# Assessment of Cleft Palate Articulation and Resonance in Familiar and Unfamiliar Languages: English, Spanish, and Hmong

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Kelly Nett Cordero

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Kathryn Kohnert, Ph.D., Karlind Moller, Ph.D.

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## Abstract

Linguistic diversity is increasing in the patients seen for cleft palate treatment and there are not enough providers who speak multiple languages. There are no published studies which directly investigate the ability to assess cleft palate articulation and resonance in a language not spoken by the examiner. The aim of this study was to determine whether listeners could make accurate judgments about articulation and resonance in languages they do not speak and to determine how experience level and familiarity with a language affect these ratings. Binary (presence/absence) and visual analog scale (VAS) judgments were obtained for hypernasality, misarticulations, speech acceptability, and overall velopharyngeal dysfunction (VPD) of English, Spanish, and Hmong samples from naïve listeners, generalist speech-language pathologists (SLPs), and specialist SLPs. The speech samples were obtained from 22 speakers, nine with a history of VPD and 13 controls. The ratings were completed by 24 native English listeners, eight at each level of experience (naïve, generalist SLP, specialist SLP).

Overall, the listeners were more accurate for determining the presence/absence of misarticulations, speech acceptability, and VPD in English compared to Hmong. Hypernasality and VPD ratings in English were more accurate than in Spanish and ratings of misarticulations were more accurate in Spanish than Hmong. VAS ratings of hypernasality were highly correlated with the nasalance values from oral phoneme reading passages. Statistically significant correlations were present for overall and group ratings in English. Less consistent correlations were observed in Spanish and no significant correlations were present in Hmong. Overall, listeners judged English ratings to be easier to make, and were made with more confidence, compared to Hmong. Overall, the SLP specialists tended to find the ratings in all languages easier to make and were more confident than naïve listeners.

Many of the expected differences for ratings based on listener experience and language familiarity were observed. There were advantages for all listener groups in English when compared to Hmong. These differences were inconsistent and weaker when Spanish was compared to English. The experience advantage for listeners was most apparent in English and Hmong.

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## REVIEW OF THE LITERATURE

### *Cleft Lip and Palate*

Cleft lip and/or palate is one of the most common congenital birth defects, affecting approximately 1 in 500 to 750 children, with a slightly higher prevalence in some Asian and indigenous populations and slightly lower in some African groups (Peterson-Falzone, Hardin-Jones, & Karnell, 2000; Vanderas, 1987). In fact, a recent report from the Centers for Disease Control (CDC) indicates that clefts affect approximately 6,800 infants per year in the United States (Moller, 2008; CDC, 2006). Cleft lip and palate affect facial appearance and growth, psychosocial development, hearing, feeding, dental status, and speech production. The velopharyngeal mechanism is altered by a cleft palate leading to the potential for disproportionate coupling of the oral and nasal cavities during speech production, resulting in excessive nasal resonance and the perception of hypernasality. In addition, velopharyngeal closure dysfunction, missing teeth, and dental alignment issues are frequently present and can lead to articulation errors as well. Based on these speech articulation and resonance concerns and the prevalence of cleft palate, it is important that we have appropriate methods for assessment and treatment of the communication skills in this population (Kuehn & Moller, 2000; Kummer, 2001; Peterson-Falzone, et al., 2000).

Results from the 2000 U.S. Census show the growing population of individuals in this country who speak a language other than English at home, numbered at approximately 47 million in 2000 (U.S. Census Bureau, 2000). The results of the 2005 American Community Survey demonstrated that the largest group is from Spanish-speaking backgrounds, encompassing 12.0% of the population (or approximately 35 million) (U.S. Census, 2005). There are also other linguistic groups which are concentrated in particular geographic regions. For example, in Minnesota there are over 22,000 households where Hmong (also referred to as Mong) is the primary language spoken (Minnesota Department of Education (MDE), 2007). Hmong is one of the Miao-Yao/Hmong Mien languages and is traditionally spoken by Hmong individuals in Laos, Thailand, Burma, Vietnam, and parts of Southern China (Bliatout, Downing, Lewis &

Yang, 1988). This population started arriving in the U.S. at the end of the Vietnam War in 1975 (McDermid, 1999). Both White Hmong and Green Hmong dialects are spoken in the U.S. Although White Hmong is more commonly used, they are mutually intelligible for most adult speakers with some lexical and phonological variation. (See Kan, Xiong, & Kohnert, 2006, and Kan & Kohnert, 2005 for additional information on the Hmong language.)

***Linguistic Diversity in Cleft Care***

The large and growing bilingual population of Spanish-English speakers seen in the U.S. is also reflected in the increasing number of native Spanish-speaking patients seen in cleft and craniofacial clinics. A 2004 survey of 171 clinics revealed that more than 25% of patients seen in 27 clinics (16% of those surveyed) were Spanish-speaking; 75 of the clinics (44%) had seen an increase in Spanish-speaking patients in the past five years (Edwards & Bonilla, 2004). While there are no published numbers regarding Hmong patients seen at cleft palate-craniofacial clinics, there are significant linguistic and cultural considerations for working with this and other Asian populations (Cheng, 1990). There is a consistent presence of Hmong patients seen in local cleft palate clinics in the state of Minnesota, with 4% Asian families seen in one such clinic in 2002 (DeMarco, Glaze, & Moller, 2003) and increases noted since. Hmong was also one of the most commonly requested languages for interpreters at that same clinic (DeMarco et al., 2003).

In addition to the increasing number of individuals who speak languages other than English seen in U.S. cleft palate-craniofacial clinics, there are also surgical teams who travel to developing countries to provide surgical intervention for individuals with cleft palate and related craniofacial conditions. These trips have been documented for at least the past 50 years and continue currently, with teams originating from the U.S., the United Kingdom as well as other countries (Mars, Sell, & Habel, 2008; Sell, 2007a, 2007b). Typically, the surgical professionals are treating patients who speak a language other than their own and very often a local speech-language pathologist (SLP) is not available. A recent investigation revealed that only 51 nations and territories have training programs for speech-language pathology or audiology (Bleile, Ireland & Kiel, 2006). Since articulation and resonance assessment is critical for individuals with cleft palate, it is important that we continue to improve our evaluation techniques for working with individuals who speak languages other than English. Linguistic and cultural clinical competence is essential for working with language minority groups at home (Kohnert, Kennedy, Glaze, Kan & Carney, 2003), as well as for professionals who serve on surgical teams who travel to other countries (Cordero, 2008; Mars, et al., 2008; Wirt, Wyatt, Sell, Mars, Grunwell, & Lamabadusuriya, 1990). Significant cross-cultural variation in beliefs surrounding the etiology of cleft palate, social perception of craniofacial conditions, patient and family concerns, and desired treatment outcomes continues to be documented in the literature (Cheng, 1990; Hinton, 2008; Meyerson, 1990; Ortiz-Monasterio & Serrano, 1971; Ross, 2007; Scheper-Hughes, 1990; Strauss, 1985, 1990; Toliver-Weddington, 1990 & Weatherley-White, Eiserman, Beddoe & Vanderberg, 2005).

One concern regarding the evaluation of speech and resonance among a diverse patient population is the relative lack of diversity among SLPs involved in patient care. In 2001, only 0.6%, (or approximately 749 of over 127,000 American Speech-Language-Hearing Association [ASHA] members) identified themselves as sufficiently bilingual to provide services in a language other than English (Holliday, 2001). Although the percentage increased to 3.5% by 2007 (A. Moxley, personal communication, June 25, 2007), there is still a significant shortage of bilingual professionals when compared to the population that is being treated. For example, a survey of SLPs in the state of Minnesota revealed that 35% provide treatment to patients from at least four different linguistic backgrounds (Kohnert et al., 2003). The discrepancy between the language spoken by the provider and the patient begs the question; can trained English-speaking professionals identify cleft palate speech and/or resonance distortions in a language that they do not speak?

***Judging articulation and resonance in an unfamiliar language***

A small number of published studies are relevant to this question. English-speaking SLPs have judged the adequacy of speech or resonance in Vietnamese (Landis, 1973; Landis & Cuc, 1975), Slovak/Slovakian (Morris, 1978), and Sinhala (Sell, 1992, 2008; Sell & Grunwell, 1990, 1993, 1994; Sell, Grunwell, & Mars, 1994). However, it was not necessarily the specific goal of these studies to investigate whether a native English-speaking SLP could accurately judge cleft palate speech articulation and resonance distortions in an unfamiliar language. The Vietnamese studies examined the speech patterns of individuals aged three to 24 years (mean = 11.8 years) with unrepaired cleft palate (Landis, 1973; Landis & Cuc, 1975). The Sinhalese studies examined speech patterns following late palatal closure (11-19 years) (Sell, 1992, 2008; Sell & Grunwell, 1990, 1993, 1994; Sell et al., 1994). The Slovakian study was completed to assess the results of one particular type of cleft palate surgery at a more traditional time of 12-42 months (Morris, 1978). Although these studies were completed with different goals, they highlight important methodological issues to be considered when evaluating speech resonance and articulation in an unfamiliar language.

In her 1973 article about cleft palate speech articulation and resonance assessment in Vietnam, Landis acknowledged her lack of comprehension and production skills in Vietnamese. The staff nurse trained to deliver basic speech services completed all evaluations and treatment sessions with the study author. In the original article, it was unclear how patients were chosen for treatment or exactly how speech judgments were made. Landis and Cuc's 1975 follow-up article provided more details regarding the articulation and resonance assessment completed with each patient. Nasality was judged by both authors and intelligibility was only rated by the Vietnamese paraprofessional. Although specific judgment parameters were provided, it was not clear who judged the speech articulation in the Vietnamese sample of single words, counting, and sentence repetition and no information was provided about intra- or inter-rater reliability, or how speech samples were collected. In addition, only eight of the twenty Vietnamese consonants assessed were described in this study. While the authors claimed that these eight phonemes most closely resembled English consonants, it is unclear if other factors, such as developmental effects on speech or difficulty in assessment motivated the decision to illustrate only a portion of the results. It is also unclear if these eight phonemes adequately reflect the distributional characteristics of Vietnamese (Pham, Kohnert, & Carney, 2008).

Morris (1978) also addressed the issue of assessing speech resonance and articulation in an unfamiliar language. With the support of a Slovakian phoniatrist, Morris developed word, sentence, and reading level articulation measures he used in combination with instrumental measures to assess articulation and resonance in speakers of Slovak. However, only one clinical judgment was made to determine the adequacy of velopharyngeal system (velopharyngeal competence, incompetence, or marginal competence). Morris stated that he only judged the presence of intraoral pressure for Slovakian plosives, fricatives, and affricates, not whether they were accurately articulated. He also judged overall 'voice quality' in terms of hypernasality. Morris reported a 74.7% agreement between himself and the Slovakian phoniatrist who made independent ratings for placing patients into the three 'competence' categories. Based on these findings Morris concluded that "…speaking the language of the patients is not essential to making a reliable diagnosis of velopharyngeal competence" (Morris, 1978, p. 162).

Sell and colleagues (Sell 1992; 2008; Sell & Grunwell, 1990; 1993; Sell et al., 1994) evaluated the speech articulation and resonance skills of native Sinhala-speaking patients from Sri Lanka before and after initial cleft palate repair surgery completed in adolescence, using a more detailed analysis than Morris (1978). Their original scale assessed consonant placement, manner, and voicing; nasality; and grimace (facial and/or nasal) on six-point equal appearing interval scales (EAIs) (Sell & Grunwell, 1990). The scales were revised to include four to eight points after initial studies of reliability. These scales were used to develop 17 speech patterns which were later grouped into six categories used to determine prognosis, surgical recommendations and speech therapy targets (Sell et al., 1994).

Although reliability measures were completed on the scales with Sell and at least three trained co-workers, it was not noted whether any of these individuals were native or proficient Sinhala speakers. Sell and colleagues found that ratings for consonant placement, manner, and voicing were most reliable within and across listeners (with all correlation coefficients .79 or higher). For nasality, coefficients were lower ranging from .68 to.76. The authors speculated that articulation disorders may have contributed to the difficulty in making nasality judgments. In an effort to improve intra- and inter-rater reliability, the six point scale was changed to four points (Sell & Grunwell, 1993). Investigators used broad speech sound categories instead of detailed phonetic transcription, as it would have been very difficult to maintain consistency while rating sounds that are not present in their native language (e.g.,Brøndsted et al., 1993; 1994). Sell (2008) also pointed out the importance of using a structured speech sample of repeated words and sentences when assessing in an unfamiliar language since, "natural conversational speech cannot be evaluated by a non-native speaker" (Sell, 2008, p. 183). (See Sell & Grunwell, 1994, for a review of studies completed on cleft palate care in the developing world.)

Outside of the realm of cleft palate, Van Borsel and Pereira (2005) completed a relevant study which examined the ability to identify stuttering in a speaker's native language vs. in an unknown language. Native-speaking Dutch and native-speaking Portuguese individuals (who did not have any knowledge of the other language) viewed video-recorded speech samples of individuals speaking both languages and were asked to judge whether the individuals were stuttering. They found that the listeners could successfully identify individuals who stuttered in both the familiar and unfamiliar languages, but were more accurate in their native language. Native Dutch speakers were significantly better than native Portuguese speakers, perhaps reflecting their greater educational level within the discipline (Van Borsel & Pereira, 2005). Currently, there are no published studies that offer this comparison about identifying cleft palate speech articulation and resonance in native and unfamiliar languages.

***Factors affecting articulation and resonance***

Regardless of the language spoken, there are many factors which contribute to the presence of hypernasality and articulation differences in individuals with repaired cleft palate. In relation to the adequacy of velopharyngeal closure, it is important to consider the following: the status of primary and secondary palatal repair(s); the presence of compensatory articulation patterns; the integrity, size and relationships of oral, pharyngeal and nasal structures (dental alignment, presence of fistulae, status of tonsils and adenoids, patency of nasal passages, etc.) as well as the general velopharyngeal anatomy and physiology (Kuehn & Moller, 2000; Kummer, 2001).

There are also variations between languages that could lead to differential effects of cleft palate-related speech articulation and resonance. For example, languages with larger numbers of, or more frequently occurring, high pressure consonants (such as fricatives, stops, and affricates) could be more affected by velopharyngeal dysfunction (VPD) than those with fewer high pressure consonants. An example of contrasting phonetic inventories can be found when comparing English to Hawaiian. Hawaiian has two high pressure consonants and English has 16 (Hutters & Henningsson, 2004).

Languages which have a higher frequency of occurrence for vowels overall may also have increased opportunities for hypernasal resonance since this phenomenon is perceived on vowel productions. For example, Spanish has approximately 48% vowels in conversational speech (Guirao & Jurado, 1990) while English has only 38-40% (Mines, Hanson, & Shoup, 1978). In addition, the height of the vowels in the inventory could also play a role. Studies have shown higher, tighter, more rapid velopharyngeal closure for high vowels such as /i, u/ and lower, slower closure for low vowels, such as /a, æ/, leading to the possibility of increased nasalization of low vowels in typical speakers of a given language (Clumeck, 1976; Henderson, 1984; Lintz & Sherman, 1961). However, studies have also demonstrated that individuals with a compromised velopharyngeal mechanism may be more hypernasal on high vowels, both perceptually (Carney & Sherman, 1971) and instrumentally on the Nasometer (KayPENTAX, Lincoln Park, NJ) (Lewis, Watterson & Quint, 2000). However, in their study Lewis and colleagues also found that typical speakers had higher nasalance scores (a ratio of nasal to oral-plus-nasal acoustic energy) on the Nasometer for high vowels, with /i/ as the highest. It is clear that vowel height plays a role in presence and perception of nasality in speech, however the link between the nasality perceived and the nasalance measured needs further investigation.

There can also be diversity between languages based on the number and type of nasal phonemes in the consonant repertoire and how much assimilatory nasalization is observed in connected speech. Although most languages have nasal phonemes, there are some extreme examples cited in the literature in regards to cross-linguistic nasalization. Reportedly, Puget Salish only uses nasals in child-directed speech and Guaraní has a nasalized vowel contrast for each non-nasal vowel as well as a relatively large inventory of nasal stops, prenasalized stops, and nasal continuants and glides (Ferguson, 1974). In comparison English is fairly typical with three nasal consonants (and no phonemically nasalized vowels) while Hmong has 27 consonants with some nasal component and two phonemically nasalized vowels (Heimbach, 1980). The nasalized Hmong vowels include the following: /ɛ̃ŋ/ written orthographically as 'ee' and /ɔ̃ŋ/ written as 'oo' (Lewis, Vang & Cheng, 1989). The inclusion of /ŋ/ in these vowels is the only occurrence of a syllable final consonant phoneme in Hmong, but it is typically classified as part of the nasal vowel (Heimbach, 1979). In spite of these differences in number of nasal phonemes, it is essential to consider frequency of occurrence of these phonemes to determine the actual consequences for conversational speech. Based on corpora data, the frequency of occurrence of nasal consonants in Hmong is 9.86% (Kan & Kohnert, 2004), very similar to the 10.8% in English (Mines et al., 1978). However, when adding the two nasal vowels in Hmong to this total, the combined overall frequency of these nasal phonemes is approximately 15.13% (Kan & Kohnert, 2004), 50% higher than the overall frequency of occurrence of nasal phonemes in English.

Leeper, Rochet, and MacKay (1992) conducted a study which compared relative 'nasality' of two linguistic groups, one with nasal vowels and one without. They tested 395 Canadian French-speakers and 1356 Canadian English-speakers on the Nasometer to obtain normative nasalance scores. They examined three passages: oral phonemes only (0% nasal phonemes), 13.75% nasal phonemes, and 28% nasal phonemes. They found that while strictly oral phoneme passages were equivalent, both oral-nasal and nasal passages had significantly higher nasalance scores in English, indicating a higher degree of nasality. Leeper and colleagues provided three explanations for these cross-language differences. First, it is possible that nasalance values are lower for nasal vowels than nasal consonants and only the French stimuli contained nasal vowels. Second, there could be decreased carryover of nasalization to neighboring sounds in French since phonemic nasalization of vowels requires active control of this process. Increased assimilatory nasalization for vowels in American English compared to French, Swedish, Amoy Chinese, Hindi, and Spanish has been noted in previous studies (Clumeck, 1976, Rochet & Rochet, 1991; Solé, 1992). Third, there could be a cross-linguistic difference between English and French in the amount of oral-nasal coupling present, as has been suggested in cross-dialectal nasalance differences previously reported (Seaver, Dalston, Leeper, & Adams, 1991). More recently, Trindade, Genaro, and Dalston (1997) also found that speakers of Brazilian Portuguese, another language with phonemically nasalized vowels, had average nasalance scores for non-nasal passages that were lower than those reported for most English and Spanish dialects.

Another phonological cross-linguistic difference that could affect the perception of speech distortions related to cleft palate is the presence of glottal stop /ʔ/ in the phonemic inventory of a language. This glottal stop is one of the most commonly reported compensatory articulation (CA) errors related to VPD (Trost, 1981). Shahin (2002) found that two of three Arabic-speaking children with cleft palate demonstrated the glottal stop /ʔ/ as a CA error even though its phonemic status in that language resulted in a compromised message. In Hmong, the glottal stop occurs before many, but not all, vowel-initial words (Heimbach, 1980). It is debatable whether the glottal stop should be considered in the phonemic inventory of Hmong since it occurs mainly in word-initial position before vowels and could be qualified as the onset of the vowel (P.F. Kan, personal communication, October 17, 2007). However, there are two uvular stop phonemes in Hmong (Heimbach, 1980). Uvular phonemes are present in less than 20% of the world's languages (Maddieson, 2008) and their posterior place of articulation could be confused with a pharyngeal CA to an unfamiliar listener. In addition, Matisoff, (1975) suggested that languages with glottal phonemes may demonstrate increased nasalization of the following vowels since velopharyngeal closure is not necessary for a phoneme such as a glottal stop. Therefore, if the glottal stop is produced with a lowered velum then it may not necessarily raise for production of the following vowel (Matisoff, 1975).

In addition to differences in phonetic inventory for high pressure consonants, high vs. low vowels, nasal consonants and vowels, and glottal phonemes, there are also a few studies regarding characteristics of cleft palate speech in speakers of tonal languages, such as Cantonese. In their 1996 study on Cantonese-speaking children with cleft palate, Stokes and Whitehill reported a relatively high rate of initial consonant deletion which they attributed to the possibility that the participants were producing lexical contrasts through the use of tone versus correct production of consonants. Although this pattern was not seen in a subsequent study by Gibbon, Whitehill, Hardcastle, Stokes and Nairn (1998), it is possible that languages with lexical tones could have some distinct speech patterns associated with cleft palate speech. Hmong is also a tonal language, with seven tones and an unmarked eighth tone, all with lexical and/or morphological functions (Ratliff, 1992). In Hmong written language, these tones are noted by consonant graphemes b, j, v, s, d, m, g or –in word-final position. This does not present any confusion with word pronunciation because Hmong does not have any syllable-final phonemic consonants. In terms of the types of tones used in Hmong, it is important to note that 'g' is a 'low falling, breathy end' tone and 'm' is 'low falling, glottalized' tone (Lewis et al., 1989). The 'd' tone ('low falling-raising') is related as it is only found in phrase final position for words that would otherwise have an 'm' tone (Heimbach, 1979). These three tones are the least frequently occurring in Hmong and they account for approximately 20% of tones used (Kan & Kohnert, 2004).

Although there have been no specific studies published on the speech patterns of Hmong speakers with cleft palate, one could hypothesize that non-native listeners judging a Hmong speech sample could potentially mistake the breathy quality of the 'g' tone for a difference in vocal quality. In addition, the glottalized quality of the 'm' (and possibly 'd') tones could be confused with the glottal quality of some CA patterns seen in individuals with velopharyngeal incompetence, or glottal fry. Similar consideration has been recommended for the 'stød' in Danish, which is a within syllable, prosodic 'creaky' voice produced with irregular vocal fold vibration (Hutters & Brøndsted, 1987). It is related to word tones of Norwegian and Swedish and in Danish it occurs with high vowels, which are commonly utilized in assessment protocols for velopharyngeal function (Hutters & Henningsson, 2004).

In response to the wide range of contrasts that exist across languages, several studies have investigated cleft palate-related articulation errors in different sound systems. The Eurocleft Speech Project examined 131 speakers, with repaired cleft palate, who spoke the five Germanic languages of Danish, Dutch, English, Norwegian, and Swedish. They found some evidence for 'universal' speech disorder characteristics which were observed consistently in English and other languages, including errors related to nasal airflow, glottal realizations, alveolar deviations and sibilant deviations (Brøndsted et al., 1993, 1994). These results were similar to those found in earlier studies which examined the universality of passive and active strategies for articulation compensation in speakers with cleft palate in 38 English-speaking and five Danish-speaking patients with cleft palate (Harding & Grunwell, 1998; Hutters & Brøndsted, 1987).

Many definitions and groupings have been described along the lines of passive and active strategies for coping with VPD. In general, the *passive* strategies included no adaptation in response to velopharyngeal incompetency resulting in nasal air emission and weak pressure consonant production, while the *active* strategies involved nasopharyngeal fricatives and glottal or pharyngeal misarticulations (Harding & Grunwell, 1998). Hutters and Brøndsted, (1987) pointed out that although both of these strategies are observed in various linguistic groups, it is uncertain if one could be more predominant in a given language based on the linguistic ramifications for the speakers. Based on the characteristics of the language, the ramifications of the 'universal' speech patterns associated with cleft palate could be stronger (Hutters and Henningsson, 2004). However, it should also be pointed out that the Eurocleft model for evaluation of cleft palate related articulation has not been tested extensively on non-European languages, or in patients with unrepaired cleft palate. One study, examining this framework for the assessment of Nepali speakers with unrepaired cleft palates, found that although the Eurocleft model captured approximately 50% - 70% of the error types observed in the six speakers, it did not account for consonant deletion, weakened consonants, and realization as /h/. While consonant deletion and weakened consonants were related to the severe degree of VPD observed, the realization of phonemes as /h/ was attributed to the aspiration contrasts present in Nepali (Shan, 2001). Therefore, it is still important that even models designed cross-linguistically be examined when assessing patients from distinct linguistic backgrounds, or different surgical histories.

