of Speech and Hearing Research, 38*, 99-111.

Carrow, E. (1972). Auditory comprehension of English by monolingual and bilingual preschool children. *Journal of Speech and Hearing Research, 15*, 407-412.

Christensen, K.M. (1985). Conceptual sign language as a bridge between English and Spanish. *American Annals of the Deaf, 130*(3), 244-249.

Comstock, C.L., & Martin, F.N. (1984). A children's Spanish word discrimination test for non-Spanish-speaking clinicians. *Ear & Hearing, 5*(3), 166-170.

Conn, M., Dancer, J., & Ventry, I.M. (1975). A spondee list for determining speech reception thresholds without prior familiarization. *Journal of Speech and Hearing Disorders, 40*, 388-396.

Crandell, C.C., & Smaldino, J.J. (1996). Speech perception in noise by children for whom English is a second language. *American Journal of Audiology, 5*, 47-51.

Dolch, E.W. (1948). *Problems in reading*. Champaign, Illinois: The Garrard Press.

Elliot, L.L., & Katz, D. (1980). Development of a new children's test of speech discrimination. St. Louis: Auditec.

Escarce, J.J. & Kapur, K. (2006). Access to and Quality of Health Care. In M. Tienda & F. Mitchell (Eds.), *Hispanics and the Future of America* (410-455). Washington, D.C.: The National Academies Press.

Etymotic Research. (2005). Bamford-Kowal-Bench Speech-in-Noise test (Version 1.03) [Audio CD]. Elk Grove Village, IL: Etymotic Research.

Ferullo, R.J. (1983). Objectivity in the assessment of preschool hearing impaired bilingual-Hispanic children. *The Journal of School Health, 52*(2), 131-135.

Flores, G., Olson, L., & Tomany-Korman, S.C. (2005). Racial and ethnic disparities in early childhood health and health care. *Pediatrics, 115*(2), e183-e193.

Gallaudet Research Institute. (2002). Regional and national summary report of data from the 2000-2001 annual survey of deaf and hard of hearing children & youth. Washington, D.C.: GRI, Gallaudet University.

Gallaudet Research Institute (2011). Regional and national summary report of data from the 2009-2010 annual survey of deaf and hard of hearing children & youth. Washington, D.C.: GRI, Gallaudet University.

Goldstein, B., & Kohnert, K. (2005). Speech, language, and hearing in developing bilingual children: Current findings and future directions. *Language, Speech, and Hearing Services in Schools, 36*, 264-267.

Guiberson, M. (2014). Survey of Spanish parents of children who are deaf or hard of hearing: Decision-making factors associated with communication modality and bilingualism. *American Journal of Audiology, 22*, 105-119.

Harrison-Harris, O. (2002, November 5). AAC, literacy, and bilingualism. *ASHA Leader*, 20.

Hurtado, N., Marchman, V.A., & Fernald, A. (2007). Spoken word recognition by Latino children learning Spanish as their first language. *Journal of Child Language, 34*(2), 227-249.

Jerger, J.F., & Hayes, D. (1976). The cross-check principle in pediatric audiology. *Archives of Otolaryngology, 102*(10), 614-620.

Jerger, J., Speaks, C., & Trammell, J.L. (1968). A new approach to speech audiometry. *Journal of Speech and Hearing Disorders, 33*(4), 318-328.

Kalikow, D.N., Stevens, K.N., & Elliott, L.L. (1977). Development of a test of speech in noise using sentence materials with controlled word predictability. *Journal of the Acoustical Society of America, 61*, 1337-1351.

Martin, F.N. & Hart, D.B. (1978). Measurement of speech thresholds of Spanish speaking children by non-Spanish speaking clinicians. *Journal of Speech and Hearing Disorders, 43*, 255-262.

McNaughton, D., Fallon, K., Tod, J., Weiner, F., & Neisworth, J. (1994). Effect of repeated listening experiences on the intelligibility of synthesized speech. *Augmentative and Alternative Communication, 10*, 161-168.

Mehra, S., Eavey, R.D., & Keamy, D.G., (2009). The epidemiology of hearing impairment in the United States: Newborns, children, and adolescents. *Otolaryngology—Head and Neck Surgery, 140*, 461-472.