There have also been studies which found evidence for both shared and language-specific error patterns. Stokes and Whitehill (1996) examined seven Cantonese-speaking children with repaired cleft palate. They found that plosives, fricatives, and affricates were the most affected categories of speech sounds and that posterior substitutions were frequent, as would be the case in English. They also observed language-specific patterns, such as bilabial productions of /s/ and /f/. In addition, affricates were the weakest sound class in manner of production, similar to findings in Mandarin (Wu, Chen, & Noordhoff, 1988) and palatalized productions were frequent, as seen in Japanese data (Ainoda, Yamashita & Tsukada, 1985).

Two other small studies examined the speech error patterns of individuals with repaired cleft palate in Arabic (n=3) (Shahin, 2002) and Spanish (n=5) (Guillen & Barlow, 2006). Both studies demonstrated a variety of 'universal' speech error patterns related to cleft palate as well as a few novel patterns. For example, although Shahin (2002) found that compensatory glottal articulation was still observed in a language with phonemic use of the glottal stop, as mentioned earlier, she also observed error patterns involving an implosive airstream, which has not been widely reported. Guillen and Barlow (2006) observed backing of alveolar trill /r/ to uvular trill /R/ and backing of labiodental fricative /f/ to velar fricative /x/. Although very specific to Spanish phonemes, these patterns are still cross-linguistic for speakers with cleft palate in the sense that they move in a posterior or 'backed' direction. However, the occurrence of these speech patterns within each language was difficult to generalize due to small sample size in these studies.

In Harding and Grunwell's (1998) article they discussed 'backing to uvular' and 'backing to velar' as active cleft-type articulation errors, since backing of sounds "…contrasts with the fronting pattern seen in normal development" (Harding & Grunwell, 1998, p. 336). However, recent studies of typical children have demonstrated that while fronting is more commonly seen in English, backing is more common in

Japanese (Beckman, Yoneyama & Edwards, 2003) and there are similar occurrences of both in Greek (Nicolaidis, Edwards, Beckman & Tserdanelis, 2003). Additional studies have also demonstrated differences in order of acquisition of similar phonemes across languages, based on frequency of occurrence and other factors. One example is the acquisition of alveolar fricative /s/ before the post-alveolar fricative /ʃ/ in English, but the post-alveolar counterpart/ɕ/ before alveolar /s/ in Japanese (Li, Edwards & Beckman, 2008). All of these studies point to cross-linguistic differences that could affect expectations for speech production when examining speakers of different languages.

In addition to cross-linguistic differences in presence and frequency of occurrence of high pressure consonants; nasalized vowels; glottal, uvular, and/or pharyngeal phonemes; and lexical tones, there are also differences between phonemes that may initially appear to be similar cross-linguistically. For example, voice onset time (VOT), stop-gap duration, and aspiration of similar phonemes can vary across languages. VOT is the duration of time from when the articulatory posture for a stop consonant is released and the voicing of the following phoneme is initiated. The 'stop-gap' is the duration of time the articulatory posture is held from initiation to release. In Spanish, VOT is considered short-lag, less than 35 milliseconds (ms), for stop consonant production of the phonemes /p, t, k/. However, in English these same phonemes are produced with a long-lag VOT, greater than 35 ms, which results in aspiration before the subsequent vowel (Lisker & Abramson, 1964; Zampini & Green, 2001). This creates the need for a longer velopharyngeal port closure interval for voiceless, aspirated, long-lag stops in English /p, t, k/ when compared to their voiceless, unaspirated, short-lag counterparts in Spanish. The longer duration of closure and relatively louder 'stop explosion' in the English sounds could lead to a demand for increased 'articulatory force' (Lisker & Abramson, 1964).

Hutters and Brøndsted (1987) reported that unvoiced, unaspirated stops occur in Danish and that passive articulation distortions related to cleft palate are different for this category of sounds when compared to their aspirated counterparts. In the case of velopharyngeal incompetency, unvoiced aspirated stops may be realized as unvoiced nasal consonants with a variable degree of nasal frication. However in this same case, an unvoiced unaspirated stop is typically produced as a voiced nasal consonant (Hutters & Brøndsted, 1987). Individuals with marginal velopharyngeal closure may have a more difficult time maintaining closure for the longer interval required in English aspirated stops with long-lag VOT. Gaylord and Zajac (2006) found that VOT and stop gap duration decreased as level of VPD increased in English during production of aspirated, long-lag VOT alveolar stop /t/ by children with cleft palate. They hypothesized that this may have been a strategy adapted by the child in an effort to minimize the presence of nasal air emission (Gaylord & Zajac, 2006). In contrast, Casal et al. (2002) found no significant difference in the VOT of unaspirated stops with short-lag VOT /p, t/ in Spanish-speaking two-year-olds with cleft palate, when compared to typically developing peers. Therefore, there may be different productions of very similar phonemes across languages and a greater potential for nasal emissions during the production of the initial /p/ in the English word ‘paper’ vs. the initial /p/ in the Spanish word for paper, *‘papel’*.

Although there may be a slightly higher possibility for nasal emissions to occur on aspirated, long-lag stops (Gaylord & Zajac, 2006), it may also be possible for languages with more voiced stop consonants to be perceived as more hypernasal due to transpalatal nasalance. Bundy and Zajac (2005) examined the amount of nasalance that could be contributed to the transfer of acoustic energy via the palate (transpalatal transfer) during production of voiced stop consonants in non-cleft speakers. They found that 80% of the nasalance measured during the production of the English voiced stop consonants /b, d, g/ could be attributed to transpalatal transfer (Bundy & Zajac, 2005). Again, in regards to Spanish, the phonemes /b, d, g/ are produced slightly differently than their English counterparts. In phrase-initial position, these phonemes are produced with prevoicing, which means voicing is initiated before the release of the articulation posture, leading to a negative VOT value. Also, intervocalic /b, d, g/ are changed in manner to voiced approximants, sometimes referred to as spirants and produced as [β, ð, ɣ] (Branstine, 1991). Theoretically, the longer duration of voicing in Spanish could lead to a possibility of increased transpalatal nasalance. For these reasons, it is not only important to consider the phonemes of a language, but also their slight differences in voicing and timing, as they may lead to different cleft palate-related articulation and/or resonance distortions.

The current investigation focused on speakers of three different languages: English, Spanish and Hmong. Table 1 illustrates some of the basic characteristics of the three languages examined in this study, including the number of various types of phonemes in the phonetic repertoire, frequency of occurrence for the various categories of phonemes, as well as language type and presence of lexical tones.

***Assessment of articulation and resonance***

Along with considerations specific to the sound system of a language, it is also necessary to address the methods used to assess speech in cleft populations. Resonance can be measured both perceptually and instrumentally. Perceptual measures include listener judgments completed by SLPs. Typically listeners are asked to judge speech samples using equal appearing interval (EAI) scales with five, seven, or nine points (Kuehn & Moller, 2000). An example of clinical use of EAI scales can be found in a recent article published by a working group for the 'Universal Reporting Parameters for the Speech of Individuals with Cleft Palate' (Henningsson, et al., 2008). This group detailed two global parameters and five speech parameters that should be assessed in all patients with cleft palate in order to promote consistent multi-center, cross-linguistic analysis. The two global parameters are *speech understandability,* which is a measure of how easy conversational speech is to understand, and *speech acceptability*, which measures how much speech deviates from 'normal', considering the whole speech sample collected. It is proposed that both of these global parameters should be assessed on a four-point equal appearing interval scale (0-normal, 1-mild, 2-moderate, 3-severe) (Henningsson, et al., 2008).

In addition to the two global parameters, the international working group recommends the assessment of five speech parameters. These include: *hypernasality* (excessive nasal resonance perceived on vowels and possibly voiced consonants), *hyponasality* (inadequate nasal resonance perceived on nasal consonants and vowels), *voice disorder* (anatomical or physiological disorder at the level of the larynx leading to a deviation in voice production), *audible nasal emission and/or turbulence* (audible escape of air through the nares which may or may not be accompanied by a ‘snorting’ or turbulent sound), and *consonant production errors* (eight categories of articulation errors, encompassing those typical to cleft palate speech and other/developmental misarticulations). *Hypernasality* is judged on the same four-point EAI scale mentioned above. *Hyponasality, voice disorder,* and *audible nasal emission and/or turbulence* are documented with binary measurements (0-absent/WNL, 1-present). Finally, the category of *consonant production errors* is scored in a binary manner and the eight categories of articulation distortions can be checked if present. The goal of these ‘universal parameters’ is to promote a consistent manner of documenting and sharing speech outcomes (Henningsson et al., 2008).

Although they are reportedly used less in clinical settings, direct magnitude estimation (DME) and visual analog scaling (VAS) have also been used to evaluate cleft palate speech (Zraick & Liss, 2000; Brancewicz & Reich, 1989). EAI scales are traditionally used to scale along a linear, metathetic dimension, or one that changes in quality – such as pitch. DME is most often used with nonlinear, prothetic dimensions, which change in quantity – such as loudness (Stevens, 1975). Similarly, VAS has traditionally been used to rate variables which fall on a continuum, and are not easily broken down into categories, such as pain, mood or foreign accent (Flege, Munro, & MacKay, 1995).

In their 2000 study of nasality ratings on synthetic vowel stimuli, Zraick and Liss found that 12 graduate student listeners were more ‘consistent and reliable’ using DME than EAI scaling. Similar results, with a curvilinear relationship between DME and EAI, were obtained by Whitehill, Lee, and Chun (2002) for ratings of hypernasality in 20 speakers with repaired cleft palate. This is indicative of a more prothetic nature of hypernasality. Similar results were found by Baylis (2007) in her comparison of EAI and DME scaling for rating audible nasal emission (ANE). Baylis found a curvilinear relationship between EAI and DME for ratings of ANE in addition to higher inter- and intra-rater reliability for the DME judgments. Despite this recent support for DME, it may not be a practical clinical tool as it may be less clear for listeners than EAI scaling and it can be harder to compare data across settings (Baylis, 2007; Whitehill et al., 2002).

Therefore, it has also been suggested that other measures, such as transcription tasks, paired comparisons, multidimensional scaling or VAS may provide more effective options for perceptual ratings in the case of resonance (Whitehill, 2002; Whitehill et al., 2002). However, there are potential manipulations that can be used with EAI rating scales to improve reliability. Gerratt, Kreiman, Antonanzas-Barroso and Berke (1993) found that EAI ratings for rough voice severity were significantly more reliable when collected with anchors for each point on the scale, compared to an unanchored condition. The issue still remains that if hypernasality is truly prothetic in nature, it should not be rated with the metathetic scaling of EAI.

In their 1989 study of perceived “nasality” in normal speakers, Brancewicz and Reich had 10 certified SLPs judge “nasality” of normal speakers in three sentences with different phonetic properties at different speaking rates. They employed VAS with a 100 mm-long vertical line entitled ‘nasality’ with ‘none’ and ‘extreme’ at the bottom and top of the line respectively. They found relatively strong intrajudge reliability correlation coefficients of .84 to .90 and weaker interjudge reliability of .66 to .75. Although all judges clustered their ratings in a small area of the VAS, precise placement on the line varied, leading to the reduced interjudge reliability. Keuning, Wieneke, and Dejonckere (1999) used VAS to rate the speech of individuals with cleft palate before and after pharyngeal flap surgery. They used five 100 mm horizontal lines with ‘normal’ on the left and ‘extremely deviant’ on the right to judge hypernasality, audible nasal emissions, intelligibility, misarticulations, and voice quality for sentence reading and sentence repetition tasks. They found that three of the six judges (who had varying professions and experience levels treating patients with cleft palate) utilized the entire line while one used the left end and two stayed near the right end. Intrajudge reliability was measured with the intraclass correlation coefficient of reliability and found to be fairly strong, ranging from .56 to .86 (mean = .68). Reliability between judges, was extremely variable, with Spearman rank correlation values ranging from .05 to .81 between pairs of raters. Overall, slightly higher reliability was noted in the SLPs with experience rating cleft palate speech. Keuning and colleagues also reported minimal to no differences in ratings on read vs. repeated sentences and when using three vs. ten sentences per rating group. (Keuning et al., 1999).

A follow-up study by Keuning, Wieneke, van Wijngaardern, and Dejonckere (2002) also examined the use of VAS rating techniques in comparison to the nasalance scores as obtained from Nasometer measurements. As described earlier, the Nasometer provides nasalance values, which are objective, clinically relevant measures of the ratio of nasal acoustic energy to the sum of oral and nasal energy collected during speech (Dalston, Warren, & Dalston, 1991). In this study Keuning and colleagues examined the VAS ratings (overall severity, hypernasality, audible nasal emission, VPI misarticulations, and intelligibility) of six SLPs for an oral-only passage and mixed oral-nasal passage, both in Dutch, and similar in length to the Zoo passage. The ratings were compared between judges and also compared to the scores obtained on the Nasometer. Inter-judge Spearman correlation coefficients were strongest for intelligibility ($r = .70$) and weakest for hypernasality ($r = .49$). In addition, the oral-only passages were rated more severely and more severe ratings were given by SLPs with less expertise, although these experience-based listener differences were not statistically significant. Fairly low correlation coefficients were found between the perceptual ratings of hypernasality and the nasalance scores ($r = .31$ to $r = .60$).

In a recent study, Whitehill, Cheng, and Jones (2007) examined the use of VAS and DME in ratings of hypernasality. They had 200 naïve undergraduate student listeners judge hypernasality in 20 English-speaking subjects with repaired cleft palate. The subjects had a mean age of 9.6 years and only included subjects without evidence of a syndrome, hyponasality, poor articulation or severe nasal air emission. The speech samples consisted of five sentences with seven to ten syllables and mixed oral and nasal sounds. The DME ratings were completed with a modulus and the VAS ratings were collected in groups of five and then repetition of the initial sample (as a type of anchor). Calculations of both intra- and inter-rater reliability were very similar for each rating scale. The intrarater reliability had strong intraclass correlation coefficient of reliability values of .96 for VAS and .92 for DME while interrater reliability was also relatively high with Pearson's r of .78 for VAS and .79 for DME ($p<.001$). Based on these results

Whitehill and colleagues determined that VAS and DME are both valid and reliable methods for judging hypernasality (Whitehill et al., 2007).

In addition to perceptual evaluation, instrumental assessment is also an important part of speech and resonance management in individuals with velopharyngeal closure issues. Instrumental measures may include videonasopharyngoscopy, videofluoroscopy, pressure-flow measures and Nasometry, among others (Kuehn & Moller, 2000; Kummer, 2001). Information on nasalance values has been collected for a variety of languages, including Brazilian Portuguese (Trindade et al., 1997); Cantonese (Whitehill, 2001); Finnish (Haapanen, 1991); Flemish (Van Lierde, Wuyts, De Bodt, & Van Cauwenberge (2001); French (Leeper et al., 1992); Japanese (Tachimura, Mori, Hirata, & Wada, 2000); Mandarin (Luo, 1992); and Spanish (Anderson, 1996; Dalston, Neiman, & González Land , 1993; González-Landa, Sánchez-Ruiz, Pérez-González, Santos-Terrón, & Miró-Viar, 2000; Nett & Ochoa, 2004; Nichols, 1999; Santos-Terrón, González Landa & Sánchez-Ruiz, 1991). Studies have also been completed on various dialects of English, including American (Seaver, Dalston, Leeper, & Adams, 1991; Mayo, Floyd, Warren, Dalston & Mayo, 1996); Australian (van Doorn & Purcell, 1998); Canadian (Kavanagh, Fee, Kalinowski, Doyle, & Leeper, 1994); and Irish (Sweeney, Sell, & O'Regan, 2004). These studies have shown inconsistent differences in nasalance values cross-linguistically and cross-dialectally for age, gender, and type of reading passage (oral, mixed, nasal).

There are many studies which have addressed the correlation of Nasometer scores with perceptual ratings. The study by Keuning and colleagues (2002), introduced earlier, showed an inconsistent correlation of perceptual ratings and Nasometer scores. However, several studies have shown contrasting findings. In 1976, Fletcher examined the correlation of the numerical scores obtained on the Tonar II (a precursor to the Nasometer which also measured nasalance) and perceptual judgments. He collected samples from 23 children with repaired cleft palate on the Tonar II and then had 20 naïve listeners make a variety of judgments on the samples – first distinguishing 'abnormal' from 'normal' nasality, then ranking them in severity, and finally assigning a score to reflect the nasality present. When mean scores of the judges were compared with the nasalance scores a correlation of .91 was obtained. Fletcher concluded that naïve listeners could reliably judge nasality and that scores obtained on the Tonar II (nasalance) were also a valid correlate to these perceptual results (Fletcher, 1976).

Dalston et al. (1991) also examined the correlation of nasalance scores on the Nasometer with listener judgments and velopharyngeal area calculations from pressure-flow results. They examined 117 patients and found that using a cut-off nasalance score of 32. The nasalance scores obtained on the Nasometer had sensitivity of .78 for determination of velopharyngeal areas of less than .10 $cm^2$ and .79 for velopharyngeal areas of more than .10 $cm^2$. In addition, when compared to six-point EAI ratings made by the first author (without knowledge of Nasometer and pressure-flow results), the nasalance ratings had a sensitivity value of .78 and specificity of .95 for determination of more than mild hypernasality ($\geq$ 3 on 6 point EAI). Dalston and colleagues concluded that the Nasometer is ‘an appropriate instrument that can be of value in assessing patients suspected of having velopharyngeal impairment’ (Dalston et al., 1991, p. 184).

Hardin, Van Demark, Morris, and Payne (1992) used seven-point EAI scales to examine the correlation of nasalance scores and perceptual listener judgments of hypernasality and hyponasality of 51 participants with repaired cleft palate along with 23 controls. Three experienced listeners served as judges. They found high interjudge reliability with Pearson r coefficients of .82 to .92 for hypernasality and .80 to .93 for hyponasality. Intrajudge reliability was also high with .80 to .93 for hypernasality and .90 to 1.0 for hyponasality. In addition, using a cut off nasalance score of 26 for hypernasality, sensitivity of .76 and specificity of .85 were obtained. This yielded an efficiency score of 82% correct diagnostic classifications of resonance based on the Nasometer. This was significantly lower than the 93% reported by Dalston and colleagues in 1991. However, the authors still concluded that the Nasometer may provide valuable information although it should be not used as the only instrumental measure during assessment of patients with potential VPD.

Another study examining the relationship of perceptual nasality ratings and nasalance scores also addressed potential differences related to the academic training and clinical experience of the listeners. Lewis, Watterson, and Houghton (2003) investigated the ratings made by three general teachers (no academic or clinical training in cleft palate speech), three graduate SLP students (academic training in cleft palate speech, but no clinical training), three craniofacial surgeons (clinical experience with cleft palate speech but no academic training), and three SLPs with both academic training in cleft palate speech as well as extensive clinical experience. These four groups of listeners made ratings on five-point EAIs with anchor stimuli for 'normal' (1) and 'severely hypernasal' (5). The listeners heard a single utterance with a variety of vowels from 20 subjects representing normal to severely hypernasal resonance. They found that the most experienced rating groups were more reliable (all three Kappas $\geq$.70 for SLP listener pairs, but all $\leq$.70 for graduate student pairs) and also provided less severe ratings. For example, the mean rating was 2.55 (S.D., 1.0) for the SLP group and the mean rating was 2.82 for the teacher group, a statistically significant difference (p=.019). Finally, the relationship between listener ratings from any group and nasalance scores obtained from the Nasometer was low to modest. The *r* values ranged from .29-.57 resulting in a low to moderate correlation. Although less severe and more reliable perceptual ratings were provided by the most experienced listeners, no pattern was seen in the relationship of nasalance values and listener experience. The low correlation was attributed to other factors affecting nasalance scores (Lewis et al., 2003).

Another study which looked specifically at the effect of listener background and ratings of cleft palate speech was completed by Starr, Moller, Dawson, Graham, and Skaar (1984). They examined nasality and articulation ratings made on seven-point EAIs by six groups of listeners (clinic SLPs, school SLPs, parents of a child with a cleft, parents with no child with a cleft, children with clefts, and children without clefts). The ratings were made of 15 patients with cleft palate during a recorded 250 word reading passage. Looking at mean ratings for each listener group, the only significant differences were seen in the ratings by children in the noncleft group. The highest correlation between two groups was Pearson *r* = .96 between the clinic and school SLPs. The authors concluded that there was no evidence of differences in ratings between any of the six groups, except noncleft children. The noncleft children may have made lower (more typical ratings) because they were not as familiar with the concept of nasality. In addition, the authors also concluded that school and clinic SLPs made ratings which did not correlate highly with the other listener groups (that did have high intergroup correlations). It was hypothesized that the SLP groups likely differentiated articulation and resonance in a way that was unlike the other listener groups.

## SIGNIFICANCE OF THE PROBLEM

Based on the preceding background and review of relevant literature, it appears appropriate to conclude that there is an increasing level of linguistic diversity in patients seen for cleft palate treatment in the U.S. and abroad, as well as a considerable mismatch between provider and patient languages. Currently, there are no published studies which directly investigate the ability to assess cleft palate articulation and resonance in a language not spoken by the examiner. There is a need for appropriate speech and resonance evaluation involving perceptual and instrumental components. Emerging evidence suggests that perceptual measurements for parameters such as hypernasality are most accurately captured by methods such as VAS or DME, as compared to EAI scales or other interval measures.

## SPECIFIC AIMS AND OBJECTIVES

The main objective of this study was to determine whether listeners could make accurate judgments about cleft palate articulation and resonance in languages they do not speak. More specifically, listeners with three different experience levels completed speech ratings of samples from speakers of three different languages. The aim was to investigate the roles that professional experience and linguistic knowledge play in the ability to make accurate judgments of the speech of speakers with VPD. This goal was addressed by collecting speech samples from speakers of English and Spanish with VPD related to cleft palate or another craniofacial condition and control speakers of English, Spanish, and Hmong with typical articulation and resonance. One Hmong speaker with a slight articulatory distortion was also included. Ratings of the speech samples were then collected from naïve listeners, generalist SLPs, and specialist SLPs. The specific questions investigated in this study included the following:

1. Can listeners make accurate judgments of the presence or absence of cleft palate articulation and resonance disorders in a language they do not speak?

It was hypothesized that native English-speaking listeners would be able to identify the presence or absence of an articulation or resonance disorder related to cleft palate in the unfamiliar languages of Hmong and Spanish, based on the findings from English-speaker ratings of Slovak and Sinhala (Morris, 1978; Sell, 1992; Sell & Grunwell, 1990). Further support for this hypothesis may be found in the Van Borsel and Pereira (2005) study which demonstrated that native Dutch and native Portuguese-speaking individuals successfully identified individuals who stuttered in both a familiar and unfamiliar language.

a. Does the accuracy of listener judgments improve as a function of expertise with speech characteristics of speakers with cleft palate, in spite of the unfamiliar language? That is, are ratings more accurate for SLP specialists vs. SLP generalists vs. naïve listeners?

It was hypothesized that the 'specialist' group will make more accurate ratings of articulation or resonance disorder when compared to the 'generalist' group. Several studies have shown greater reliability in judging cleft palate speech and resonance was present with increased experience levels (Lewis et al., 2003; Keuning et al., 1999) Although the listeners will be making judgments in a language they do not speak, many characteristics of cleft palate may be universal and, therefore, apparent across languages. A trained listener should be able to identify many of these characteristics regardless of the language spoken by patient or examiner (Ainoda et al., 1985; Brøndsted et al., 1994; Guillen & Barlow, 2006; Hutters & Brøndsted , 1987; Stokes & Whitehill, 1996; Wu et al., 1988). In addition, Van Borsel & Pereira (2005) found that Dutch judges may have had slightly more accuracy in judging the presence of stuttering in Brazilian Portuguese due to more training and coursework, as compared to the Brazilian ratings of the Dutch speakers.

b. Does the accuracy of listener judgments improve as a function of the similarity between English and the target language? That is, for native English-speaking listeners, are their ratings more accurate for Spanish (more typologically similar) as compared to Hmong (more typologically distant)?

It was hypothesized that ratings would be easier to make and more accurate in Spanish, as compared to Hmong. Spanish and English have many similar sounds in their phonemic inventories and between the languages there are at least 3,000 cognates (cross-language synonyms which share a certain degree of overlap or similarity in their production, such as 'lion' and '*león*') (Kohnert, Windsor & Miller, 2004). Theoretically this may make it easier to identify speech errors if the listeners are coming from a native-English speaker perspective. The presence of lexical tones, a significantly wider variety of nasal phonemes, and the glottal stop phoneme in Hmong (Heimbach, 1980) may make it more difficult to judge articulation and resonance skills for Hmong speakers with cleft palate, as noted in the case of the phonemic glottal stop in Arabic (Shahin, 2002). In addition to some universal error patterns, there may also be some unexpected articulation distortions (for English-speaking listeners) in articulation and resonance characteristics related to cleft palate in Hmong, as found in the other Asian languages of Cantonese (Stokes & Whitehill, 1996), Mandarin (Wu et al., 1988), and Japanese (Ainoda et al., 1985).

2. Are listener VAS hypernasality ratings of English, Spanish, and Hmong samples positively correlated with objective, instrumental nasalance scores collected on the Nasometer?

Listener judgments will be positively correlated with the nasalance scores obtained on the Nasometer. The Nasometer has been shown to be 'an appropriate instrument that can be of value in assessing patients suspected of having velopharyngeal impairment' (Dalston et al., 1991; Hardin et al., 1992).

a. Do the ratings made by the more experienced listeners have stronger correlation values when compared to the instrumental data collected on the nasometer? That is, do the ratings made by specialist listeners have stronger correlation values than those of the generalist listeners and naïve listeners?
b. Do the ratings made for the more familiar languages have stronger correlation values with the nasometer data than those made for less

familiar languages? That is, are the strongest correlations present for English and the weakest for Hmong, with Spanish falling in between?

Based on the evidence provided for questions 1a and 1b, it was hypothesized that the strongest correlations between VAS ratings and nasometer data would be present for the specialist listeners, followed by the generalists, and then the naïve listeners, due to experience with rating individuals with VPD. In addition it was hypothesized that the strongest correlations would exist between the nasometer data and VAS ratings of English speakers, followed by Spanish speakers and then Hmong speakers, as overall listener ratings were expected to be most accurate in the language they speak and least accurate in the language that is more typologically distant (Hmong).

3. Are experience and language differences reflected in VAS ratings of ease of judgment and confidence in ratings?
   a. Do naïve listeners rate the judgments as more difficult, with less confidence than generalist and specialist listeners?
   b. Are the ratings of English speakers judged as easier, with more confidence than those of the Spanish and Hmong speakers?

It was hypothesized that due to their experience making articulation and resonance judgments of individuals with cleft palate, the specialists would be most confident and find the ratings easiest to make, followed by the generalists and then the naïve listeners. It was also hypothesized that ratings would be viewed as easiest to make with the highest confidence level in English, followed by Spanish, and then Hmong, based on typological distance from English.

# METHOD

## Participants

### *Speakers*

Forty six participants were enrolled in this study, of which 22 participated as speakers. The speakers included nine native English-speaking, eight native Spanish-speaking and five native Hmong-speaking individuals with repaired cleft palate or other palatal dysfunction and some degree of residual resonance with or without articulation distortion. The speaker subjects were between the ages of 7 and 32 years. Children younger than age seven were not included as the stimuli were too difficult for them to read, even with assistance. The speakers included 11 males and 11 females. Each speaker was matched with a control participant with an intact palate and normal resonance and articulation skills. The controls were matched for gender and linguistic background to the highest degree possible. The subjects with cleft palate or VPD caused by another medical condition were recruited through the Cleft and Craniofacial Clinic at the University of Minnesota. Other than age, the only exclusionary factors were a hearing loss requiring amplification or a global developmental delay. Clinical assistants provided information about the study to families at the weekly clinics. Flyers were also posted in the clinic and mailed to families and individuals who have regularly attended the clinic. The matched (control) speakers were recruited through the clinic (siblings, cousins, and friends) and flyers posted in university buildings. Table 2 provides the demographic information of the matched pairs of speaker subjects.

All Hmong speakers who participated had typical resonance, with no history of VPD due to cleft palate or any other medical condition. All feasible recruitment efforts were exhausted and no Hmong individuals with VPD were able to be recruited. One contributing factor may be that the investigator speaks both Spanish and English, but not Hmong. Although a Hmong research assistant was used in the project, the lack of linguistic skills on the part of the examiner may have impeded open communication with potential participants with this cultural and linguistic background. In addition, many Hmong immigrants who were not born in the U.S. do not read in Hmong and may have variable skills in English, depending on the type of education received (Lewis et al., 1989).  Therefore, it is possible that written materials sent to Hmong homes, in both English and Hmong, were still difficult to understand.

Finally, there is documented hesitation and resistance from some individuals in the Hmong community to complete even necessary medical procedures due to beliefs about spirits, health, and healing.  In addition, such a decision could require consultation with an elder and would not be left to the discretion of the individual or even the parents (Johnson, 2002).  It is difficult to determine how voluntary participation in a research study that will not provide direct benefit to the individual may be viewed by some people of the Hmong culture.  Therefore, four of the five native Hmong speakers who participated in this study had typical articulation and resonance skills and one had a slight articulation distortion secondary to jaw alignment.  These five speakers, two who use primarily White Hmong dialect and three who use primarily Green Hmong dialect, served as a type of cross-linguistic foils.  The similarities and differences between these two dialects are discussed in the speaker stimuli section.

***Listeners***

There were a total of 24 female listeners in this study, who ranged in age from 19-62 years.  They included eight naïve listeners, eight generalist SLPs and eight specialist SLPs. The naïve listeners were university students who had taken no more than a single course in the Department of Speech-Language-Hearing Sciences and had no personal knowledge related to cleft palate.  The generalists were practicing SLPs who had seen three or fewer patients with cleft palate or VPD, had not participated on a cleft palate team, and had not taken professional continuing education courses (since graduate coursework) related to cleft palate.  The specialists were practicing SLPs who had experience (recent or current) on a cleft palate team, had worked regularly with five or more patients with cleft palate, and had completed professional continuing education courses related to cleft palate.  Four of the eight specialists had also completed one or more trips with cleft palate teams to developing nations.

All of the listeners were native-English speakers with no university-level coursework or oral proficiency in Hmong.  Four of the eight listeners in each group spoke Spanish proficiently and on average had completed 10.5 semesters of Spanish instruction.

The remaining four listeners in each group reported no proficiency in Spanish. They had an average of two semesters of Spanish instruction. For the analyses of English (as a native language) and Hmong (as an unfamiliar language) the ratings from all 24 listeners were included. However, only the ratings of listeners with no Spanish proficiency (12) were included in the analyses of the Spanish speakers, to ensure that Spanish was an unfamiliar language in that condition as well. All listeners passed (or reported a date in which they had passed) a hearing screening at 20 dB in both ears at 500, 1000, 2,000, and 4,000 Hz. Naïve listeners were recruited by posting flyers in buildings on the university campus. Generalist and specialist SLP listeners were recruited via postings on email list serves. Table 3 provides listener participant demographics.

In order to recruit an adequate number of specialist SLP listeners, it was necessary to reach beyond the local area. Four of the eight specialist listeners were from out of state. To increase procedural reliability with the specialist group, all of the specialists completed the listening session in a packet that was mailed to them. Also, due to scheduling conflicts two of the naïve listeners with Spanish background could not come in for a testing session. To maintain procedural reliability all of the naïve listeners with Spanish background completed the study offsite in the mailing packet format as well. Of the 24 listeners, 50% completed the listening session onsite with the examiner and 50% completed it offsite via the mailing packet. For the offsite listeners, self-report of a passed hearing test was accepted in lieu of the actual screening provided to onsite listeners.

## Procedure

### *Speaker Procedures*

Each speaker completed a consent form and/or assent form and a brief questionnaire about medical history and linguistic background. See Appendix A for the Speaker Background Questionnaire. In a sound-proof booth each participant produced audio samples which were digitally recorded on a Marantz Solid State Recorder PMD 670 via a table-top microphone placed at a distance of approximately six-eight inches from the mouth. Speakers completed three separate tasks in their native language of English, Spanish, or Hmong: (1) an oral reading of a list of 25 single words and 15 short sentences developed with guidance from the *Universal Parameters* (Henningsson et al., 2008); (2) a story re-telling of 'Frog, Where are You?' (Mayer, 1969); and (3) a one to two minute monologue about family, friends, and daily life. In addition, they also completed the *Picture Cued Subtest* (sentence level) and *Reading Subtest* (paragraph level) portions of the standardized Nasometer evaluation protocol, *Simplified Nasometric Assessment Procedures (SNAP) - Revised* (MacKay & Kummer, 1994; Kummer, 2005) on the Kay Elemetrics Nasometer II 6400 (Kay Elemetrics, Lincoln Park, NJ). The headset was placed per manufacturer's instructions and the two subtests were given according to administration instructions.

***Speaker Stimuli***

The first task completed by speakers was the production of single word and short sentence stimuli. These stimuli were developed in English, Spanish, and Hmong using the framework provided in the *Universal Parameters* as a guide (Henningsson et al., 2008). According to this working group, the sample should include 25-30 single words and 18-25 short sentences. The single words should meet the following criteria: 10 words with high vowels only, other words with mid/low vowels; no nasals; and pressure consonants only. Ideally the words should also incorporate all of the pressure phonemes in the language, in all positions of occurrence, in consonant-vowel (CV) or consonant-vowel-consonant (CVC) words, with one target per word, and with any other consonants needed having a similar place as the target and approximant status. For this study, 25 single words were included in each language. The following exceptions to the criteria should be noted: In English, the low frequency phoneme /ʒ/ was not included. In Hmong, a large variety of pressure consonants were assessed, but several low frequency of occurrence phonemes were not included. This is because there are 24 high pressure consonants in Hmong, not including the pressure consonants with a nasal component (Heimbach, 1980). The phonemes were also not assessed in all positions of occurrence in any of the three languages due to the large number of stimuli that would have resulted. Instead, the goal was to include a wide variety of the appropriate consonants within the 25 word set.

According to the *Universal Parameters*, 15-20 short sentences should include the following: voiced and unvoiced pressure consonants, one target consonant type per sentence, and at least two to three target words per utterance. In addition, for assessment of hyponasality, there should be three to five short sentences with a mixture of nasal consonants, no pressure consonants (if possible) and non-nasals/approximants (if necessary) (Henningsson et al, 2008). For this project a total of 15 sentences were developed in each of the three languages with two nasal sentences in English and three each in Spanish and Hmong. Several of the English sentences were taken from Henningsson et al. (2008) and Sell, Harding and Grunwell (1999). There are no published stimuli that fit the *Universal Parameters* framework in Spanish or Hmong. Therefore, this is an initial attempt to develop the stimuli in these languages, following the recommended guidelines to the extent possible. Several of the Spanish sentences are based on examples from unpublished protocols used in Spanish-speaking countries. Due to the difficult, time-consuming nature of adaptation, the same 15 sentences used for the SNAP *Picture Cued Subtest* in Hmong were utilized for this section. Although they do not test each pressure consonant in Hmong, a large sample is represented and the general framework of 12 oral and 3 nasal sentences was matched to Spanish. Recently, American English stimuli for the *Universal Parameters* system have been prepared by Trost-Cardamone and Kuehn (2008). However, these stimuli have not yet been published and were able to be obtained by the author only after speaker testing was completed. See Appendix B for single word and short sentence stimuli in English, Spanish, and Hmong.

The second task completed by the speakers was a story retelling of the wordless picture book, 'Frog, Where are You?" (Mayer, 1969). This task was utilized to provide a semi-structured speech sample which was not repeated or read directly. Story retelling (instead of original story telling) was utilized since it has been found that narratives produced as a result of a retelling are often longer, more detailed, and less variable in content (Lofranco, Peña & Bedore, 2006; Merritt & Liles, 1989). Specifically for examination of articulation, story retelling has been demonstrated to yield similar results as single word and nonsense word articulation tests and potentially provide more opportunities to assess consistency of errors over time (Kenney, Prather, Mooney &

Jeruzal, 1984). The speakers were told the following: "I am going to tell you a story based on this picture book. After I'm finished I'd like you to tell the story back to me." The speaker looked at the book while listening to the script in their native language. It was read by the author in English and Spanish. In Hmong, a recording of the reading by a trained Hmong research assistant was played from a CD. See Appendix C for transcripts of the story used in English, Spanish, and Hmong.

The third task completed by the speakers was a brief monologue, approximately 45 – 120 seconds in length. The speakers were requested to talk about their family, plans for the summer, or the upcoming school year. This sample was collected to obtain an example of conversational speech, which can be helpful in higher level judgments such as speech acceptability (Henningsson et al., 2008).

In addition to the three audio recorded tasks, the speakers also completed two subtests of the *SNAP-R* (or Spanish or Hmong adaptations) on the Nasometer. The original *SNAP* was developed, and normative data was collected, in 1994 as a standardized examination for the Nasometer which would be simple enough for children to complete. The normative information for the revised *SNAP-R* was collected on 68-272 (varied by subtest) typical three to nine year olds in 2005. It includes a *Picture Cued Subtest* which examines four groups of three sentences each that contain only oral phonemes, and specifically target bilabial stops, alveolar stops, velar stops and fricatives, with a fifth group assessing nasals. It also contains a *Reading Subtest* with two paragraphs. One paragraph, 'A School Day for Suzy', contains only oral phonemes and is loaded with sibilants. The second paragraph, 'Bobby and Billy Play Ball' is a mixed oral and nasal paragraph which is loaded with plosives (MacKay & Kummer, 1994; Kummer 2005). They are similar to the higher reading level 'Zoo Passage' (Fletcher, 1978) and 'Rainbow Passage' (Fairbanks, 1960) . The *SNAP-R* also contains a *Syllable Repetition/Prolonged Sounds Subtest* which was not used for this study.

The adaptations of the *Picture Cued Subtest* and *Reading Subtest* of *SNAP-R* were designed to follow a similar format. As noted earlier, Jy Xiong adapted the stimuli to Hmong for this study. The Spanish adaptation was developed earlier (Nett & Ochoa, 2004). However, due to cross-linguistic differences in the sound systems, there are some differences in the tools. In Spanish, only the voiceless stops are assessed in the first three sections of the *Picture Cued Subtest.* This decision was made due to several factors addressed earlier. Voiceless stops in Spanish have short lag VOT (similar to voiced stops in English), but voiced stops in Spanish have prevoicing in phrase initial position and change to spirants intervocalically (Branstine, 1991; Lisker & Abrahamson, 1964). Prevoicing could possibly lead to increased transpalatal nasalance, hypothetically a level even higher than that seen in voiced English stops by Bundy and Zajac (2005). Frication would also change the target being assessed. In addition, for the second section of the Picture Cued subtest, it should be noted that in English alveolar placement is assessed with /t, d/, but the /t/ in Spanish is produced with dental placement. Finally, both /s, z/ are assessed in the fourth section of the *Picture Cued Subtest* in English. However, only /s/ is examined in Spanish since /z/ is not a contrastive phoneme in Spanish (Anderson & Centeno, 2007).

There are also some differences in the Hmong adaptation of the *Picture Cued Subtest* of *SNAP-R* to address. All stimuli were adapted from English to White Hmong. A speaker of Green Hmong also reviewed the stimuli to ensure they would be intelligible to speakers of that dialect as well. White and Green Hmong are described as mutually intelligible dialects of Far Western Hmong, with mainly phonological and some lexical differences. For example, White Hmong has voiceless nasal phonemes not seen in Green Hmong, and Green Hmong has an additional nasalized vowel and laterally released dental stops not present in White Hmong (Mortensen, 2004). As noted earlier, three of the Hmong speakers in this study spoke Green Hmong and two spoke White Hmong. Nasal vowels were counted as nasal phonemes in construction of the stimuli, as they were in the French stimuli developed by Leeper et al. (1992). Therefore, the first four sections which assess only oral phonemes do not contain any nasal vowels. Second, the only voiced stop consonants in Hmong are coarticulated with nasals and are typically called prenasal stops (Heimbach, 1980). Therefore, the first three sections of the *Picture Cued Subtest* in Hmong only assess voiceless stops. Similar to Spanish, there is no /z/ phoneme in Hmong and therefore /s, ts, ʃ/ are examined in the fourth section.

With regard to the adaptation of the two paragraphs of the *Reading Subtest* to Spanish and Hmong, the main factors kept constant were the presence or absence of nasal phonemes and the length of each passage in words. The *SNAP-R* passage, 'Bobby and Billy Play Ball' has 52 words and is loaded with stop plosives and four total nasal phonemes. For Spanish the passage '*Sofía'* is used. Although this passage has both fricatives and stop phonemes, it also contains four nasals and is 50 words in length. Development of a new passage with fewer fricatives was considered. However, pilot data on this paragraph was collected with 35 typical bilingual children and could be helpful for comparison (Nett & Ochoa, 2004). The Hmong paragraph, '*Paiv Thiab Phiab'* (Pai and Phia Toss Ball), developed for this study, is 51 words in length, contains four nasal consonants, no nasal vowels, and is loaded with stops. This and other Hmong stimuli were created by Jy Xiong, in collaboration with the researcher. The *SNAP-R* passage, 'A School Day for Suzy' has 44 words, no nasal phonemes and is loaded with fricatives. In Spanish, the passage, 'Las Galletas' is used. This passage has 46 words, no nasal phonemes and has both fricatives and stop consonants. It was developed in the early 1990's in Miami, Florida (Cruz, n.d.) and has been used in clinics in Florida and Texas since that time, as well as in the study by Nett and Ochoa (2004). The Hmong paragraph, '*Xob Xais Tes*' (Xao Massages Hands) was developed for this study. It contains 49 words, no nasal consonants or vowels, and is loaded with fricatives. See Appendix D for Nasometer passages in English, Spanish, and Hmong.

***Listener Stimuli***

The digital audio recordings from each speaker were equalized for volume using the trial version of GoldWave v5.25 software (GoldWave, Inc., 2008). The samples were RMS equalized, except for instances when clipping would have occurred. In those cases, the average level was reduced. The four samples for judging by the listeners (word stimuli, sentence stimuli, frog story narration, and monologue) were segmented into separate digital audio files and all words produced by the examiner were trimmed. Next, a silent interval of .75 second was inserted between each single word stimulus and 1.5 seconds between each sentence stimulus. Also, the frog story narrative and the monologue were each trimmed to 30 seconds. All samples started at the beginning and were trimmed at the closest natural pause to 30 seconds. The four samples for each speaker were kept together as each speaker was rated individually by each listener. The samples were blocked by language to help the listeners be as consistent as possible within one language. The blocks of languages were randomized for each listener and the six possible orders of presentation were used (English, Spanish, Hmong; Spanish, Hmong, English, etc.).

In accordance with the number of speaker subjects, there were nine English samples, eight Spanish samples, and five Hmong samples. In English five of the speakers had residual velopharyngeal impairment and four had typical communication skills. In Spanish, three of the speakers had residual velopharyngeal impairment, four with typical communication skills, and one speaker with a repaired cleft palate, adequate velopharyngeal function, but a residual articulation distortion of a dental lisp. In Hmong, all five speakers were considered to have overall typical communication skills. However, one speaker had very mild articulation distortions secondary to an anterior crossbite dental malocclusion (which is common in individuals with cleft palate) and oral airflow that was at times confused with audible nasal emission. Overall, the English samples were slightly more severe than Spanish due to an English speaker with a severe rating in the area of hypernasality and the most severe Spanish speakers both had moderate hypernasality.

In addition, each language block had a sample from a typical speaker of the language that was played in the beginning of the block and once in the middle of the block. The listeners were told that the speaker was a typical speaker of that language and they did not have to rate that speaker. To examine intra-rater reliability one subject from each language block was rated twice. Some of the listeners reported that they could tell a speaker had been repeated, typically as a result of the narrative. However, the instructions were clear that the listener could not look back at completed sheets or change any ratings after moving on to another speaker sample.

***Listener Procedures***

Each listener completed a consent form and a brief questionnaire about educational and/or professional history and linguistic background. See Appendix E for the Listener Background Questionnaire. All onsite listeners then completed a hearing screening at 20 dB in both ears at 500, 1000, 2,000, and 4,000 Hz. All offsite listeners were asked to provide a date for the last time they passed a hearing test. The entire test protocol, including all instructions, was recorded on CD and presented via a Sony walkman with over-the-ear headphones. The listeners were able to adjust the volume to their preferred, comfortable level. The offsite listeners were told to listen to the CDs over the best headphones that they had available to them. Along with the audio instructions, each listener was then presented with an instructional handout which contained definitions of the parameters they would be judging and examples of VAS scales. The order of randomization of languages for that speaker was also listed on that form. A total of four CDs were used for each listener, an introduction, and one for each language of English, Spanish, and Hmong.

The listeners were given the opportunity to verbally clarify any of the definitions on the sheet but they were not provided any audio examples or imitated models of the speech characteristics, in order to maintain the experience level differences between the listener groups (naïve, generalist SLP, and specialist SLP). Although offsite listeners did not have the examiner present for clarification of definitions, this should not bias any of the results because none of the onsite listeners requested any additional explanation about the terms. All onsite listeners were provided a fine to medium point black pen to make their lines on the VAS rating scales. The offsite listeners were provided with a pen in their packet or advised to use a fine to medium point black pen. All listeners complied and this helped to make the hand measurements of the VAS ratings more consistent. See Appendix F for the Listener Instructions handout.

The listeners were provided their rating form for the ‘sample’ speaker of the first language. The sample speaker for each language had typical speech and resonance skills, which was specified to the listeners. See Appendix G for the Listener Ratings Form. The rating task on this form included eight VAS judgments and eight binary judgments. VAS judgments were used based on the work of Baylis (2007), Keuning and colleagues (1999; 2002), and Whitehill and colleagues (2007). Whitehill and colleagues demonstrated that judgments of hypernasality completed via VAS were as valid and reliable as those completed by DME, which theoretically is an accurate way to measure the prothetic construct of hypernasality. Baylis (2007) demonstrated that judgments of audible nasal emissions also have curvilinear relationships which could warrant the use of DME (or potentially VAS) as well. VAS was chosen for this study as it has the potential to feel more comfortable and applicable in a clinical situation (Whitehill et al., 2007). Binary judgments were requested for hyponasality as this construct is not considered prothetic in nature and a binary judgment is requested for the *Universal Parameters* paradigm (Henningsson et al., 2008). In addition, binary judgments about the presence/absence of cleft palate related articulation or resonance disorders were collected to make comparisons with data collected on native language and non-native language judgments of fluency disorders by Van Borsel and Pereira (2005).

After completion of the listener instruction CD, each listener moved to their first language. In order to complete the two-page rating form for each speaker, they first heard the single words (25), sentences (15), and 30-second portion of the frog story narrative. They were then asked to complete the ratings for hypernasality, hyponasality, audible nasal emissions, and misarticulations (Items 1-4 on Listener Ratings Form). Then, they heard the 30-second portion of the monologue and were asked to rate voice quality, speech acceptability, and an overall judgment of VPD (Items 5-7 on Listener Ratings Form). This division of samples and subsequent ratings was also based on suggestions in the *Universal Parameter* document (Henningsson et al., 2008). Again listeners were instructed not to replay any samples, change any ratings after moving to a new form, or go back to any forms at a later time. Finally, listeners made ratings about their confidence in their judgments, as well as the ease of making judgments for this particular speaker. They were then encouraged to write any comments about the speaker on the blank lines at the end of the sheet (items 8-11 on Listener Ratings Form). Listeners were encouraged to take breaks between language blocks (if necessary) and instructed to complete all of the ratings during one session, which took approximately two hours to two and one-half hours.