Mendel, L.L. (2008). Current considerations in pediatric speech audiometry. *International Journal of Audiology, 47*, 546-553.

Mendel, L.L., Elkins, R., McNiece, C., Lane, K., Carter, M., & Taylor, J. (2013). *The development of speech recognition tests for Spanish-speaking children*. Poster presented at the American Speech-Language-Hearing Association meeting, Chicago, IL, November.

Morrison, A.M. (2008). Providing culturally effective audiological services to the Hispanic pediatric population. Retrieved from http://kb.osu.edu/dspace/handle/1811/49164

Muñoz, K., Caballero, A., & White, K. (2014). Effectiveness of questionnaires for screening hearing of school-age children: A comprehensive literature review. *International Journal of Audiology, 20*(1).

Nelson, P., Kohnert, K., Sabur, S., & Shaw, D. (2005). Classroom noise and children learning through a second language: Double jeopardy? *Language, Speech, and Hearing Services in Schools, 36*, 219-229.

Peterson, G.E., & Lehiste, I. (1962). Revised CNC lists for auditory tests. *Journal of Speech and Hearing Disorders, 27*, 62-70.

Peyton, J.K., Ranaard, D.A., & McGinnis S. (Eds.) (2001). Heritage languages in America: Preserving a national resource. McHenry, IL: Delta Systems.

Rhoades, E.A., Price, F., & Perigoe, C.B. (2004). The changing American family and ethnically diverse children with hearing loss and multiple needs. *The Volta Review, 104*(4), 285-305.

Ross, D.S., Holstrum, W.J., Gaffney, M., Green, D., Oyler, R.F., & Gravel, J.S. (2008). Hearing screening and diagnostic evaluation of children with unilateral and mild bilateral hearing loss. *Trends in Amplification, 12*(1), 27-34.

Ross, M. & Lerman, J. (1970). A picture identification test for hearing impaired children. *Journal of Speech and Hearing Research, 13*, 44-53.

Schildroth, A. & Hotto, S.A. (1993). Annual survey of hearing impaired children and youth. *Annals of the Deaf, 138*(2), 68-71.

Schildroth, A.N., & Hotto, S.A. (1994), Inclusion or exclusion?: Deaf students and the inclusion movement. *American Annals of the Deaf, 139*(2), 239-242.

Shi, L.F. (2014). Speech audiometry and Spanish-English bilinguals: Challenges in clinical practice. *American Journal of Audiology, 23*, 243-259.

Smyk, E., Restrepo, M.A., Gorin, J.S., & Gray, S. (2013). Development and validation of the Spanish-English Language Proficiency Scale (SELPS). *Language, Speech, and Hearing Services in Schools, 44*, 252-265.

Spitzer, J.B. (1980). The development of a picture speech reception threshold test in Spanish for use with urban U.S. residents of Hispanic background. *Journal of Communication Disorders, 13*, 147-151.

Steinberg, A., Bain, L., Li, Y., Delgado, G., & Ruperto, V. (2003). Decisions Hispanic families make after the identification of deafness. *Journal of Deaf Studies and Deaf Education, 8*(3), 291-314.

Tabri, D., Chacra, K., & Pring, T. (2010). Speech perception in noise by monolingual, bilingual, and trilingual listeners. *International Journal of Language and Communication Disorders*, 1-12. doi: 10.3109/13682822.2010.519372

Talamantes, M., Lindeman, R., & Mouton, C. (2001). Health and health care of Hispanic/Latino American elders. *Curriculum in Ethnogeriatrics*. Retrieved from http://www.stanford.edu/group/ethnoger/

United States Department of Education. (2004). Topic: Changes in initial evaluation and reevaluation. Retrieved from http://idea.ed.gov/explore/view/p/,root,dynamic,TopicalBrief,4,

Walker-Vann, C. (1998). Profiling Hispanic Deaf students: A first step toward solving the greater problems. *American Annals of the Deaf, 143*(1), 46-54.

Zimmerman, I.L., Steiner, V.G., & Pond, R.E. (2002). Preschool Language Scale, Fourth Edition (English Edition). San Antonio, TX: Harcourt Assessment.