## Data Scoring

### *Speaker Data*

Aside from the audio samples, the only other speaker data collected for data analysis was obtained using the Nasometer. The mean nasalance for each passage was obtained using the 'calculate statistics' option on the Nasometer. Minimum and maximum nasalance values were also recorded. Mean nasalance values were placed in a spreadsheet for subsequent analysis. A total of 8 (36%) of speakers completed the Nasometer protocol at the beginning and at the end of the session to collect data on test-retest reliability.

### *Listener Data*

All of the listener data were collected in paper and pencil format on the Listener Rating Forms. The binary responses were coded as 1 = yes (present) and 0 = no (absent) and the values were entered into a spreadsheet. Also entered in the spreadsheet were the results of the last Cleft Palate Clinic evaluation for all of the speakers with VPD (9). Speech evaluations at the University of Minnesota Cleft Palate Clinic are completed with multiple trained listeners (typically two-four) and the results reflect the impressions of all the examiners. The results of the evaluation were also coded in the same format, 1 = yes (present) and 0 = no (absent), to facilitate calculation of the accuracy of the ratings made by the listeners. For example, one of the binary questions asked of the listeners was, "Does this speaker sound hypernasal?" If the multi-listener judgments from the most recent Cleft Palate Clinic evaluation demonstrated that marginally acceptable to unacceptable hypernasality was present then a 1 was scored, if not a 0 was recorded.

For the remaining typical speakers (13), all 0's were entered, except for the Hmong speaker mentioned earlier who had mild misarticulations secondary to her jaw discrepancy. Agreement to score misarticulations as a 1 (present), but overall speech acceptability also as 1 (present) for this subject was reached between the examiner and the Hmong research assistant. There were also two other typical subjects (both English speakers) who were noted to have potential deviations in voice quality. Voice ratings were not analyzed in this study. After all of the binary data and previous evaluation results were recorded, the listener judgments were transformed to signify 1 = correct, 0 =

incorrect, to calculate overall accuracy of binary judgments. For example, if the listener rated a typical subject as '0' in regards to the binary hypernasality question (which would be accurate), that response was changed to a '1' for correct.

For the VAS ratings, the measurements were made manually with a transparent ruler. The placement of the rating line by the listener was measured to .5 mm by the examiner and recorded in a spreadsheet. To calculate measurement accuracy of the examiner, a research assistant re-measured the rating sheets for five (approximately 20%) of the listeners. The VAS values were then recorded in a spreadsheet for statistical analysis.

## Statistical Analyses

### *Research Question 1a – Binary listener judgments based on experience*

SPSS for Windows 16 Graduate Pack (SPSS Inc., 2007) was used to complete all statistical analyses. In order to answer research question 1a the accuracy of binary ratings of naïve, generalist, and specialist listeners were compared. The accuracy of presence/absence listener judgments of hypernasality, misarticulations, overall speech acceptability, and overall VPD ratings were calculated for English, Spanish, and Hmong speakers. These four dependent variables were chosen as they have the most relevance in judging the presence of VPD. Voice quality (reflective of laryngeal functioning) is a related, but not essential rating when examining velopharyngeal function. In the most recent cleft palate clinic speech evaluations of all participants with velopharyngeal conditions, hyponasality was only present in one speaker (inconsistently) and therefore it was not included in the analyses. Also, ANE (audible nasal emission) was excluded because it may have been difficult to separate from the hypernasality judgment. Several naïve listeners reported that they did not appreciate the difference between the two. Also, several specialist listeners found it difficult to judge ANE with only an audio sample.

Kruskal-Wallis non-parametric one-way analysis of variance (Kruskal & Wallis, 1952) was used to determine if there were significant differences in accuracy between the three listener groups (naïve, generalist, and specialist) on the four dependent variables (hypernasality, misarticulations, speech acceptability, and VPD). Separate tests examining the three groups were completed for each of the four variables. This non-parametric measure was used due to the binary data and the relatively low and unbalanced listener sample size. Although all three listener groups had eight subjects each, all of their ratings were not used in each language. Each listener group had four individuals with Spanish proficiency and four with minimal to no knowledge of Spanish. For the English and Hmong ratings, the entire sample of 24 listeners (eight in each of the three groups) were used since all were native English-speakers and none had knowledge of Hmong. However, for the Spanish ratings, the individuals with Spanish proficiency were left out of the analyses since this is a familiar language to them. Therefore an unbalanced comparison of 24 listeners for English and Hmong and 12 listeners for Spanish was completed.

Mann-Whitney post-hoc tests (Mann & Whitney, 1947) were used to investigate any significant results obtained from the initial Kruskal-Wallis analysis in order to determine which of the three listener groups was significantly different in its ratings. Bonferroni corrected p-values, which varied depending on the number of post-hoc comparisons completed, were used in the analysis.

***Research Question 1b – Binary listener judgments based on language***

In order to answer research question 1b the same binary data from the first analyses were used. However, since this question examined the differences in accuracy of ratings across languages (collapsing across experience groups), a different analysis was used. Although the Friedman Test (Friedman, 1937) is often used for two-way repeated measures analysis of variance by ranks in non-parametric circumstances, it does not allow for unbalanced listener groups. Therefore, the Wilcoxon Signed Ranks Test (Wilcoxon, 1945) was used, which is the non-parametric equivalent of the Student's paired t-test. This analysis was completed first on all listener data to look for general differences across the three languages and then a second time to look for these same potential linguistic differences within each experience level listener group.

***Research Questions 2a and 2b – Correlation of VAS listener ratings and nasalance***

To examine research questions 2a and 2b Pearson product moment correlation coefficients were calculated to obtain $r$ values. Parametric correlations were used because the VAS ratings are a continuous variable, and they were compared to

Nasometer (nasalance) scores, which are also continuous variables. Several studies have shown strongest correlations between listener judgments of hypernasality and nasalance scores on non-nasal (oral only) paragraphs (Dalston et al., 1993; Seaver et al., 1991). Therefore, the nasalance scores for the oral paragraph were compared to the VAS ratings of hypernasality made by the listeners. Correlations were completed considering experience level of the listener and language of the speaker.

***Research Questions 3a and 3b – Ease of and confidence in ratings based on language and listener group***

To investigate questions 3a and 3b, 'Do naïve listeners rate the judgments as more difficult, with less confidence than generalist and specialist listeners?' and 'Are the ratings of English-speakers judged as easier, with more confidence than those of the Spanish and Hmong-speakers?', several analyses were completed. First, a correlation analysis was completed to examine the relationship of the ease of rating and confidence in rating variables overall. Since both of these were collected as VAS ratings (continuous variables) the parametric Pearson's *r* correlation was used. Then, paired t-tests were used to compare the confidence in rating and ease of rating data to look for significant differences between either experience level (group) or language. Since each of the four t-tests (confidence x language, confidence x experience level, ease x language, and ease x experience level) had three comparisons (English-Spanish, Spanish-Hmong, and English-Hmong or naïve-generalist, generalist-specialist, and naïve-specialist) Bonferroni-corrected p-values of .05/3 or p = .0167 were used. T-tests were used instead of the nonparametric Kruskal-Wallis tests used in the earlier analyses because this data was based on the continuous VAS data, not binary responses.

**Reliability**

***Test-Retest Reliability for Nasometer***

In order to examine the test-retest reliability of the Nasometer results, eight of the 22 speakers (36%) were randomly selected to complete the protocol at the beginning and end of their testing session. Although it would have been ideal to have speakers return at a later date for this testing, the distance speakers traveled to the center was considered a burden. By completing the testing at the beginning and end of the session, this allowed for the headset to be placed again, which could potentially be a source of some variation in scores. The pre and post session Nasometer scores were entered into a Pearson product moment correlation analysis. The values obtained for the eight individuals (36% of the speakers) ranged from .973 to 1.00 (mean = .988, s.d. = .010).

***Reliability of VAS Line Measurement***

A computer-based administration format was considered for this study in order to most efficiently capture both the VAS and binary data. However, a paper and pencil task was used due to the constraints on testing location for many of the listeners. As indicated earlier, 50% (12) of the 24 listeners in this study received a mailing packet they completed offsite due to their distance from the test center or inability to come in for study participation. The paper and pencil VAS scales were measured by hand with a transparent ruler by the author. Then, five complete participant files (approximately 20%) were randomly selected to be re-measured by a research assistant. The original and secondary measurements were entered into a Pearson product moment correlation analysis. The values obtained for the five samples completed (20% of the data) ranged from .982 to .999 (mean = .992, s.d. = .008).

***Intra-rater Reliability***

As described earlier, in order to examine the intra-rater reliability of listener judgments, the sample of one speaker from each language was repeated. Reliability analyses were completed for only the variables addressed in this paper. For the binary judgments, the point by point concordance between the original and secondary set of ratings was calculated as a percent of agreement and compared across languages rated and listener experience levels. The straight percentages ranged from 56% - 94% for naïve listeners, 72% to 97% for generalist SLPs and 56% - 97% for specialist SLPs. Then, to correct for chance agreement, the results were entered into the Cohen's Kappa equation (K = observed agreement-chance agreement / 1 – chance agreement) (Cohen, 1960; Norman & Streiner, 1986). This resulted in a change in the ranges changed from 12% - 88% for naïve listeners, 38% - 94% for generalists and 12% - 94 % for specialists. Overall, the naïve listeners were most consistent in their binary ratings for the Spanish-speaker, while the generalists and specialists were most consistent in their ratings for the

English-speaker. All three groups were least consistent in their ratings for the Hmong-speaker. See Figures 8 and 9 for summary of these findings.

For VAS judgments the Pearson product moment correlations were taken on the dependent variables and examined for differences based on the language rated and experience levels of the listeners. First, an overall correlation analysis was run with all listeners together. This revealed correlations of .341 for English (not significant), .513 for Spanish (not significant) and .677 for Hmong (significant at the $p \leq .01$ level). Then individual correlation analyses were run for each listener group. The naïve listeners had a similar trend with the only significant correlation for Hmong ($r = .840$, $p \leq .01$). The generalist listeners demonstrated a different trend with the only significant correlation in English ($r = .865$, $p \leq .01$). The specialist listeners also had a different trend with the only significant correlation in Spanish ($r = .986$, $p \leq .05$). See Table 12 for a summary of values.

***Inter-rater Reliability***

In order to determine the reliability of ratings between listeners, the VAS ratings for the four main variables (hypernasality, misarticulations, speech acceptability, and VPD) were entered into intraclass correlation coefficient analyses (ICC) (Shrout & Fleiss, 1979). They were divided by group and language to examine any differences that may exist. A two-way mixed effects model was used and both single and average measures were calculated. This test was completed on the ratings from all 24 listeners that were collected for eight of the speakers (five English and three Hmong) because all other speakers had one or more missing data points due to items skipped by listeners (six) and items excluded based on Spanish-speaking status of the listener (eight). Therefore, 36.4% of the data were included, revealing an intraclass correlation coefficient of r = .690 for single measures and r = .982 for average measures. Overall it appeared that the VAS ratings made by the 24 listeners for the eight complete speakers had moderate to high levels of inter-rater reliability.

## RESULTS

The aim of this study was to determine whether listeners could make accurate judgments about cleft palate articulation and resonance in languages they do not speak. This objective was met by obtaining binary and VAS judgments of English, Spanish, and Hmong samples from naïve listeners, generalist SLPs, and specialist SLPs.

***Binary listener judgments based on experience***

The Kruskal-Wallis Test was used to examine the accuracy of the binary judgments of hypernasality, misarticulations, speech acceptability, and VPD made by the members of the naïve, generalist SLP and specialist SLP listener groups. An individual test was completed for each variable. For hypernasality, a group difference in accuracy was noted for the speakers of English (H= 14.398, df = 2, p=.001) and Spanish (H=8.8, df=2, p=.012). Subsequently, a series of post-hoc Mann-Whitney Tests were completed to determine which listener group or groups were different. Due to the three pairs of tests in English (for each group) and three in Spanish, a Bonferroni-corrected p value of .05/6, (p = .008) was used. Results revealed a significant difference between both the naïve listeners and generalist SLPs (Mann-Whitney *U* = 5, Z = -3.049, p = .002) and the naïve listeners and specialist SLPs (Mann-Whitney *U* = 1, Z = -3.410, p = .001) in their ratings of English hypernasality, showing higher accuracy for the generalist and specialist SLPs when compared to the naïve listeners. The specialist listeners were also found to be more accurate than the naïve listeners in their ratings of Spanish hypernasality (Mann-Whitney U = .000, Z = -2.646, p = .008). There were no differences found between the generalist and specialist listeners in English or Spanish binary judgments of hypernasality.

The Kruskal-Wallis test for the variable of misarticulation did not reveal any significant difference between the judgments made in the three languages. Therefore, no post-hoc tests were performed. The Kruskal-Wallis test for the variable of speech acceptability revealed a significant difference between the groups when rating the Hmong samples (H = 8.986, df = 2, p = .011). The post-hoc Mann-Whitney Test, using a Bonferroni-corrected p-value of .05/3 (p = .0167) revealed a significant difference between the naïve listeners and specialist SLPs (Mann-Whitney U = 8, Z = -2.908, p

=.004) and between the generalist SLPs and specialist SLPs (Mann-Whitney U = 12, Z = -2.568, P = .010). Both results indicated higher accuracy for the specialist SLPs (when compared to naïve listeners and generalist SLPs) in making binary judgments of speech acceptability.

For examination of the VPD variable, the Kruskal-Wallis test produced a significant difference for the rating of the English (H = 12.534, df = 2, p = .002) and Spanish (H = 6.417, df = 2, p = .040) samples. The post-hoc Mann Whitney Test was completed using a Bonferroni-corrected p-value of .05/6 (p = .008). It revealed a significant difference (Mann-Whitney *U* = 8, Z = -2.902, p = .004) between the naïve listeners and generalist SLPs, indicating higher accuracy for the generalist SLPs in their binary judgments of the presence of an overall VPD in English. None of the other pairs revealed a significant difference. See Table 5 and Figures 3, 4, and 5 for a summary of the results.

In summary, the examination of the accuracy of the binary ratings revealed several significant differences based on the experience level of the listener group. The specialist SLPs were more accurate than the generalist SLPs for binary judgments of speech acceptability in Hmong. The generalist SLPs were more accurate than the naïve listeners for binary judgments of hypernasality and VPD in English. The specialist SLPs were more accurate than the naïve listeners for binary ratings of hypernasality in English and Spanish and speech acceptability in Hmong. There were no significant differences in binary ratings of misarticulation.

***Binary listener judgments based on language***

The Wilcoxon Signed Ranks Test was used to the binary judgment data analyzed for research question 1b for difference in accuracy based on language, collapsed across listener group. First, overall comparisons were completed by compiling the listener ratings for language and completing the following 12 comparisons: four dependent variables (accuracy for binary judgments on hypernasality, misarticulations, speech acceptability, and VPD) by three languages (English, Spanish, and Hmong). The comparisons for Spanish-English and Spanish-Hmong had involved 12 subjects, while those for Hmong-English involved 24 subjects. The test revealed six overall comparisons to have significant differences. When comparing Hmong and English, the three significant comparisons were in judgments of misarticulations (p = .001), speech acceptability (p = .022), and VPD (p = .008). For each of these, there were a higher number of ranks which indicated increased accuracy in English compared to Hmong. When examining Spanish and English there was one comparison which revealed significant results, VPD (p = .011). Again, the ranked comparisons indicated higher accuracy in English compared to Spanish. For the comparisons of Hmong and Spanish, there was only one significant difference, the judgment of misarticulations (p = .034) and the ranks indicated higher accuracy in Spanish compared to Hmong. See Table 6 and Figure 6 for a summary of these results.

After the overall analysis by language was completed, the Wilcoxon Signed Ranks Test was completed again to look for language differences within each group. The results do have the same strength as the overall analysis because the comparisons of Spanish-English and Spanish-Hmong had four subjects while the Hmong-English involved eight subjects. The group analysis revealed four significant comparisons, two within the naïve listeners, and one each in the generalist and specialist listener groups. The significant naïve comparisons were accuracy for judgment of misarticulations (p = .035) and speech acceptability (.026) in Hmong vs. English. In both comparisons, the ranks indicated that accuracy was higher in English compared to Hmong. For the generalist listeners the only significant result was misarticulation when comparing Hmong-English (p = .011), indicating a higher degree of accuracy in English. For the specialist listeners there were no significant differences in any of the comparisons. See Table 7 and Figures 7, 8, and 9 for a summary of these results.

In summary, overall listeners were more accurate when determining the presence/absence of misarticulations, speech acceptability, and VPD in English compared to Hmong. Stronger performance was also noted by the listeners when judging VPD in English compared to Spanish and misarticulations in Spanish compared to Hmong. No overall differences were noted in ratings of hypernasality across the languages. When looking at individual listener groups, the naïve listeners were more accurate in binary judgments of misarticulations and speech acceptability in English compared to English.

The generalist listeners were more accurate in rating misarticulations in English compared to Hmong and the specialists did not show any differences based on language. Again, there were no significant differences in hypernasality ratings for the individual groups. However, it is interesting to note that the naïve listeners were most accurate in Hmong followed by Spanish and least accurate in English, while the generalists had the inverse pattern, they were most accurate in English, followed by Spanish, and then Hmong. The specialists had similar accuracy, over 90% in each of the three languages.

***Correlation of VAS listener ratings and nasalance***

When looking at the oral-only phoneme passage on the Nasometer, the typical English-speakers in this had a mean of 16 and a range of 12-19. The typical Spanish-speakers had a mean of 16 and a range of 9 – 32. The typical Hmong-speakers had a mean of 14 and a range of 6 -20. The English-speakers with hypernasality had a mean of 49 and a range of 41 – 60. The Spanish-speakers with hypernasality had a mean of 66 and a range of 62 – 70. These results are detailed in Table 8.

Pearson product moment correlations were calculated to examine the correlation between the VAS ratings of hypernasality and the objective nasalance scores obtained on the oral-only phoneme paragraph from the Nasometer. The initial correlation analysis completed on the VAS hypernasality ratings by listener group (naïve, generalist specialist) had data collapsed from all 22 speakers (English, Spanish, and Hmong). It revealed significant correlations between listener judgments and nasometer scores. The naïve listener hypernasality VAS ratings and the oral nasometer paragraph had a correlation value of $r$ = .579, the generalist listener ratings correlated with a value of $r$ = .803 and the specialist listener ratings correlated with a value of $r$ = .873. All values were significant at the p = .01 level. The second analysis examined results by language, but collapsed for listener group. This Pearson product moment correlation revealed significant positive relationships in English ( $r$ = .945) and Spanish ($r$ = .853), but no correlation in Hmong ($r$ = .079). See Table 9 for a summary of these results.

After the overall correlation analyses between nasometer scores and VAS listener ratings were completed, Pearson product moment correlations were carried out to look at the relationship of these measures in each individual language for each listener group. In

English, the VAS listener ratings of hypernasality for each listener group were again significantly correlated to the nasalance scores for the oral paragraph on the Nasometer (at $p \leq .01$ level). The *r* values for the naïve, generalist, and specialist groups were .826, .963, and .894 respectively. Differences between the correlations in the VAS ratings of hypernasality and nasalance scores were observed on the test comparing the data for Spanish speaking participants. The moderate correlation of *r* = .556 was not significant for the naïve listeners, the correlation value of *r* = .717 for the generalist listeners was significant at the $p \leq .05$ level and the *r* = .949 value for the specialist listeners was significant at the $p \leq .01$ level. Finally, in Hmong, none of the correlation values between the VAS hypernasality ratings and nasalance scores were significantly related. The *r* values for the naïve, generalist, and specialist groups were -.106, .195, and .131 respectively. See Table 10 for a summary of these results.

In summary, overall the VAS ratings of hypernasality were highly and positively associated with Nasometer values. These correlations were present in the overall analyses as well as in all listener subgroups for English. The correlations were significant for Spanish overall and individually for the generalist and specialist listeners, but not naïve listeners. In Hmong, associations between VAS ratings and Nasometer values were much weaker and not statistically significant for any of the listener subgroups. This indicated that the VAS ratings were not related to the numeric nasalance scores for hypernasality, possibly due to less accuracy in the Nasometer values, the VAS ratings, or both.

***Ease of and confidence in ratings based on language and listener group***

The initial examination of the ease of ratings and confidence in ratings data was completed with a Pearson product moment correlation of these VAS ratings in English, Spanish, and Hmong for all listener groups combined. There were strong negative correlations between these variables in all three languages with *r* = -.837 in English, *r* = -.763 in Spanish and *r* = -.938 in Hmong. This finding was logical since lower values on the ease of rating scale (very easy to very difficult) indicated easier judgments and higher values on the confidence of rating scale (not at all confident to very confident) indicated more confidence in ratings. Therefore, the listeners were consistently judging samples that were easiest to rate as judgments they were most confident in and vice versa.

Then Paired t-tests were completed to determine if there were any significant differences in ease of ratings and confidence in ratings for language or listener groups. Bonferroni-corrected p-values of .05/3 ($p = .0167$) were used for all analyses in this section. For between language comparisons in the ease of making ratings, English ratings were significantly easier than Hmong ($p = .001$). Similarly, for confidence in ratings based on language, listeners' judgments reflected significantly more confidence in the English ratings when compared to the Hmong ratings ($p = .006$). Differences did not reach conventional level for statistical significance between the English and Spanish or Spanish and Hmong ratings. See Table 11 for a summary of results.

When examining the differences between listener groups for the ease of ratings, the paired t-tests revealed that the specialist listeners found the ratings easier to make than the naïve listeners. However, this difference ($p = .0499$) did not reach significance under the adjusted p-value ($p = .0167$). The t-tests which compared the confidence in ratings found that the specialist listeners were less confident than the specialist listeners in their judgments. The result ($p = .0194$) did not reach, but was approaching significance. There were no significant differences found between naïve and generalist listeners or generalist and specialist listeners. See Table 12 for a summary of results.

In summary, the trends of the data revealed that English ratings were judged to be easier to make and with higher confidence levels than those in Hmong. Also, specialist listeners tended to find the ratings in all languages easier to make and with higher confidence than the naïve listeners. There were no significant differences found in ease of ratings and confidence in ratings for English-Spanish, Spanish-Hmong, naïve-generalist or generalist-specialist comparisons.

## DISCUSSION

The aim of this study was to determine whether listeners could make accurate judgments about cleft palate articulation and resonance patterns in languages they do not speak and explore how these ratings were affected by the experience level of the listener or familiarity with the language being assessed. This objective was addressed with three primary research questions and this discussion will review the results for each and explore the findings in comparison with available literature.

The first question sought to examine listener judgments of the presence or absence of cleft palate articulation and resonance disorders in a language they do not speak. In particular, the question of whether the accuracy of the listener judgments improved as a function of expertise with speech characteristics of speakers with cleft palate, in spite of making judgments in unfamiliar language, was examined. The binary ratings of the naïve, generalist SLP, and specialist SLP listeners revealed several significant differences based on the experience level of the listener group. The specialist SLPs were more accurate than the generalist SLPs for binary judgments of speech acceptability in Hmong. The generalist SLPs were more accurate than the naïve listeners for binary judgments of hypernasality and VPD in English. The specialist SLPs were more accurate than the naïve listeners for binary ratings of hypernasality in English and Spanish and speech acceptability in Hmong. There were no significant differences in binary ratings of misarticulation.

It appears that when contrasting listener groups by experience level the most notable differences were in English and in Hmong. The higher accuracy level for generalists and specialists in ratings of hypernasality in English compared to naïve listeners was not surprising as English was considered a control language in this study. English-speaking SLPs have been trained to judge hypernasality in their native language and have varying levels of experience doing this in professional settings. On the other hand, naïve listeners were not provided a model of hypernasality and were less accurate in judging this unfamiliar parameter. A few studies have shown slightly greater reliability in judging cleft palate resonance and/or articulation with increased experience levels (Lewis et al., 2003; Keuning et al., 1999).

Current findings are consistent with previous studies in this regard, but with a potentially stronger role of experience. This could be due to the fact that no other studies have addressed judgments in a language not spoken by the listener, a situation that could require a stronger reliance on clinical skill versus impressions that are made about the quality of a speech sample, or its ‘goodness’ or ‘naturalness’ in a person’s native language. There have been several studies published showing the ability of listeners to make ‘goodness’ or ‘naturalness’ ratings based on the fluency or stuttering and dialect (Franken, Boves, Peters & Webster, 1995; Mackey, Finn, & Ingham, 1997), VOT and voicing (Kazanina, Philips & Idsardi, 2006), and recently in cleft palate articulation and resonance (Benoit, 2008). The majority of listeners in these studies were making judgments about their native language, or in reference to their native language – not in a different language entirely. However, Kazanina and colleagues (2006) found that five-point EAI scale naturalness ratings were not successful in demonstrating the perception of the VOT differences along the /ta – da/ continuum in Korean speakers, who do not use these two phonemes contrastively. It is possible that listeners make a completely different type of judgment in an unintelligible language, when compared to those made about their native language.

The significant difference in accuracy for rating speech acceptability in Hmong (when comparing specialist listeners to both generalist and naïve listeners) is also congruent with differing listener experience levels. The specialists identified, with 100% accuracy, that the five Hmong speakers in this study all had acceptable speech. It is possible that their increased experience listening to the patterns of articulation and resonance related to cleft palate gave them the advantage, or at least the confidence to report that every speaker had acceptable speech. This finding is consistent with those of Morris (1978), Sell (1992) and Sell & Grunwell (1990) who found that experienced, trained English-speaking listeners could successfully make judgments of VPD in the unfamiliar languages of Slovak and Sinhala, respectively. It also supported, to some extent, Van Borsel and Pereira’s (2005) study which demonstrated that native Dutch and native Portuguese-speaking individuals successfully identified individuals who stuttered in both a familiar and unfamiliar language. However, since none of the other studies in the area of cleft palate directly analyzed the accuracy of ratings made in specific areas (such as misarticulations, hypernasality, etc.) in an unfamiliar and native language, there are few direct comparisons that can be made between the individual rating categories from this and previous studies.

Comparison of these findings to those of Landis (1973) and Landis and Cuc (1978) is also interesting because, although Landis did judge nasality in the unfamiliar language of Vietnamese, she deferred the judgment of intelligibility to a Vietnamese-speaking paraprofessional. She also only assessed eight (of 20) phonemes in Vietnamese which were most closely related to English. It is possible that the specialist listeners were able to key in on the shared phonemes between in English and Hmong (such as /p, k, f, v, s/) (Heimbach, 1980) and use those familiar phonemes to assist with judgments. Speech intelligibility is distinct from speech acceptability, but it is worth noting that in this study the specialist listeners were more accurate in rating speech acceptability when compared to hypernasality and VPD. However, the fact that there were no significant differences between listener groups in rating misarticulations, and therefore no demonstrated benefit from expertise, may support Landis' deferral of the intelligibility judgment in Vietnamese.

One key difference to point out between the current study and the findings of Landis (1973), Landis and Cuc (1978), Morris (1978), Sell (1992), and Sell & Grunwell (1990) is that no training about the phonetic inventories of Spanish or Hmong was provided to the listeners. That is, they were not provided with the information needed to be as prepared as they could have been to make these judgments. They were not told, for example, that Hmong has uvular stops (Heimbach, 1980) that may have the potential to be perceived as compensatory articulation patterns by listeners accustomed to the English language. Sell (1992), in particular, reported extensive training in the Sinhalese language before attempting to complete articulation and resonance evaluations (Sell, 1992).

Alongside differences found based on listener experience, there were other ratings that were not affected by experience. In Spanish, there was a relative comparability across listener groups, for some measures. Recall that there were fewer listeners for Spanish (12 listeners, instead of the 24 in English and Hmong). It is possible that there was not enough power to find any significant differences. The overall trend was still present that accuracy was highest for specialist ratings and lowest for naïve ratings, with generalist listeners in the middle. However it should also be noted that some studies have not shown consistently more accurate or more reliable ratings with increased experience levels. A 1984 study by Starr and colleagues found that four groups of adults (cleft clinic SLPs, school SLPs, parents of children with clefts, and parents of noncleft children) made similar ratings of articulation and nasality. Additionally, Whitehill and colleagues (2007) found that naïve undergraduate listeners were able to make reliable and valid ratings of hypernasality on both VAS and DME scales. It appears necessary that more studies be completed examining the accuracy of judgments made on speech samples in an unfamiliar language, including analysis of the role of experience. This is especially important in the area of cleft palate as teams continue to travel to developing countries to provide care for individuals who speak unfamiliar languages (Mars et al., 2008).

In addition to the role of the experience in the accuracy of listener judgments of cleft palate articulation and resonance, this study also examined the ratings in regard to how typologically similar the target language of the speaker (Spanish or Hmong) was to the listeners' native language of English. When the ratings of all listeners were combined for a single analysis, they were more accurate for determining the presence/absence of misarticulations, speech acceptability, and VPD in English compared to Hmong. Stronger performance was also noted by the listeners when judging VPD in English compared to Spanish and misarticulations in Spanish compared to Hmong. These results did produce the expected trend for this question. Overall, three areas (misarticulations, speech acceptability, and VPD) of rating were more accurately rated in English, the native language for all listeners, compared to Hmong, the most typologically distant language. Whereas only one of the rating areas was more accurate in English compared to Spanish (VPD) and Spanish compared to Hmong (misarticulations). This is logical when comparing English and Spanish because they are more closely related than

English and Hmong. It also makes sense in Spanish and Hmong because they are both unknown languages. Therefore, the highest degree of contrast in accuracy was seen between the two most unrelated languages (English and Hmong).

In relation to the extant literature, these findings are very logical. It was hypothesized that ratings would be easier to make and more accurate in Spanish, as compared to Hmong. Recall that in Spanish and English there is considerable overlap with phonemic inventories and cross-linguistic cognates (Kohnert et al., 2004). This may make it easier for native English-speakers to identify speech errors in Spanish, as compared to Hmong. The presence of lexical tones, a significantly wider variety of nasal phonemes, and the uvular and potentially glottal stop phonemes in Hmong (Heimbach, 1980) may make it more difficult to judge speech/resonance skills in Hmong speakers with cleft palate. In addition to some universal error patterns, there may also be some language-specific articulation distortions in cleft palate speech in Hmong, as found in the other Asian languages of Cantonese (Stokes & Whitehill, 1996), Mandarin (Wu et al., 1988), and Japanese (Ainoda et al., 1985). Language-specific articulation distortions would contribute to the difficult of evaluating speech in an unfamiliar language.

However, it should also be noted that although Spanish is more similar to English than Hmong is, it was still a largely unintelligible language for 12 listeners in this study. Therefore, the fact that they were at times more accurate, in Spanish when compared to Hmong, may demonstrate some support for the idea of speech and resonance characteristics which are present cross-linguistically for speakers with the anatomical and physiological concern of VPD (Brøndsted et al., 1994; Hutters & Brøndsted , 1987; Henningsson et al., 2008). Several authors have noted that it should make little difference which language is assessed because traits related to nasal airflow, glottal productions, and alveolar and sibilant deviations are ‘universal’ (e.g. Brøndsted et al., 1994). Additionally, it has been claimed that a trained listener should be able to perceive many of these traits in an unknown language (Brøndsted et al., 1994; Morris, 1978; Sell, 1992; and Sell & Grunwell, 1990). It is important to note that Brøndsted and colleagues' 1994 article was framed around the Eurocleft Speech Group which involves the five Germanic languages of Danish, Dutch, English, Norwegian, and Swedish. Therefore, it makes sense that the findings would best support the relationship of ratings in English and Spanish. Although Spanish is a romance language, it still shares more features with English than does Hmong. As discussed earlier, one study which attempted to apply the Eurocleft evaluation framework to the Nepali language found that it did not account for three common categories of errors found (Shan, 2001). However, the current study results cannot specifically speak to ratings for Hmong speakers with cleft palate because no individuals with VPD were included. It does appear that more studies, on a variety of speakers with VPD from typologically diverse languages, would more fully illustrate the roles of both language-specific and cross-linguistic (or universal) error patterns seen in individuals with cleft palate articulation and resonance disorders.

Another goal of this study was to investigate the relationship of the VAS hypernasality ratings of the listeners in comparison to the objective, instrumental nasalance scores collected on the Nasometer. Specifically, the affect of listener experience and linguistic familiarity on the correlation values between VAS ratings and nasalance scores was examined. To address this question, speakers' nasalance scores needed to be examined for each passage completed. This is necessary because not all of the oral passages used for this study have been examined to the same degree in previous studies. The English passage 'A School Day for Suzy' is part of the published SNAP-R protocol which has standardized procedures and normative information (Kummer, 1995; MacKay & Kummer, 1994). Although the Spanish passage, 'Las Galletas' (The cookies) has pilot data (Nett & Ochoa, 2004), it has not been tested to the same degree as the English passage. Finally, the Hmong passage, 'Xob Xais Tes' (Xao Massages Hands) was developed for this study and although it was adapted with appropriate phonetic characteristics, it has only been used with one pilot subject and the five Hmong speakers in this study. Importantly, the average values for all of the typical speakers on the oral passage in their native language were within the average range of 2-18 (10 +/- 2 s.d., s.d. = 4) that is suggested for the 'Suzy' passage on the SNAP-R (Kummer, 2005). The test-retest reliability for the Nasometer samples in this study was $r = .988$ (s.d. = .010). The VAS measurement reliability was also $r = .992$ (s.d. = .008). Therefore, it does not appear that any extreme or inconsistent measurements were obtained by the Nasometer or VAS scales in English, Spanish, or Hmong.

In light of previous reports, further examination of Spanish and Hmong nasalance scores is warranted. Several studies have found relatively similar (Nichols, 1999), and at times slightly higher oral passage values in Spanish compared to English on the Nasometer (Anderson, 1996; Dalston et al., 1993; Santos Terrón et al., 1991). For example, in their study of patients from three cleft and craniofacial centers, Dalston and colleagues found that a cut-off of 33 for an oral passage was more appropriate to differentiate typical from hypernasal resonance while 25 and 29 were used in the two American English dialects assessed. The Spanish-speakers in this study had a mean nasalance values of 16.33 (s.d.= 8.4, range = 9 – 32) so the cut-off values of 33 as a starting point for hypernasality looks like it may apply to these data. However, the Spanish-speakers did have a mean lower (but overlapping) with scores reported on similar stimuli by Santos Terrón et al. (1991) and Anderson (1996) who reported (mean = 19.56, s.d. = 5.6) and (mean = 21.95, s.d. = 8.688), respectively. Although there has not been a study published on Nasometer scores in Hmong, there is a relevant study on Cantonese, another tonal, Asian language (Whitehill, 2001). This study found that an oral only paragraph in Cantonese had a mean nasalance score of 13.68 (s.d. = 7.16, range = 4.54 – 41.14). The mean for this small Hmong sample was 13.6 (s.d. = 5.3, range = 6 – 20). Although Whitehill assessed Cantonese, that study provided remarkably similar results to those of our Hmong speakers and helps to support the validity of the nasalance scores. Although this study had a fairly small number of speakers in each language, their scores on the Nasometer are consistent with published literature.

Overall, collapsing across language groups, the Pearson product moment correlations completed with the VAS ratings of hypernasality and nasalance scores on the oral passage revealed positive associations for all listener groups (naïve $r$ = .579, generalist $r$ = .803, specialist $r$ = .873, all at $p \leq .01$). A closer look at the VAS – nasalance score relationship in each language revealed that the overall correlation values in the current study ranged from $r$ = .945 in English to $r$ =.853 in Spanish (both with values of $p \leq .01$) to $r$ =.079 in Hmong (not significant). The correlations were the strongest for all listener groups for English with the following values: naïve $r = .826$, generalist $r = .963$, and specialist $r = .894$, all significant at $p \leq .01$. The correlations were significant for Spanish for the generalist ($r = .717$, $p \leq .05$) and specialist listeners ($r = .949$, $p \leq .01$), but not for naïve listeners ($r = .556$). In Hmong, the low correlation values were not significant for any of the individual listeners groups (naïve $r = -.106$, generalist $r = .195$, and specialist $r = .131$). It is interesting to note that several of the correlation values obtained for the English and Spanish VAS hypernasality ratings and oral phoneme passages on the Nasometer were higher than some of the correlations for listener judgments and nasalance scores previously reported. For example, a multi-center study by Dalston et al. (1993) found that hypernasality ratings from trained SLPs (in their native language) and Nasometer test results for an oral passage had Pearson correlation values of .60 for a center in Spain (with native Spanish-speaking judges) to .70 for a center in Akron, Ohio and .83 for a center in Chapel Hill, North Carolina. Dalston and colleagues noted they did not control the content of the perceptual evaluations used to obtain the listener ratings which were compared to the nasalance scores. These could have been different across the three centers, contributing to some differences in the correlation values. In addition, the perceptual ratings of hypernasality for that study were completed on four to six point EAIs, with one or two different listeners at each study. It is possible that the use of metathetic EAI scales instead of a prothetic method such as VAS or DME did not capture the hypernasality rating as accurately as possible (Baylis, 2007, Whitehill et al., 2002, 2007).

When comparing correlations for listener groups across languages, it is interesting that all three groups (naïve, generalist, and specialist) have ratings which correlate to the Nasometer scores at the $p \leq .01$ level. However, the correlations decrease in Spanish, with no significant correlation for the naïve listeners, correlation at $p \leq .05$ for the generalists, and at $p \leq .01$ for the specialists. In Hmong, none of the listener groups produced VAS ratings of hypernasality which significantly correlated to Nasometer scores. These correlations point directly to possible effects of both listener experience and language knowledge. In English, all listeners were able to make VAS hypernasality ratings which highly correlated to nasalance scores. In Spanish, the specialists' ratings had strongest correlations, followed by the generalists, and then the specialists. While in Hmong there were no significant correlations. Although no previous studies have been completed on the correlation of perceptual judgments and Nasometer data in a language not spoken by the examiner, it stands to reason that similar trends may be seen as with the binary data – the most accuracy in English, with some differences in Spanish, and the most differences in Hmong. This study has provided preliminary data on the role of language knowledge in the perceptual ratings of hypernasality and how these ratings may correlate with instrumental nasalance scores. It is important that further studies be completed with more listeners and in other languages to gain more information about both the perceptual ratings and nasalance scores in speakers from diverse language backgrounds.

There have been studies completed which included listener experience as a consideration in strength of correlation between perceptual judgments of hypernasality and Nasometer scores. However, a reliable relationship between listener experience and instrumental measures of nasalance was not established. Lewis and colleagues (2003) completed a study that correlated five-point EAI perceptual ratings of hypernasality with Nasometer data. They examined differences in the correlation values for 12 listeners (four SLPs, four MDs, four graduate students, and four teachers) and found low to moderate correlations for each group, with Kappa values ranging from .29 to .57. They found that experience, as operationally defined, was not a factor. As mentioned earlier, this result may be at least partially explained by the type of scaling method used. Perhaps the use of VAS or DME would have yielded different results. In addition, it is possible that some teachers may have had more experience overall listening to children's speech (even typical) and the experience level groups may not have been distinct enough from one another. The authors did note the graduate students had the more dissimilar ratings than the supposedly least experienced group, the teacher. However, they did report that the listeners with higher levels of experience (SLPs and MDs) had stronger inter-rater reliability, showing a benefit in that area (Lewis et al., 2003).

Keuning and colleagues (2002) compared VAS ratings of hypernasality with Nasometer data from an oral phoneme passage (Dutch speakers and raters). They did not find a significant difference in ratings for their three SLPs with cleft experience (similar to the specialist group included in this study) and the three who did not have any cleft experience (similar to the generalist group in this study). The overall Spearman rho correlation for the VAS ratings of hypernasality and the oral passage on the Nasometer for the six listeners combined was .43. The authors noted that lower correlations may have been seen in their study since no examples of severely hypernasal patients were included. They also concluded that higher levels of clinical experience did not result in perceptual ratings that were more significantly correlated with instrumental measures. The lower correlation values obtained by Keuning and colleagues could be due to the fact that the VAS ratings of hypernasality were only based on two passages read on the Nasometer. In the current study, the hypernasality VAS judgment was based on a larger sample of 25 words, 15 sentences, and a 30 second narrative passage. In addition, the relatively small groups in the study by Keuning and colleagues were both SLPs and the difference may have been greater between the listener groups if more subjects or more distinct experience levels had been included.

Previous studies have not demonstrated a robust relationship between listener experience and instrumental measures of nasalance when listeners are making judgments in their native language (Keuning et al., 2002; Lewis et al., 2003). The findings of this study support that trend. Although the correlation values reported for English VAS ratings of hypernasality and nasalance scores on an oral-only passage on the Nasometer are much higher in this study than in reported literature, they were consistent for the English speakers. The ratings from all of the groups were significant at the $p \leq .01$ level. The experience differential was primarily apparent in Spanish, when the significance of the correlation varied between groups. For Spanish, the VAS ratings of hypernasality for the naïve listeners were not correlated with the nasalance scores, the correlation values for the generalists were significant at the $p \leq .05$ level and for the specialists at the $p \leq .01$ level. None of the listener ratings were significantly correlated with nasalance scores in Hmong, a more typologically distant language. Therefore, the experience difference was also not present in Hmong. It seems that the generalist and specialist (to an even higher degree) listeners were able to use their experience in perception of hypernasality in

English  to assist with judgments in Spanish, but that some aspect of judging hypernasality in Hmong yielded different results, that did not correlate with the Nasometer. In this study, listeners heard a wider variety of speech samples from speakers than in the majority of other studies. This could have provided the opportunities for higher correlation values in comparison and possibly helped point to some practical procedures for clinical assessments.

In addition to listeners' lack of familiarity with Hmong, there may be other reasons that the judgments of hypernasality in Hmong did not show stronger correlations with nasalance scores. Although these cross-linguistic comparisons of cleft palate speech are valuable, it is also important to consider the possibility of cross-cultural variation in the acceptability of resonance distortions, including hypernasality. Very few studies have examined this topic directly, but differences have been suggested between native English and native Spanish-speaking judges. It has been proposed that Spanish-speakers may perceive a higher level of hypernasality in conversational speech to be acceptable (Daltson, et al., 1993; González Landa, 1991). A similar suggestion was also made about Brazilian Portuguese speakers who were found to have a mean of 12 (s.d.5.4) on an oral phoneme passage (Trindade et al., 1997). However, it is important to point out the fact that there were no native Hmong listeners tested during this study. In order to make any judgments about differences in the level of acceptable nasality in Hmong, native Hmong-speaking listeners would also need to be included.

In addition to the possibility of cultural and dialectal differences in what is considered appropriate 'nasality' when speaking, there have also been a few studies which point to reasons that some languages may have slightly lower or higher nasalance scores than others. For example, Leeper and colleagues (1992) examined nasalance values in French and English samples from Canada. French is a language which contains phonemically nasalized vowels and they were included as nasal phonemes in the oral-nasal mixed passages. The nasalance values for these mixed Nasometer passages were actually lower in French than English. They hypothesized that nasalized vowels do not contain as much nasal airflow as consonants. They also hypothesized that since vowel nasalization is phonemic in French and not English that when a nasal phoneme occurs in

English it could actually cause nasalization of surrounding phonemes. However, in French this would be less likely since it could change the meaning of the word. Hmong also has nasalized vowels, which could potentially affect the nasalance scores as well. However, the correlations that were run for this study were only completed on the oral passage, which should not be affected by potential for differences in cross-linguistic differences that could be present for assimilatory nasalization in this language compared to Spanish and English with no phonemically nasalized vowels. It is interesting that the mean Hmong nasalance score for the oral passage of 13.6 (s.d. 5.3) is lower than that reported for many English, and especially Spanish, samples. It is more similar to the mean of 12 (s.d. 5.4) seen in Portuguese (Trindade et al., 1997) and the mean of 13.6-14.5 (s.d. 5.1 – 9.2) seen in French (Leeper et al., 1992).

In this study, the correlation values for VAS ratings of hypernasality and nasalance scores for an oral-only phoneme passage on the nasometer were strongest for English, followed by Spanish, and then Hmong. Listener experience level appeared to affect judgments in Spanish, but not in English or Hmong. While many factors could have affected judgments due to linguistic differences, it is clear that additional studies are needed to look not only at cross-linguistic judgments of hypernasality, but also Nasometer values in Hmong.

The final analyses in this study were completed to examine potential experience and language differences reflected in the VAS ratings of ease of judgment and confidence in ratings that were made by each listener after rating each speaker. Overall, this listener experience data revealed that English ratings were judged to be easier to make and were made with higher confidence levels than those in Hmong. These findings support those of Van Borsel and Pereira (2005) which involved making judgments about stuttering in a familiar and unfamiliar language (Dutch and Brazilian Portuguese). Even though the listeners had success identifying stuttering in the language they did not speak, they were more accurate, more confident, and reported less effort when judging speech adequacy in their native language. These findings demonstrate that although listeners are more comfortable making speech judgments in their native language, they may also be successful doing so in an unfamiliar language.

With regard to experience level in this study, the specialist listeners tended to find the ratings in all languages easier to make and made them with higher confidence than naïve listeners. There were no significant differences found in ease of ratings or confidence in ratings when English and Spanish, Spanish and Hmong, naïve and generalist or generalist and specialist groups were compared directly. However, English judgments overall were rated as significantly easier to make ($p = .001$) and were made with significantly more confidence ($p = .006$) when compared to Hmong. Although the results did not reach significance, the specialist listeners also demonstrated a trend for judging ratings to be easier to make ($p = .0499$) and made with more confidence ($p = .0194$) when compared to the naïve listeners. Although these results are not surprising, they lend support for many of the differences found in this study, especially those between English and Hmong ratings, including significantly higher accuracy overall in English for binary judgments of misarticulations, speech acceptability, and VPD. They also support the differences seen between naïve and specialist listeners, including significantly higher accuracy for the specialist listeners in binary judgments of hypernasality in English and Spanish, and speech acceptability in Hmong. It appears that these differences, in both actual ratings and the perception of those ratings, were fewer and more fine-grained between the relatively more similar languages of Spanish and English, than the less familiar languages of Spanish and Hmong. It is also possible that the difference was not great enough between the naïve and generalist listeners or the generalist and specialist listeners to capture as many differences as were apparent between the two more distinct listener groups.

Finally, the methodological shortcomings of this study, and how they may affect results, should be noted. Due to the geographic location of the specialist listeners, it was necessary to use the paper and pencil VAS rating format and have them completed independently through the mail. Although there was no way to control for how many times the listeners may have listened to each sample, or if they reviewed any notes or other sources for the ratings, explicit instructions were provided and the listeners were aware of the expectations for the study. There could also be errors in line measurements made by hand, but hopefully this was kept to a minimum as the inter-rater line measurement correlation value was high for the five samples (20% of the data) analyzed, ranging from .982 to .999 (mean = .992, s.d. = .008). However, one benefit of using the paper and pencil format was that it may have created a first step toward a clinical tool using VAS ratings. Several of the specialist listeners said they could imagine using the ratings forms for clinic patients. This could be beneficial since many clinics currently use EAI scales (Kuehn & Moller, 2000), but emerging evidence points to DME and/or VAS scaling as more valid measurements of hypernasality and nasal emissions (Baylis, 2007; Whitehill et al., 2002; & Whitehill et al., 2007).

In conclusion, this study has shown that it is possible for listeners to judge some aspects of cleft palate articulation and resonance in a language that they do not speak. However, it appears that there are distinct benefits when a listener has more experience in judging these parameters and if the language is typologically similar in some aspects (phonology, cognates) to the native language of the examiner. Although listeners in this study showed inconsistent success for making binary judgments about hypernasality, speech acceptability or naturalness, and overall VPD, there were more difficulties judging misarticulations. Speech intelligibility could not be judged in a language the listener did not understand. In addition, the results of this study showed that VAS ratings of hypernasality were very consistent with nasalance scores for an oral phoneme passage when rating in the native language of English, more variable in Spanish and not correlated in Hmong. There were distinct advantages for all listener groups in English when compared to Hmong. These differences were inconsistent and weaker when Spanish was compared to English. The differences in experience level showed up most in the shared language of English and least familiar language of Hmong. With regard to language-specific errors and 'universal' characteristics of speech and resonance related to cleft palate speech, this study indirectly suggests that both may be present. Although specific analysis of error patterns in English, Spanish, and Hmong were not completed on the speakers in the study, the accuracy of several ratings in all languages points to the fact that there are traits, even in an unfamiliar language, that indicate VPD is present. However, a much more detailed analysis of the speech samples completed for each speaker would need to be completed to add any further information about language-specific error patterns.

Due to the paucity of bilingual practitioners and increasing linguistic diversity on caseloads discussed earlier in this paper, it is important to consider how the results of this study can be used to assist SLPs who work with speakers of unfamiliar languages with cleft palate, both in the U.S. and abroad. First of all, this study demonstrated that experience with the language and experience with the characteristics of speech and resonance related to cleft palate can contribute to accuracy of judgments, as well as the confidence and ease shown in making them. It can be recommended that SLPs assessing individuals with potential VPD who speak an unfamiliar language take the opportunity to review linguistic information prior to completing an evaluation. Ideally, they would review the phonemic inventory in terms presence and frequency of occurrence of the following: high pressure consonants; consonants vs. vowels; phonemically nasalized vowels; pharyngeal, uvular, or glottal phonemes; lexical tones (especially those involving changes in voice quality), among others. Since perceptual and Nasometer data have been collected in many languages and dialects it is also recommended that a thorough search of the literature be completed for any existing studies on VPD and the target language.

This literature search may also lead to any relevant studies related to cultural beliefs about or perceptions of cleft lip and palate or other craniofacial conditions. Although the cultural aspect was not directly evaluated in this study, there are many differences that exist between cultural groups related to beliefs about causes of clefts, types of acceptable treatment, and future implications, all of which can be important in the goal of obtaining the most appropriate and relevant evaluation (Cheng, 1990; Cordero, 2008; Meyerson, 1990; Ortiz-Monasterio & Serrano, 1971; Ross, 2007; Scheper-Hughes, 1990; Strauss, 1985, 1990; Toliver-Weddington, 1990 & Weatherley-White, et al., 2005).

**Future Research Directions**

A first logical investigation would be to have native listeners of Spanish and Hmong (who are also bilingual in English) rate the samples from all three groups of speakers. Ideally, these listeners would include both naïve and experienced individuals.

This would help to validate the 'accuracy' of ratings for the Hmong and Spanish speakers and provide a comparison for the VAS ratings made in these languages as well. It could also be a first step in looking at the rating of severity for articulation and resonance across linguistic and cultural groups. It would also be ideal to enroll some Hmong speakers with VPD to balance out the groups and provide the option for more parametric analyses. The ratings from native listeners of Hmong would be beneficial to explore the poor correlation between hypernasality VAS ratings in Hmong and the nasalance scores that were seen in this study. In addition, it would be interesting to determine if the same patterns for ratings seen in this study for experience and for language familiarity would hold for the native speakers of Spanish and Hmong, to address any cross-cultural difference in levels of acceptable hypernasality that may be present.

It is also necessary, based on the ever-increasing number of languages seen in cleft palate clinics, that we continue our development and testing of Nasometer passages and perceptual stimuli in a variety of languages. This study has demonstrated that articulation and resonance ratings for speakers of unfamiliar languages with VPD may not be as accurate or consistent as those made in a listener's native language. Although much of that difference may be due to linguistic familiarity, there is no way to be certain that valid, reliable stimuli adapted in other languages are being used, until they have been tested and rated in a culturally, linguistically, and dialectally appropriate manner.

**Table 1.** Basic Linguistic Characteristics of English, Spanish, and Hmong.

| | English | | Spanish | | Hmong | |
|---|---|---|---|---|---|---|
| Language Type | Germanic | | Romance | | Hmong-Mien / Miao-Yao | |
| Lexical Tones | - | | - | | 7 (and 1 unmarked) | |
| | Number | Freq Occ | Number | Freq Occ | Number | Freq Occ[b] |
| Consonants | 24 | 59.7% | 20 | 51.6% | 57 | 48.75% |
| Vowels | 14 | 40.3% | 5 | 48.4% | 8 | 51.25% |
| Nasal consonants and vowels | 3 | 10.8%[a] | 3 | 10.5%[a] | 29 | 15.13%[a] |
| Pressure Phonemes Stops, Fricatives, & Affricates | 16 | 32.8%[a] | 12 | 31.8%[a] | 26 | 29.76%[a] |
| Phonemic Use of Glottal or Uvular Stop | - | - | - | - | Yes | N/A[c], 5%[d] |

Note: Data adapted from the following: Guirao & Jurado, 1990; Heimbach, 1980; Kan & Kohnert, 2004; Mines, Hanson, & Shoup, 1978; and Ratliff, 1991.

[a] Frequency of occurrence for nasals and pressure phonemes was calculated as a percent of total phonemes (not as a percentage of consonants).

[b] Frequency of occurrence in Hmong was calculated of total phonemes, not including tones.

[c] Frequency of occurrence of the glottal stop in Hmong was not calculated in the source used.

[d] Frequency of occurrence of uvular and uvular aspirated stop.

**Table 2.** Speaker Participants: Experimental and Control

| Speaker Participants= 22 | Velopharyngeal Dysfunction (VPD) | | | | Control | |
|---|---|---|---|---|---|---|
| | Sex | Age (y;m) | Diagnosis | Resonance Disorder | Sex | Age |
| English = 9 | Male | 17;10 | BCLP | Mild-Mod Mixed | Male | 16;2 |
| | Female | 12;5 | NF Type 1 | Severe Hyper | Female | 12;8 |
| | Male | 8;3 | RUCLP | Mild-Mod Hyper | Male | 8;0 |
| | Female | 7;2 | BCLP | Mild Hyper | Female | 7;4 |
| | Male | 7;4 | LUCLP | Mod-Severe ANE, PSNE | None | N/A |
| Spanish = 8 | Female | 7;0 | CPO | Mild Mixed | Female | 7;1 |
| | Female | 15;10 | SMCP | Mod Hyper | Female | 11;6 |
| | Male | 12;4 | LUCLP | Mild Hyper ANE, CA | Male | 9;5 |
| | Male | 32;10 | NP Tumor | Moderate Hyper | Male | 29;9 |
| Hmong = 5 | Female | N/A | *None | Typical | Female | 23;2 |
| | Female | 17;0 | *Mild Jaw Discrepancy | Mild Artic Difference | Female | 19;5 |
| | Male | 21;7 | *None | Typical | Male | 21;9 |

y= years, m=months, BCLP= bilateral cleft lip and palate, L/RUCLP = left/right unilateral cleft lip and palate, SMCP= submucous cleft palate, Mixed= mixed hypernasal and hyponasal resonance, Hyper= hypernasal, Mod = Moderate, Artic = articulation ANE= audible nasal air emissions, PSNE= phoneme specific nasal air emission, CA= compensatory articulation, NF Type 1 = Neurofibromatosis Type 1, and NP Tumor = nasopharyngeal tumor. Resonance disorder information was taken from the most recent Cleft Palate Clinic report. * = no Hmong participants with VPD were tested.

**Table 3.** Listener Participants: Naïve, Generalists SLPs, and Specialist SLPs

| Listeners = 24 | No Spanish Proficiency | | | Proficient in Spanish | | |
|---|---|---|---|---|---|---|
| | Age | Major or Yrs-SLP Specialty | Languages Spoken | Age | Major or Yrs-SLP Specialty | Languages Spoken |
| Naïve = 8 | 19;0 | Neuro-science | German | 20;0 | Psychology | Spanish |
| | 19;5 | Un-decided | German, French | 20;3 | Economics | Spanish |
| | 24;3 | Dental | German | 20;11 | Linguistics | Spanish, Italian |
| | 27;11 | English | German | 21;2 | Education | Spanish |
| Generalist SLPs = 8 | 27;5 | 3 yrs - Ad Dysphagia | None | 30;1 | 5 yrs – Ped Sp & Lang | Spanish |
| | 35;6 | 6 yrs – Ped Sp & Lang | French, Japanese | 37;8 | 2.5 yrs – Mixed Otpt | Spanish, French |
| | 46;7 | 21 yrs – Ped Sp & Lang | German | 38;7 | 13 yrs – Ped Sp & Lang | Spanish |
| | 57;10 | 30 yrs – Ped Sp & Lang | None | 41;1 | 16 yrs – Ped Sp & Lang | Spanish |
| Specialist SLPs = 8 | 32;2 | 8 yrs – Cleft Care | None | 28;11 | 5 yrs – Cleft Care | Spanish |
| | 34;0 | 10 yrs – Cleft Care | None | 33;4 | 3 yrs – Cleft Care | Spanish |
| | 47;11 | 9 yrs – Cleft Care | None | 40;9 | 11 yrs – Cleft, ESL | Spanish, Portuguese |
| | 62;10 | 40 yrs – Cleft, CAS | French | 57;11 | 29 yrs – Cleft, Sp&L | Spanish, Portuguese |

SLP = speech-language pathologist, Ad = adult, Ped = pediatric, Sp = speech, Lang = language, Otpt = outpatient, CAS=childhood apraxia of speech

**Table 4.** Intra-rater reliability for VAS hypernasality ratings for language and listener group based on Pearson product moment correlations: *r* values

| | Naïve | Generalist | Specialist | Overall |
|---|---|---|---|---|
| English | -.209 | .865** | -.075 | .341 |
| Spanish | .290 | -.607 | .986* | .513 |
| Hmong | .840** | .650 | -.119 | .677** |

* Significant at the $p \leq .05$ level

** Significant at the $p \leq .01$ level

**Table 5.** Significant listener group differences in binary judgments based on Kruskall-Wallis and Mann-Whitney test results

| Listener Group Accuracy | Binary Judgments | | |
|---|---|---|---|
| Specialist > Naive | Hypernasality: English (p = .001)* | Hypernasality: Spanish (p = .008)* | Speech Acceptability: Hmong (p = .004)** |
| Generalist > Naive | Hypernasality: English (p = .002)* | Velopharyngeal Dysfunction: English (p = .004)* | |
| Specialist > Generalist | Speech Acceptability: Hmong (p = .010)** | | |

* Bonferroni-corrected p-value for significance = .008

** Bonferroni-corrected p-value for significance = .0167

**Table 6.** Significant overall differences for binary listener judgments for language based on Wilcoxon Signed Ranks Test

| Accuracy for Language | Binary Judgments | | |
|---|---|---|---|
| English > Hmong | Misarticulation (p = .001) | Speech Acceptability (p = .022) | Velopharyngeal Dysfunction (p = .008) |
| English > Spanish | Velopharyngeal Dysfunction (p = .011) | | |
| Spanish > Hmong | Misarticulation (p = .034) | | |

p = .05

**Table 7.** Significant differences for binary listener judgments for listener group and language based on Wilcoxon Signed Ranks Test

| Listener Group | Binary Judgment Accuracy | |
|---|---|---|
| Naïve Listeners | Misarticulation<br>English > Hmong<br>(p = .035) | Speech Acceptability<br>English > Hmong<br>(p = .026) |
| Generalist SLP Listeners | Misarticulation<br>English > Hmong<br>(p = .009) | |
| Specialist SLP Listeners | No significant differences | |

p = .05

**Table 8.** Mean Nasometer scores (nasalance values) for oral phoneme only passages

| Language | Hypernasal or Typical | # of Speakers | Mean | Standard Deviation | Range |
|---|---|---|---|---|---|
| English | Typical | 4 | 16.25 | 3.1 | 12 - 19 |
| English | Hypernasal | 5 | 48.6 | 7.6 | 41 - 60 |
| Spanish | Typical | 6 | 16.33 | 8.4 | 9 - 32 |
| Spanish | Hypernasal | 2 | 66 | 5.7 | 62 - 70 |
| Hmong | Typical | 5 | 13.6 | 5.3 | 6 - 20 |

English oral passage: 'A School Day for Suzy' (MacKay & Kummer, 1994)

Spanish oral passage: 'Las Galletas' (The Cookies) (Nett & Ochoa, 2004)

Hmong oral passage: 'Xob Xais Tes' (Xao Massages Hands) (Xiong, 2008)

**Table 9.** Pearson product moment correlations between hypernasality VAS ratings by listener group and oral passage nasalance scores from the Nasometer

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Oral Passage Overall | --- | .579** | .803** | .873** |
| 2. Naive VAS Overall | | --- | .668** | .762** |
| 3. Generalist VAS Overall | | | --- | .897** |
| 4. Specialist VAS Overall | | | | --- |

** $p < 0.01$

**Table 10.** Pearson product moment correlation values from comparisons made of the oral passage nasalance scores from Nasometer and listener VAS ratings of hypernasality: *r* values

| VAS Ratings | Oral Passage Overall | Oral Passage English | Oral Passage Spanish | Oral Passage Hmong |
|---|---|---|---|---|
| English Overall | | .945** | | |
| Spanish Overall | | | .853** | |
| Hmong Overall | | | | .079 |
| Naïve Overall | .579** | | | |
| Naïve English | | .826** | | |
| Naïve Spanish | | | .556 | |
| Naïve Hmong | | | | -.106 |
| General Overall | .803** | | | |
| General English | | .963** | | |
| General Spanish | | | .717* | |
| General Hmong | | | | .195 |
| Special Overall | .873** | | | |
| Special English | | .894** | | |
| Special Spanish | | | .949** | |
| Special Hmong | | | | .131 |

All 'overall' values are averages of values within a language or listener group, naïve = naïve listeners, general = generalist SLP listeners, special = specialist SLP listeners

**Table 11.** Language differences in VAS judgments for ease of ratings and confidence in ratings based on results of paired t-tests: p values

| Language Comparisons | Ease of Ratings | Confidence in Ratings |
|---|---|---|
| English > Spanish | .056 | .259 |
| Spanish > Hmong | .159 | .172 |
| English > Hmong | .001* | .006* |

Bonferroni-corrected p-value for significance = .0167

> = higher values for confidence (higher confidence) and lower values for ease (easier)

*significant based on corrected p-value

**Table 12.** Listener group differences in VAS judgments for ease of ratings and confidence in ratings based on results of paired t-tests: p values

| Listener Group Judgments | Ease of Ratings | Confidence in Ratings |
|---|---|---|
| Specialist > Naive | .049* | .019* |
| Generalist > Naive | .473 | .391 |
| Specialist > Generalist | .387 | .297 |

Bonferroni-corrected p-value for significance = .0167

> = higher values for confidence (higher confidence) and lower values for ease (easier)

*approaching significance

**Figure 1.** Point by point % agreement for intra-rater reliability on binary judgment data

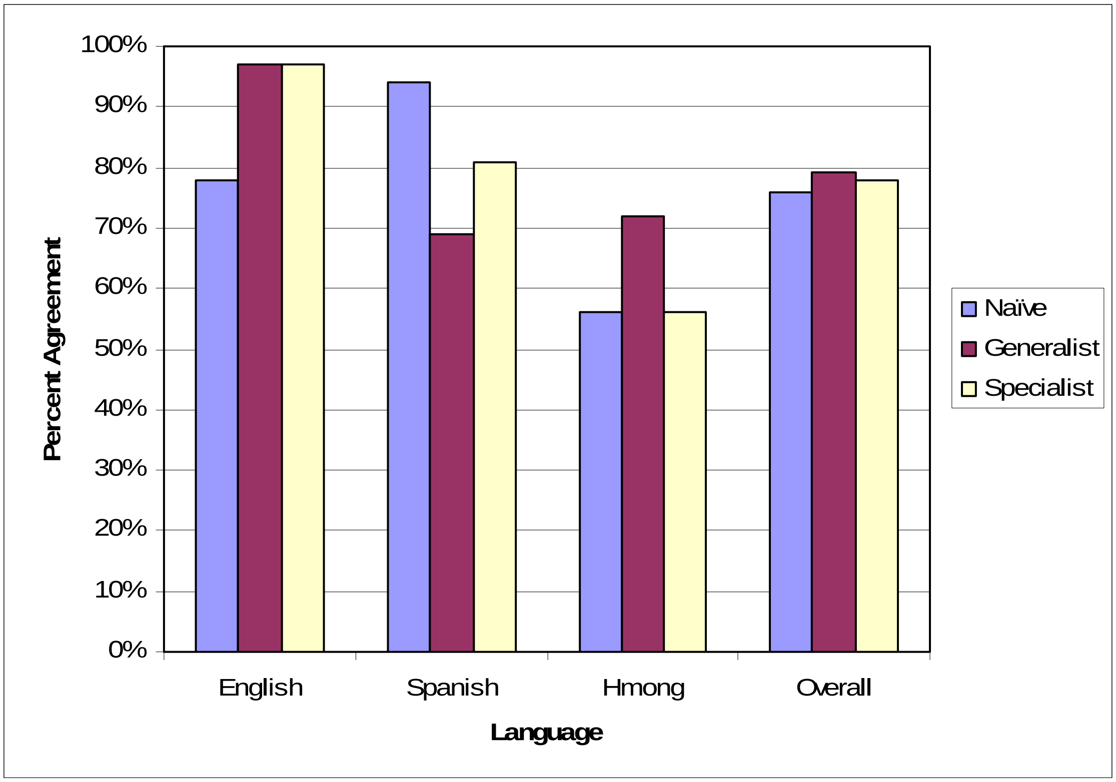


**Figure 2.** Cohen's Kappa adjusted % agreement for intra-rater reliability on binary judgment data

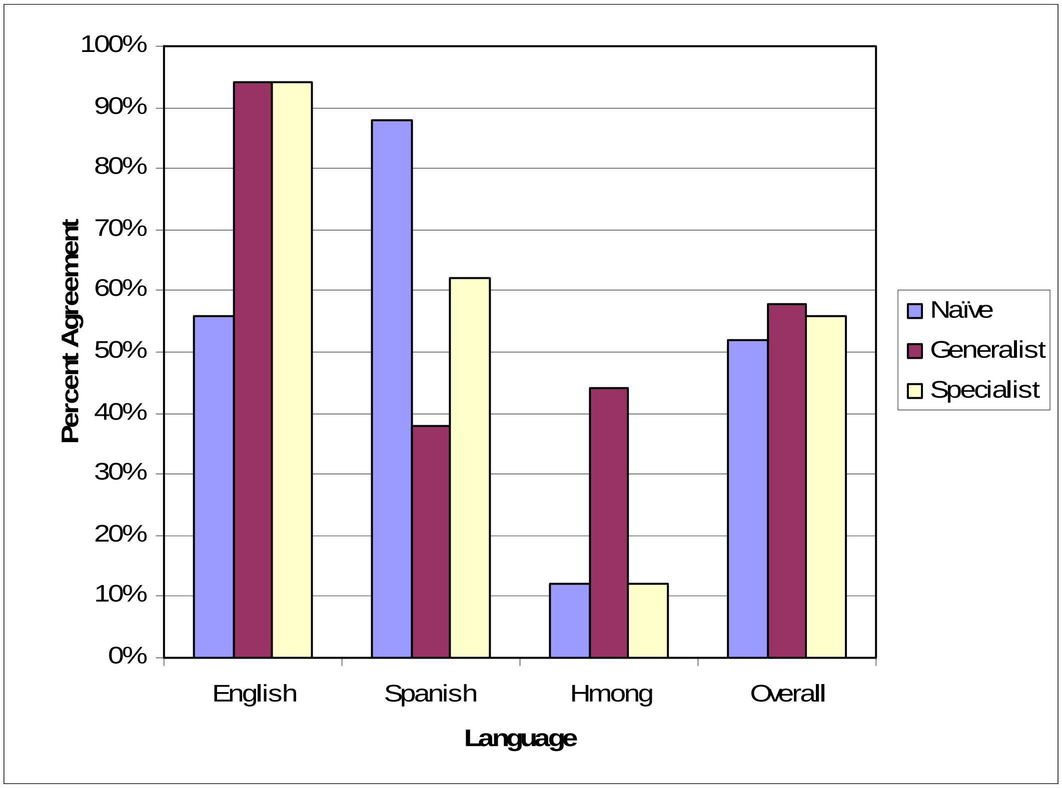
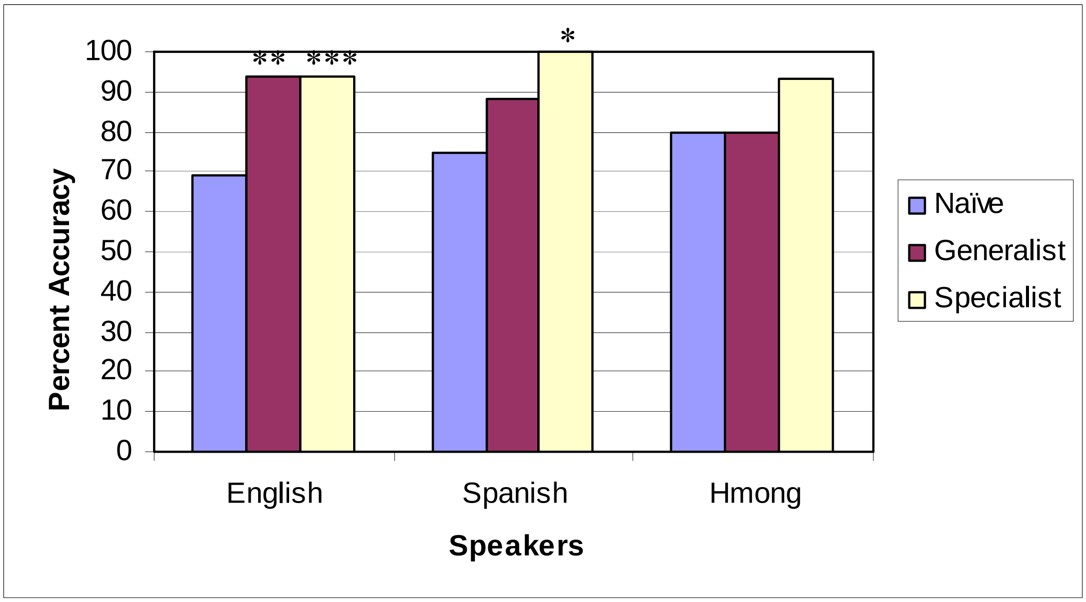


**Figure 3.** Binary judgments of presence/absence of hypernasality (by group) based on Kruskal-Wallis and Mann-Whitney test results



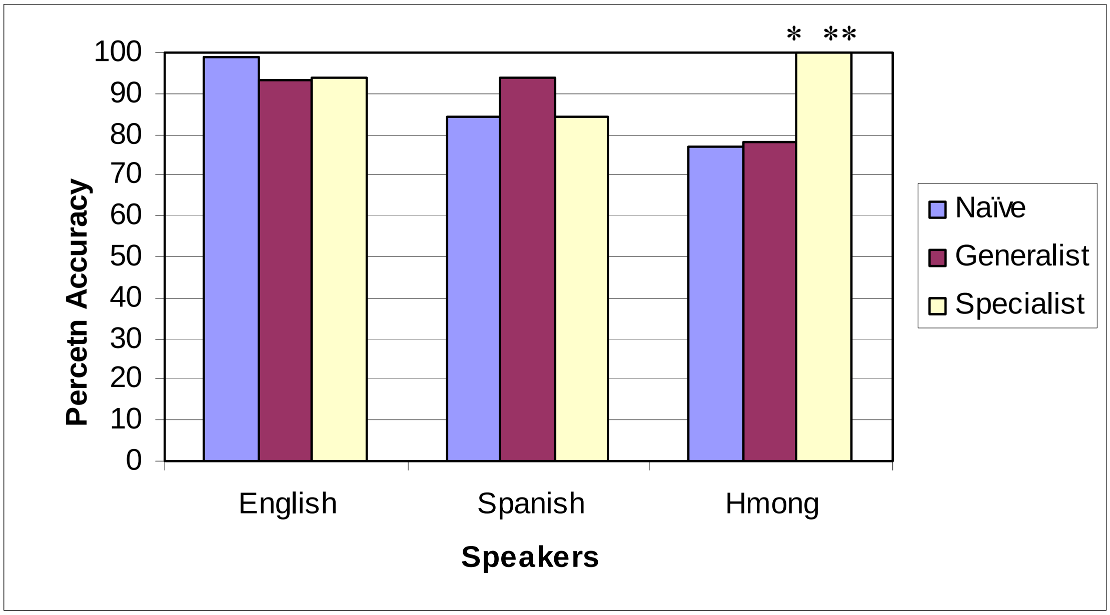

* p = .008

** p = .002

*** p = .001

Bonferroni-corrected significance level p = .008

**Figure 4.** Binary judgments of presence/absence of acceptable-sounding speech (by group) based on Kruskal-Wallis and Mann-Whitney test results

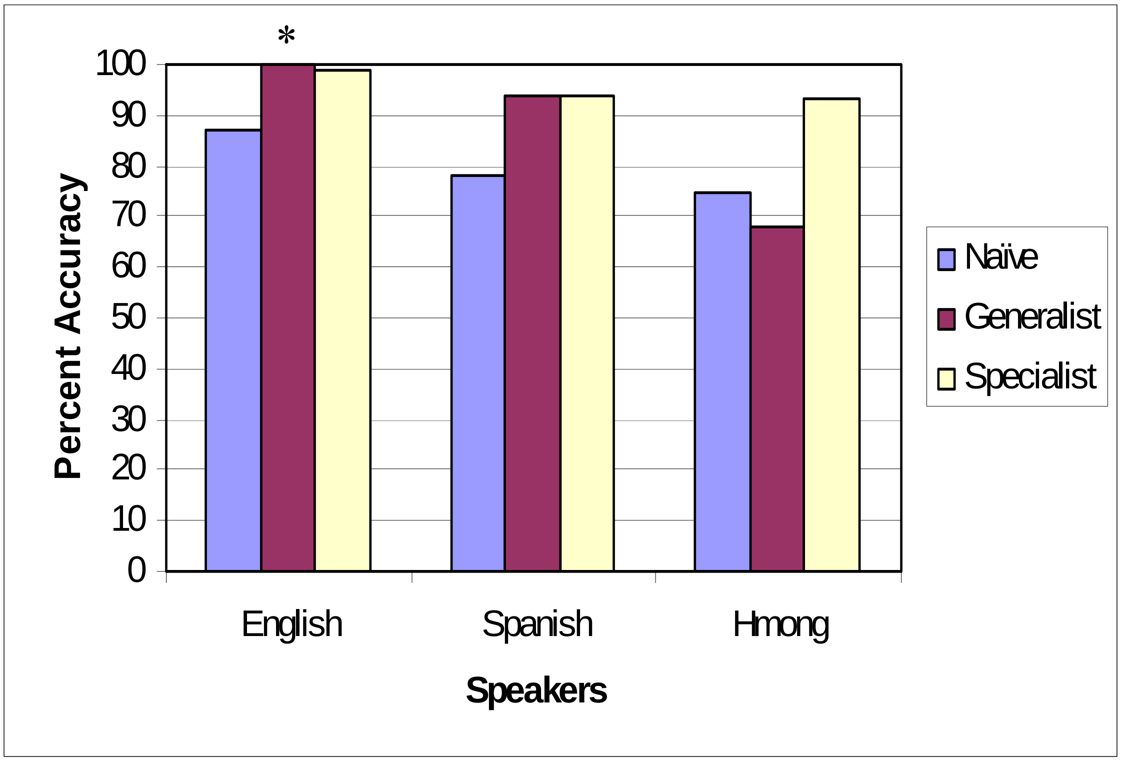



* p = .010

** p = .004

Bonferroni-corrected significance level p = .0167

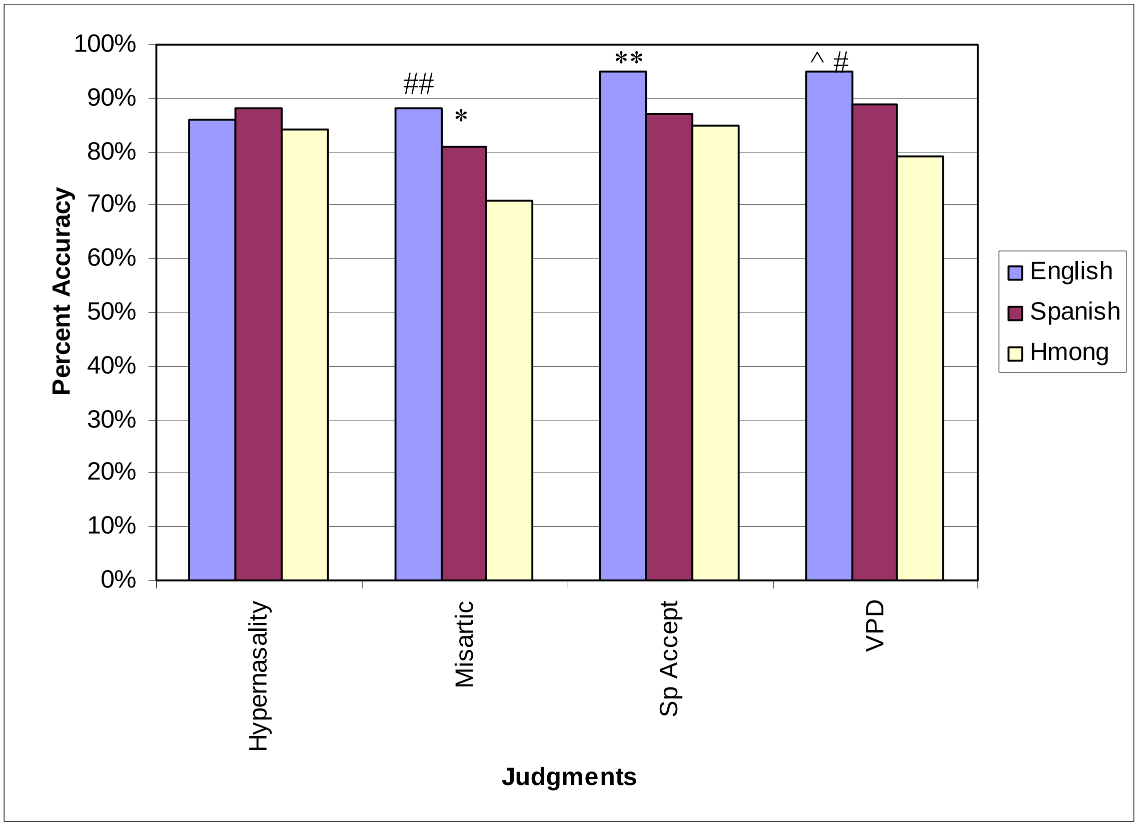
**Figure 5.** Binary judgments of presence/absence of velopharyngeal dysfunction (VPD) (by group) based on Kruskal-Wallis and Mann-Whitney test results




* p = .004

Bonferroni-corrected significance level p = .008

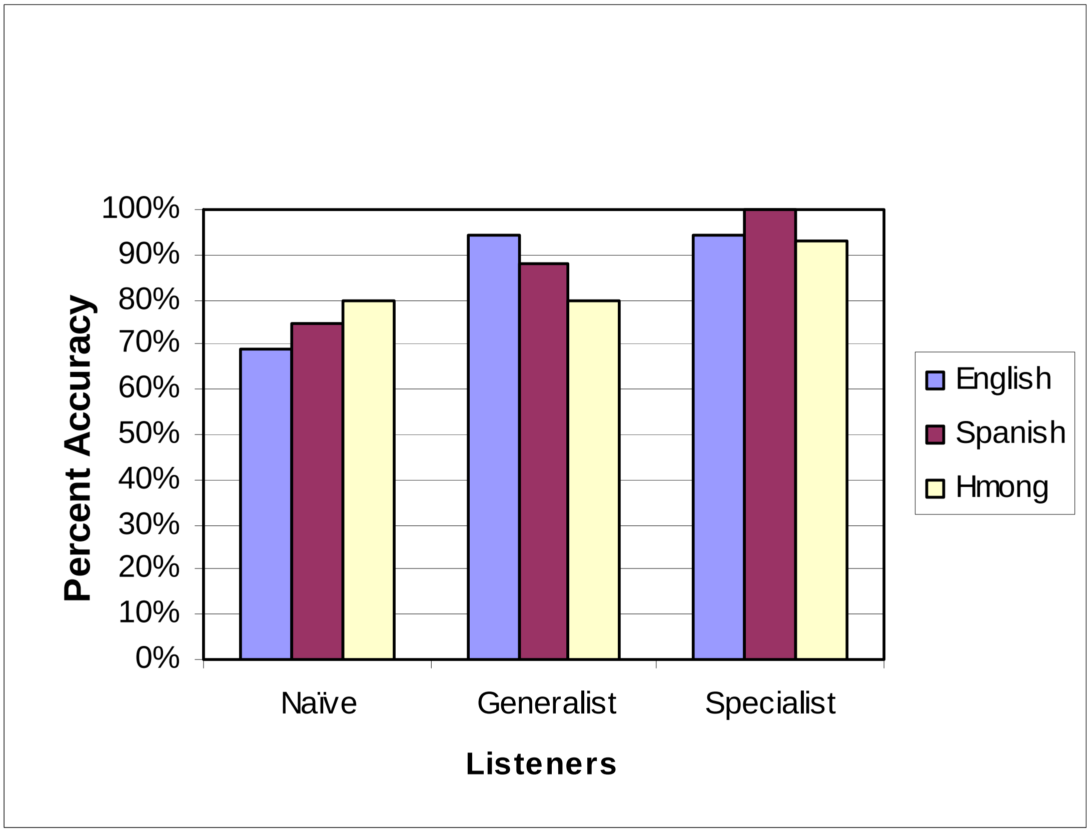
**Figure 6.** Overall accuracy for rating presence/absence for binary judgments of hypernasality, misarticulation, speech acceptability, and VPD based on Wilcoxon Signed Ranks Test




| | |
|---|---|
| * | Accuracy in Spanish > Hmong (p = .034) |
| ** | Accuracy in English > Hmong (p = .022) |
| ^ | Accuracy in English > Spanish (p = .011) |
| # | Accuracy in English > Hmong (p = .008) |
| ## | Accuracy in English > Hmong (p = .001) |

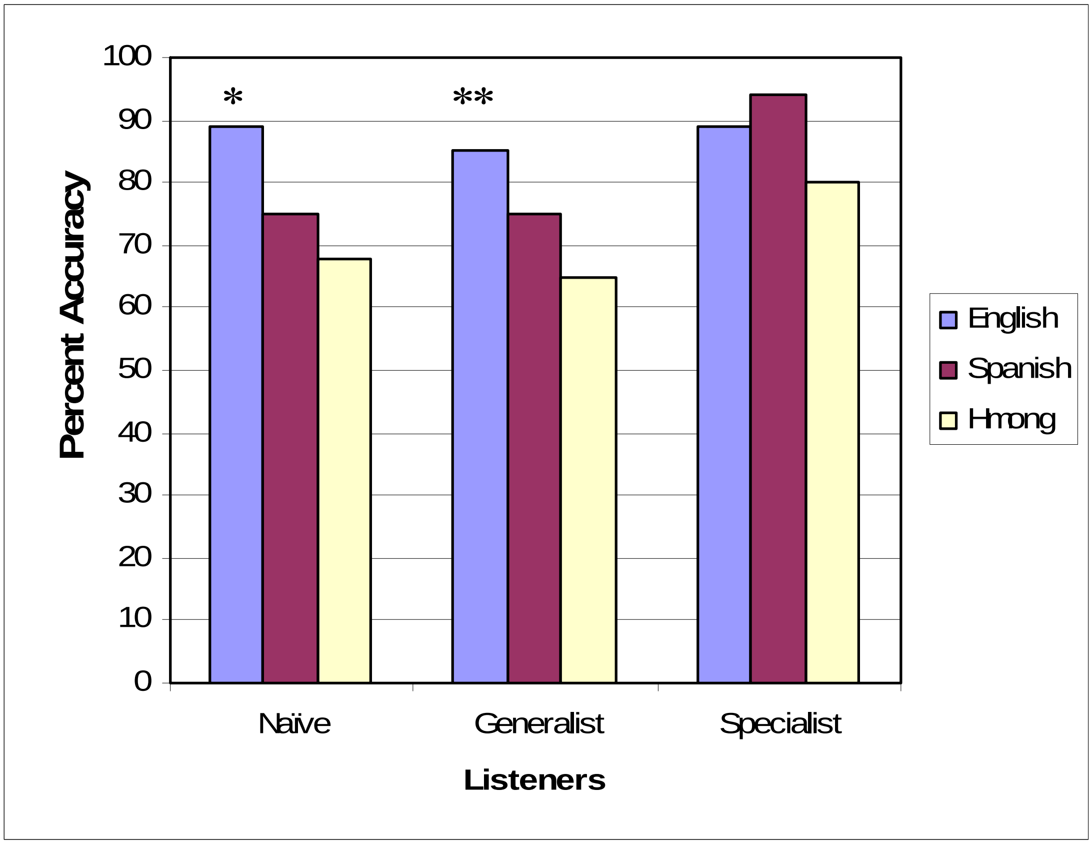
Significance level p = .05

**Figure 7.** Binary judgments of presence/absence of hypernasality (by language) based on Wilcoxon Signed Ranks Test




No significant differences found by language for binary hypernasality ratings

**Figure 8.** Binary judgments of presence/absence of misarticulations (by language) based on Wilcoxon Signed Ranks Test

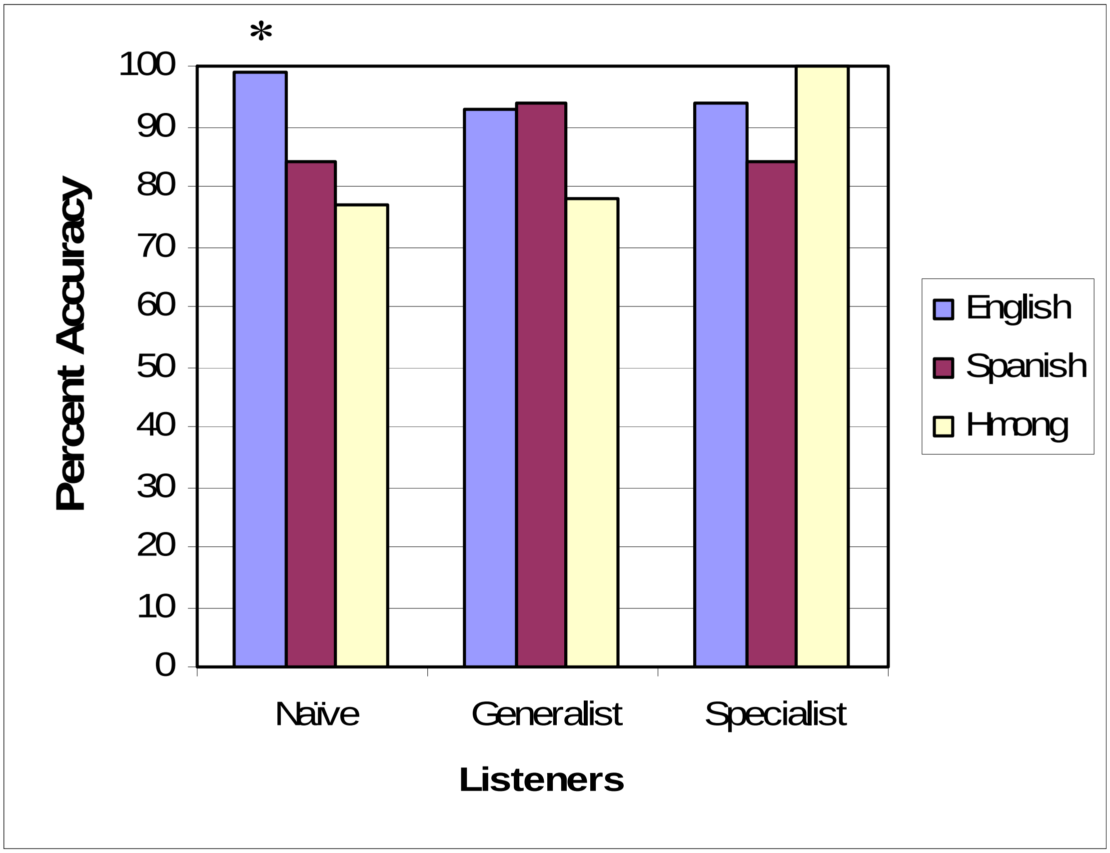



* p = .035

** p = .011

Significance level p = .05

**Figure 9.** Binary judgments of presence/absence of acceptable-sounding speech (by language) based on Wilcoxon Signed Ranks Test




***** p = .026

Significance level p = .05

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## Appendix A

## Background Questionnaire for Speakers

Participant's Name:______________________________Participant's Number:_________

Date of Session:_______________ Date of Birth:______________Age:______________

Native Language(s):_________________________________________________________

Cleft Diagnosis: ___R / L UCLP ___BCLP ____CPO ____SMCP ____N/A – Control

Do you now, or have you ever used hearing aids?_____ If yes, for how long?__________

What percent of the time do you speak each language in each situation?

| | **___English ___None** | **___Spanish ___Hmong** |
|---|---|---|
| **With Mother** | | |
| **With Father** | | |
| **With Brothers and Sisters** | | |
| **At School** | | |
| **Other (sports, church, etc.)** | | |

At what age did you start learning English?

Do you feel more comfortable speaking Hmong/Spanish or English? or equal in both?

Do you speak any languages other than English and Spanish/Hmong? If yes, explain:

**Participants with a cleft:**

When was your cleft palate repaired initially? _____________ Was a secondary surgery completed?_______ If so, what type?________________, when?_____________

Are you currently receiving speech therapy?_________, If so, since when?___________, and with what frequency?______________. If not, did you receive in the past?__________, and for how long?_______________

When was your last visit to a Cleft Palate Clinic?__________,Where?_______________

Other Comments:_________________________________________________________

**Participants without a cleft:**

Have you ever had any diagnosis related to cleft palate or velopharyngeal incompetence?______If yes, describe:________________________________________

Are you currently, or have you ever received special education services or speech therapy?_____If yes, describe:_______________________________________________

Other Comments:_________________________________________________________

## Appendix B

## Word and Sentence Stimuli

Table B1

English and Spanish Word Stimuli for Speakers

| Criteria | English[a] | Spanish[b] | English Translation |
| --- | --- | --- | --- |
| -10 words with high vowels only | 1. pea /pi/ | 1. sí /si/ | 1. yes |
| | 2. tea /ti/ | 2. tía /tía/ | 2. aunt |
| | 3. key /ki/ | 3. pipa /pípa/ | 3. pipe |
| -15 words with mid or low vowels | 4. bib /bɪb/ | 4. tito /títo/ | 4. uncle |
| | 5. sis /sɪs/ | 5. tú /tu/ | 5. you |
| -no nasals | 6. kick /kɪk/ | 6. fui /fui/ | 6. I went |
| | 7. shoe /ʃu/ | 7. búho /búo/ | 7. owl |
| -pressure consonants only | 8. chew /ʧu/ | 8. dúo /dúo/ | 8. duet |
| | 9. ooze /uz/ | 9. sus /sus/ | 9. yours |
| | 10. cook /kʊk/ | 10. uso /úso/ | 10. I use |
| -all pressure consonants of language | 11. they /ðeɪ/ | 11. yogur /yoɣúɾ/ | 11. yogurt |
| | 12. pay /peɪ/ | 12. bebé /beβé/ | 12. baby |
| -CV or CVC words | 13. dead /dɛd/ | 13. dedo /déðo/ | 13. finger |
| | 14. dad /dæd/ | 14. fe /fe/ | 14. faith |
| -ideally each sound tested in each position of occurrence | 15. coke /kouk/ | 15. te /te/ | 15. tea |
| | 16. go /gou/ | 16. ese /ése/ | 16. that one |
| | 17. taught /tɔt/ | 17. ella /éʤa/ | 17. she |
| | 18. oath /ouθ/ | 18. papá /papá/ | 18. dad |
| | 19. pop /pɑp/ | 19. chacha /ʧáʧa/ | 19. cha-cha |
| | 20. judge /ʤʌʤ/ | 20. gajo /gáxo/ | 20. slice |

| | | | |
|---|---|---|---|
| - any other consonants used should have similar place as target and approximant status | 21. cow /kau/ | 21. hago /áɣo/ | 21. I do/make |
| | 22. joy /ʤɔɪ/ | 22. raro /ráɾo/ | 22. strange |
| | 23. boy /bɔɪ/ | 23. ojo /óxo/ | 23. eye |
| | 24. pipe /paɪp/ | 24. ocho /óʧo/ | 24. eight |
| | 25. five /faɪv/ | 25. coco /kóko/ | 25. coconut |
| (Henningsson et al., 2008) | | | |

[a] Developed by the author and taken from the following sources: Henningsson et al., 2008; Sell et al., 1999.

[b] Developed by the author and reviewed by A.P. Cordero, 2008

## Appendix B

## Word and Sentence Stimuli

Table B2 Hmong Word Stimuli for Speakers

| Criteria | Hmong[ab] | English Translation |
|---|---|---|
| -10 words with high vowels only<br><br>-15 words with mid or low vowels<br><br>-no nasals<br><br>-pressure consonants only<br><br>-all pressure consonants of language<br><br>-CV or CVC words<br><br>-ideally each sound tested in each position of occurrence<br><br>- any other consonants used should have similar place as target and approximant status<br><br>(Henningsson et al., 2008) | 1. ib /i55/ | 1. one |
| | 2. dib /di55/ | 2. cucumber |
| | 3. pib /pi55/ | 3. begin |
| | 4. tw /tɨ/ | 4. tail |
| | 5. pw /bɨ/ | 5. sleep |
| | 6. lwm /lɨ21/ | 6. next |
| | 7. tim /ti21/ | 7. because of |
| | 8. hu /hu/ | 8. call |
| | 9. lus /lu22/ | 9. words |
| | 10. tus /tu22/ | 10. the |
| | 11. teb /te55/ | 11. garden |
| | 12. dev /de24/ | 12. dog |
| | 13. paj /pa52/ | 13. flower |
| | 14. xav /sa24/ | 14. think |
| | 15. cas /ca22/ | 15. what |
| | 16. phem/pʰe21/ | 16. bad |
| | 17. khob /kʰɔ55/ | 17. cup |
| | 18. liaj /lia52/ | 18. plow |
| | 19. duab/dua55/ | 19. photo/shadow |
| | 20. hais /hai22/ | 20. speak |
| | 21. saw /saɨ/ | 21. necklace |
| | 22. aub /au55/ | 22. dog |
| | 23. plaub/blau55/ | 23. hair/fur |

| | | |
|---|---|---|
| | 24. rau /ʈau/ | 24. for |
| | 25. caij /cai52/ | 25. season, length of time |

[a] Developed by J. Xiong, 2008

[b] Tones are noted with numbers in each transcription (Kan et al., 2006; Ratliff, 1991). The numbers correspond to the following tones:

| | |
|---|---|
| High level | 55 |
| High falling | 52 |
| Mid-rising | 24 |
| Mid level | 33 |
| Mid-low level | 22 |
| High-mid falling | 42 |
| Low falling | 21 |
| Low falling-raising | 213 |

## Appendix B

## Word and Sentence Stimuli

Table B3

English and Spanish Sentence Stimuli for Speakers

| Criteria | English[a] | Spanish[b] | English Translation |
|---|---|---|---|
| 15-20 sentences with: | 1. The puppy pulled a rope. | 1. Papi pide el papel. | 1. Dad asks for the paper. |
| | 2. Buy baby a bib. | 2. El bebé babea sobre el babero. | 2. The baby drools on the bib. |
| -voiced and unvoiced pressure consonants | 3. Tell the tot to talk. | 3. Tito toca la tortuga. | 3. Tito touches the turtle. |
| | 4. Daddy did the deed. | 4. A Delia se le da los dados. | 4. The dice are given to Delia. |
| -one target consonant type per sentence, and at least two to three target words per utterance | 5. Kay cooks cocoa cookies. | 5. Kiko recoge el coco que cayó. | 5. Kiko picks up the coconut that fell. |
| | 6. Greg got a gift of legos. | 6. El gato agarra el juguete. | 6. The cat grabs the toy. |
| | 7. Sissy saw Sally race. | 7. Susy se zafa su suéter. | 7. Suzy loosens her sweater. |
| | 8. The zebra was at the zoo. | 8. El chico chocó su coche. | 8. The boy crashed his car. |
| Also: | 9. Shelly sells sea shells at her store. | 9. La lluvia cayó sobre la calle. | 9. The rain fell on the road. |
| -three to five short sentences with a mixture of nasal consonants | 10. Charlie chats at church. | 10. La erre de perro y cigarro. | 10. 'The 'r' of 'dog' and 'cigar' |
| | 11. Joy is a just judge. | 11. Sofía fue a la feria. | 11. Sofia went to the fair. |

| | | | |
|---|---|---|---|
| (Henningsson et al., 2008) | 12. The thin cloth breathes well.<br>13. Phil feeds five very fat fish.<br>14. My mom made lemon muffins.<br>15. Now is not the time for the man's news | 12. Ella se queja por dejar la caja.<br>13. Mi mamá bota mucha basura.<br>14. La nena no se pone nada a la muñeca.<br>15. Mi mamá me mima. | 12. She complains about leaving the box.<br>13. My mom throws away a lot of garbage.<br>14. The girl doesn't put anything on the doll.<br>15. My mom spoils me. |

[a] Developed by the author and taken from the following sources: Henningsson et al., 2008; Sell et al., 2001.

[b] Developed by the author, from unpublished protocols, and reviewed by A.P. Cordero, 2008.

## Appendix B

## Word and Sentence Stimuli

Table B4

Hmong Sentence Stimuli for Speakers

| Criteria | Hmong[a] | English Translation |
|---|---|---|
| 15-20 sentences with:<br><br>-voiced and unvoiced pressure consonants<br><br>-one target consonant type per sentence, and at least two to three target words per utterance<br><br>Also:<br><br>-three to five short sentences with a mixture of nasal consonants<br><br>(Henningsson et al., 2008) | 1. Pov lub pob.<br>2. Pov tsab paj.<br>3. Pov lub phiab.<br>4. Thov ib khob dej.<br>5. Thov ib daim duab.<br>6. Thov ib lub thawv.<br>7. Cov khawb kev.<br>8. Cov kwv kawm.<br>9. Cov kab ke.<br>10. Txiv xaiv xauv.<br>11. Txiv xa xov.<br>12. Txiv xaws sev.<br>13. Niam ua hnab looj tes.<br>14. Niam ua nees ntshai.<br>15. Niam ua mis nchuav. | 1. Throw a ball.<br>2. Throw a flower.<br>3. Throw a bowl/basin.<br>4. Ask for a cup of water.<br>5. Ask for a photo.<br>6. Ask for a box.<br>7. They dig a road.<br>8. They carry baskets (Hmong gardening baskets).<br>9. They gather (for a meal/party).<br>10. Father picks necklaces (Hmong silver necklaces).<br>11. Father sends mail.<br>12. Father sews aprons (Hmong aprons).<br>13. Mother makes mittens.<br>14. Mother makes the horse scared.<br>15. Mother made the milk spill. |

[a] Developed by J. Xiong, 2008

## Appendix C

## *Frog, Where Are You?* Scripts

C1. English (Kan & Kluge, 2004)

The boy and his dog found a frog. They put the frog in a jar.

At night, when the boy and his dog slept, the frog jumped out of the jar, and ran away.

In the morning, when the boy and his dog woke up, they did not see the frog!

The boy and his dog searched everywhere for their frog.

They looked out the window to find the frog, but the frog was not there.

The silly dog fell out of the window and broke the jar! The boy was mad at him.

They looked outside to find the frog, but the frog was not there.

The dog looked in a beehive while the boy looked in a hole.

The boy did not find the frog, but he found an angry gopher instead!

And the dog made the beehive fall, while the boy looked in a tree.

The bees chased the dog,

And the owl chased the boy.

They looked on a rock. But found a deer instead.

The deer carried the boy to the cliff

And threw the boy and the dog into the pond!

The boy and his dog heard something in the pond.

The boy told the dog "Sh, be quiet"

They looked over the log to see if they could find the frog.

They found two frogs! They found a whole family of frogs!

The boy and his dog took a baby frog home with them, and waved "Bye" to the family of frogs.

## Appendix C

### *Frog, Where Are You?* Scripts

C2. Spanish (Cordero & Cordero, 2008)

El niño y su perro encontraron una rana. La pusieron en un frasco.

Por la noche, cuando estaban durmiendo el niño y su perro, la rana se escapó del frasco y se fue.

¡En la mañana cuando se despertaron el niño y su perro, no vieron a la rana!

El niño y su perro buscaron por todos lados a su rana.

Miraron por la ventana para encontrar la rana, pero no estaba allí.

¡El perro tonto se cayó por la ventana y se rompió el frasco! El niño se enojó con el perro.

Miraron afuera para encontrar la rana, pero no estaba allí.

El perro buscaba en una colmena mientras el niño miraba en un hoyo.

¡El niño no encontró la rana, pero a cambio halló una ardilla enojada!

El perro hizo caer la colmena cuando el niño buscaba en un árbol.

Las abejas persiguieron al perro y el búho persiguió al niño.

Buscaron en una piedra, pero a cambio hallaron un venado.

El venado cargó al niño al precipicio y tiró al niño y al perro en la charca!

El niño y su perro escucharon algo en la charca.

El niño le dijo al perro "Sh, guarda silencio".

Miraron al otro lado del tronco a ver si podían encontrar la rana.

¡Hallaron dos ranas! ¡Encontraron una familia entera de ranas!

El niño y su perro se llevaron a una ranita a su casa y se despidieron de la familia de ranas.

## Appendix C

## *Frog, Where Are You?* Scripts

C3. Hmong (Xiong, 2004)

Thaum tsaus ntuj ib tug menyuam tub thiab nws tus aub nrhiav tau ib tug qav.

Lawv muab tus qav cia rau ib lub hwj.

Thaum tsaus ntuj thaum tus menyuam tub thiab tus aub pais pw lawm, tus qav nrhia pais ces nus khiav mus lawm.

Thaum pom kev, tus menyuam tub thiab tus aub sawv, tabsis lawv nrhiav tsis tau tus qav, lawv tsis pom tus qav.

Tus menyuam tub thiab tus aub nrhiav qhov txhia qhov chaw saib pos pom tus qav.

Nkawv nyob ntawm qhovrais.

Nkawv saib saib nraum qhovrais saib pos pom tus qav, tabsis tus qav tsis nyob ntawv.

Tus menyuam tub saib saib tab sis tsis pom.

Tus aub saib ntawm qhovrais ces nws poob ntawm qhovrais ces nws ua lub hwj tawg lawm.

Tus menyuam tub ua npau taws rau tus aub, tabsis tus aub tsis paub dabtsi,

ces nws yaimyaim tus menyuam tus lub ntsejmuag xwb.

Nkawv nyob nraum zoov nkawv nrhiav tus qav, tabsis tsis pom tus qav li.

Tus aub nyob ntawm tsob ntoo nws nrhiav hauv lub tsev mub, tus menyuam tub saib hauv av.

Nws saib hauv ib lub qhov hauv av saib pos pom, tabsis pom ib tug tsiaj xwb.

Tus menyuam tub tsis pom tus qav.

Tus aub qwqw rau saum lub tsev mub, ua lub tsev mub poob- poob los hauv av.

Tus menyuam tub nce sau- sau—nce saum ib tsob ntoo saib pos pom tus qav.

Cov mub caum tus aub. Ib tug plas tawm tsob ntoo los caum tus menyuam tub.

Tus plas caum tus menyuam tub pais saum ib lub pob zeb.

Tus menyuam tub muab tus aub nyob ntawm pob zeb nhriav tus qav saib pos pom tus qav,

tabsis lawv nhriav tau ib tug moslwj.

Tus moslwj nqa tus menyuam tub thiab caum tus aub pais tom pas dej.

Tus moslwj muab tus menyuam tub poob rau hauv pas dej thiab caum tus aub poob rau hauv pas dej.

Nkawv nyob rau hauv pas dej nkawv hnov abtsi qwqw.

Nkawv saib (nahas ua cas) pom ib tug qav.

Nkawv nhriav tau ob tug qav.

Ces nkawv pais ze rua pom ib tsev neeg qav.

Tus menyuam tub thiab tus aub nqa ib tug menyuam qav pais tsev ces lawv hais “sib ntsib rua” rau tsev qav ntawv. Thab.

## Appendix D

## Nasometer Stimuli

Table D1 English and Spanish Nasometer Passages

| Criteria | English[a] | Spanish[b] | English Translation |
|---|---|---|---|
| Orals, Bilabial Stops | Pick up the book.<br>Pick up the pie.<br>Pick up the baby. | Paco pide el papel.<br>Paco pide la papa.<br>Paco pide la pelota. | Paco asks for the paper.<br>Paco asks for the potato.<br>Paco asks for the ball. |
| Orals, Alveolar Stops | Take a turtle.<br>Take a tire.<br>Take a teddy bear. | Tito toca el tete.<br>Tito toca la tortuga.<br>Tito toca la tapa. | Tito touches the pacifier.<br>Tito touches the turtle.<br>Tito touches the top/cover. |
| Orals, Velar Stops | Go get a cookie.<br>Go get a car.<br>Go get a cake. | Katy quiere la cuchara.<br>Katy quiere el coco.<br>Katy quiere la chaqueta. | Katy wants the spoon.<br>Katy wants the coconut.<br>Katy wants the jacket. |
| Orals, Alveolar Fricative | Suzy sees the scissors.<br>Suzy sees the horse.<br>Suzy sees the dress. | Susy se zafa su saya.<br>Susy se zafa su zapato.<br>Susy se zafa su suéter. | Susy unties her skirt.<br>Susy unties her shoe.<br>Susy loosens her sweater. |
| Nasals | Mama made some mittens.<br>Mama made some muffins.<br>Mama made some lemonade. | Mi mamá me mece.<br>Mi mamá me moja.<br>Mi mamá me mira. | My mom rocks me.<br>My mom wets/bathes me.<br>My mom looks at me. |

| | | | |
|---|---|---|---|
| Four Nasals Only and loaded with stops | Bobby and Billy Play Ball: Bobby and Billy go to play ball. They get a bat, a ball, and a glove. They go to the ball park. Billy took a turn at bat. Bobby tried to throw the ball. Billy hit the ball up high. Bobby and Billy like to play ball. | Sofía Sofía es chiquita y bonita. Ella se viste de rojo y azúl todos los días para ir al colegio. Allí ella lee sus libros y estudia mucho. A Sofía le gusta comer pastel y helado de chocolate. Ella baila y canta después de la escuela. Ella siempre está feliz. | Sofía Sofia is small and cute. She wears red and blue every day to school. There, she reads her books and study a lot. Sofia likes to eat cake and chocolate ice cream. She dances and sings after school. She is always happy. |
| No nasals and loaded with fricatives | A School Day for Suzy: Suzy eats cereal or toast for breakfast. After that, she rides the bus to school. Suzy likes to sit with Sally. At school, the teacher gives Suzy's class a test. Suzy likes her school. She also likes her teacher. | Las Galletas: Rafael quería galletas de dulce, pero su tía le dijo que sólo se las daría después de hacer su tarea. El quería probarlas ya, por eso que se subió a la silla para sacarlas de la gaveta. La silla resbaló y Rafael se cayó. | The Cookies: Rafael wanted cookies, but his aunt told him that she would only give them to him after he did his homework. He wanted to eat them now so he climbed up on a chair to get them out of the cupboard. The chair slipped and Rafael fell down. |

[a] (MacKay & Kummer, 1994) – Simplified Nasometric Assessment Procedures (SNAP)

[b] (Nett & Ochoa, 2004) – Spanish adaptation of SNAP ('Las Galletas' by C. Cruz, SLPA)

**Appendix D**

**Nasometer Stimuli**

Table D2 Hmong Nasometer Passages

| Criteria | Hmong[a] | English Translation |
|---|---|---|
| Orals, Bilabial Stops | Pov lub pob.<br>Pov tsab paj.<br>Pov lub phiab. | Throw a ball.<br>Throw a flower.<br>Throw a bowl/basin. |
| Orals, Alveolar Stops | Thov ib khob dej.<br>Thov ib daim duab.<br>Thov ib lub thawv. | Ask for a cup of water.<br>Ask for a photo.<br>Ask for a box. |
| Orals, Velar Stops | Cov khawb kev.<br>Cov kwv kawm.<br>Cov kab ke. | They dig a road.<br>They carry (Hmong gardening) baskets.<br>They gather (for a meal/party). |
| Orals, Alveolar Fricative | Txiv xaiv xauv.<br>Txiv xa xov.<br>Txiv xaws sev. | Father picks (Hmong silver) necklaces.<br>Father sends mail.<br>Father sews (Hmong) aprons. |
| Nasals | Niam ua hnab looj tes.<br>Niam ua nees ntshai.<br>Niam ua mis nchuav. | Mother makes mittens.<br>Mother makes the horse scared.<br>Mother made the milk spill. |
| Four Nasals Only and loaded with stops | Paiv thiab Phiab: Paiv thiab Phiab pov pob pem teb. Lawv ke tham ke pov ua si. Lawv pov pob ib hnub ib hmo. Ua daim duab ploj kiag mus. Thaum Phiab pov kos Paiv sab tes. Lawv pog cem lawv pov phem phem. Phiab thiaj khiav mus dev tom dej. | Pai and Phia: Pai and Phia toss ball (a traditional ball tossing game). The toss and chat. They toss all day, until their shadows go away. When Phia hits Pai's hand with the ball, their grandmother yells at them for tossing badly. So Phia runs off to play/fool around by the river. |

| | | |
|---|---|---|
| No nasals and loaded with fricatives | Xob xais tes: Zeb ua teb los sab sab. Xob thiaj xais Zeb tej tes xis. Txiv los hov sab thiab, xav txib Xob xais tes xais ceg. Tab sis Xob ob txhais tes tsaug. Lwm zaus Xob cog xais Xob txiv. So lub zog thiaj xais xis siab. | Xao massages hands: Ze returns from the garden tired. So, Xao massages his hands to good health. Father is also tired, so he asks Xao to massage his hands and feet. But, Xao's hands are tired. Next time his will massage his father. Rest a while and then the massage will be better. |

[a] (Xiong, 2008) – Hmong adaptation of SNAP

## Appendix E

## Background Questionnaire for Listeners

Participant's Name:______________________________Participant's Number:_________

Date of Session:_______________ Date of Birth:______________Age:______________

Is English your native language?______ Have you had coursework in another language(s)?____If yes, which language(s):_____________________________________,

At what age did you start learning this language?______ How many courses (in semesters) have you taken in this language in each of these languages?

High School:_____________ College:______________ Other:______________________

Have you ever lived, work, or studied abroad where this language is used?______ If yes, where, and for how long?__________________________________________

Have you ever had formal coursework, or extensive experience using Spanish?___ or Hmong?___If yes for either, explain courses and experience:________________________

____________________________________________________________________________

Do you consider yourself a proficient speaker of either Spanish or Hmong ?___________

Other comments on second language skills:______________________________________

____________________________________________________________________________

____________________________________________________________________________

**<u>Hearing Screening:</u>**

Have you ever had any concerns with your hearing?_____ If yes, please explain:_____________________________________________________________________

____________________________________________________________________________

| | **500 dB** | **1000 dB** | **2000 dB** | **4000 dB** |
|---|---|---|---|---|
| **Right Ear** | | | | |
| **Left Ear** | | | | |

**_____ Pass _____ Fail**

*** Listeners who completed this study at home were asked when they most recently passed a hearing screening. It was not possible to have all listeners come in to be screened as many were from other states around the country.**

**<u>Naïve Listeners</u>:**

Are you a university student ?_____ If yes, where?________________________________

What is your year?:_________Major?:_____________________________________________

Have you taken any classes in the Department of Speech-Language-Hearing Sciences (SLHS)?____ If yes, which one(s)?_______________________________________________

Do you know anyone personally who has a cleft palate?_____ If yes, please explain:__________________________________________________________________________

__________________________________________________________________________

Comments:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

**<u>Generalist SLP Listeners</u>:**

Are you a practicing speech-language pathologist?_______, for approximately how many years?______ Please describe the setting in which you practice and diagnoses seen on your caseload:___________________________________________________________________

__________________________________________________________________________

How many patients have you treated with cleft palate or velopharyngeal dysfunction?_____ Have you taken any continuing education or specific coursework on cleft palate and craniofacial conditions during your professional practice?_____ If yes, describe briefly_____________________________________________________________

__________________________________________________________________________

Do you consider yourself a specialist in this area?_____Or another area?_____ If so, which?_____________________________________________________________________

__________________________________________________________________________

Comments:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

**Specialist SLP Listeners:**

Are you a practicing speech-language pathologist?_______, for approximately how many years?______ Please describe the setting in which you practice and diagnoses seen on your caseload:____________________________________________________________

______________________________________________________________________

Are you currently , or have you recently been affiliated with a Cleft Palate or Craniofacial Team? _____ If yes, please explain your role:___________________________________

______________________________________________________________________

Have you taken any continuing education or specific coursework on cleft palate and craniofacial conditions during your professional practice?_____ If yes, describe briefly_________________________________________________________________

______________________________________________________________________

Do you consider yourself a specialist in this area?_____Or another area?_____ If so, which?_________________________________________________________________

Have you ever completed speech assessments abroad on individuals with cleft palate who speak a language other than English?______ If yes, please complete the following chart:

| | Language | Length of Visit | Duties on Trip |
|---|---|---|---|
| Country 1: | | | |
| Country 2: | | | |
| Country 3: | | | |
| Country 4: | | | |

Additional trips and comments:_______________________________________________

______________________________________________________________________

______________________________________________________________________

## Appendix F

## Listener Instructions

During this study you will be listening to a variety of speech samples from individuals who speak English, Spanish, or Hmong. Some of the speakers have a cleft palate or another condition in which their palate does not function appropriately for normal speech, leading to velopharyngeal dysfunction, or VPD. Some of the speakers have normal/typical speech skills. The number of speakers of each language is not equal and there are not an equal number of individuals with normal speech and with VPD in the entire experiment. You will be asked to make ratings about each individual's communication in the following areas:

**Hypernasality**: Hypernasality is excessive nasality perceived on vowels and possibly voiced consonants. Individuals who are hypernasal may sound like they have too much 'nasal' sound when they talk.

**Hyponasality**: Hyponasality is insufficient nasality perceived on nasal sounds and vowels. Individuals who are hyponasal sound like they have nasal congestion, or like they are 'stuffed-up'.

**Audible Nasal Emission (ANE)**: Audible nasal air emission and/or nasal turbulence, occurs when air escapes through the nose. It may sound like a rush of air or a 'snorting' or turbulent sound.

**Misarticulations:** Misarticulations are errors in the pronunciation of consonant sounds of a language, in place (in the mouth), manner (type of sound) or voicing (voiced or voiceless). For individuals with VPD, misarticulations may include sounds that are produced in the throat. Other misarticulations can also happen in individuals with dental problems and include patterns such as 'lisping'.

**Voice Quality**: Voice quality is affected by disorders at the level of the larynx, (voice box/vocal cords) leading to a deviation in voice production. Descriptors for the voice quality may include hoarse, harsh, breathy, etc.

**Speech Acceptability**: Speech acceptability reflects how close speech is to that of typical or normal speakers or how natural it sounds.

**Please let me know if you have questions about these definitions. Please keep these definitions on the table to review as needed.**

When listening to the speech samples for this study you will be making some ratings by answering yes/no questions and others by making a mark along a line. Please make a vertical slash through the point on line that best reflects your rating. You can make your mark at any point along the line. ***Examples:***

For a sample with severe hypernasality I may make the following mark on the rating line:

Normal nasality  Extreme hypernasality

But for a sample with very mild hypernasality (which sounds closer to normal) I may make the following mark:

Normal nasality Extreme hypernasality

During this study you will hear all the speakers of a particular language (English, Hmong, or Spanish) in separate groups. Before you start making ratings for that group you will hear a sample from a speaker of that particular language who does NOT have a cleft palate or any condition that affects the function of the palate for speech. This sample will be played once at the beginning of the block and once in the middle of the block of samples for that language. Experimental samples can only be heard once and ratings should be made at the indicated times.

You are welcome to take a break when needed, but it is strongly suggested that if you need a break you take it in between language blocks and not in the middle of one.

Before you start your first language block, you will hear an example from a typical English-speaker. Please complete the listener form for this individual so you become familiar with the process. Please turn to your first form; it should say Speaker #E25 in the top right hand corner. Please follow the instructions provided on your CD and let me know if you have any questions.

** You will complete the 4 CDs in the following order: 1) Intro, 2)_____ 3)_____ 4)_____
(English, Spanish, and Hmong were written in lines #2, 3, 4 based on the order of randomization for the listener.)

Thank you for your participation,

Kelly

## Appendix G

***Listener Ratings Form:*** *Page 1 of 2* – Please complete *following* **Words, Sentences,** and **Frog Story**: ***Spkr #_____*** ***Lstnr#____***

1. **Hypernasality**: Does this speaker sound hypernasal? Please check one: ____Yes ____No

In relation to the sample you just heard, how would you rate the severity of hypernasality or nasal-sounding speech from normal to extreme? Please make a vertical mark.

Normal nasality ______________________________ Extreme hypernasality

2. **Hyponasality**: Does this speaker sound hyponasal? Please check one: ____Yes ____No

3. **Audible nasal emission (ANE)**: Did the speaker you just heard have nasal emission?

Please check one: ____Yes ____No

In relation to the sample you just heard, how would you rate the severity of audible nasal emission? Please make a vertical mark.

No nasal emission ______________________________ Extreme amount of nasal emission

4. **Misarticulations**: Does the speaker have **misarticulations** that are characteristic of an individual with a *cleft palate or VPD*?

Please check one: ____Yes ____No

Do you think this speaker has **misarticulations** (such as lisping) that may be related to dental concerns?

Please check one: ____Yes ____No

In relation to the sample you just heard, how would you rate number of misarticulations? Please make a vertical mark.

Normal articulation ______________________________ Extreme number of misarticulations

***Listener Ratings Form:*** *Page 2 of 2* – Please complete *following* **Monologue**: ***Spkr #_____*** ***Lstnr#____***

5. **Voice quality**: Do you think that this speaker has deviant voice quality?

Please check one: ____Yes ____No

In relation to the sample you just heard, how would you rate voice quality? Please make a vertical mark.

Normal voice quality ________________________________ Extremely deviant voice quality

6. **Speech Acceptability**: Do you think this speaker has acceptable or natural sounding speech?

Please check one: ____Yes ____No

In relation to the sample you just heard, how would you rate speech acceptability? Please make a vertical mark.

Speech is normal/acceptable ________________________________ Speech is extremely deviant from normal

7. After completion of the judgments requested for this speaker, do you think that this speaker has a cleft palate or other type of VPD?

Please check one: ____Yes ____No

To demonstrate the certainty of your answer, please make a vertical mark on the line below:

Absolutely NO cleft or VPD ________________________________ Speaker definitely has a cleft palate or VPD

8. How confident are you about in your ratings for this speaker?

Not at all confident ________________________________ Very confident

9. How easy was it to make these judgments for this speaker?

Very easy ________________________________ Very difficult

10. Comments:________________________________________________________________