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Articulatory Patterns in Children who use Cochlear Implants: An Ultrasound Measure of Velar Stop Production in Bilingual Speakers

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Articulatory Patterns in Children who use Cochlear Implants: An Ultrasound Measure of Velar Stop Production in Bilingual Speakers

by

Katherine Javier

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science
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Abstract

Coarticulation occurs in running speech when one speech sound or phoneme overlaps with another. It can be considered a result of the way we sequence and organize our articulators to efficiently produce consecutive consonants and vowels in fluent speech. Previous research has suggested that measures of coarticulation can provide insight into the maturity of the motor speech planning system (Barbier, Perrier, Ménard, Payan, Tiede, & Perkell, 2013; Zharkova & Hewlett, 2009; Zharkova, Hewlett, & Hardcastle, 2011). Speech stability has also been suggested as an indicator of motor speech maturity in previous research using ultrasound imaging of velar-vowel targets (Frisch, Maxfield, & Belmont, 2016). This study extends research by Frisch, Maxfield, & Belmont (2016) to investigate patterns of velar-vowel coarticulation and speech stability in bilingual children who wear cochlear implants.

Ultrasound and acoustic data were recorded from one English-Spanish bilingual participant (P1) who wears bilateral cochlear implants, one English-Spanish bilingual control child (P2) with no hearing impairment, and one English-Spanish bilingual adult speaker. Measures of velar-vowel coarticulation and speech stability across three productions of English and Spanish words were recorded and analyzed following procedures of Wodzinski and Frisch (2006). The participants were asked to produce three repetitions of fifteen English and fifteen Spanish target words starting with a /k/+ vowel sequence. Ultrasound imaging was used to record and trace tongue movement at the point of maximum velar closure. Data was compared between English and Spanish words, across participants, and between repetitions of the same word.
In comparing English and Spanish words, child participants (P1 and P2) demonstrated increased coarticulation during Spanish productions. All participants showed decreased stability in Spanish productions when compared to English. Adult participant (P3) showed greater overall stability in productions and consistent coarticulation across both languages. Measures of coarticulation and overall stability were relatively equal across P1 and P2, while P3 showed greater and more stable coarticulation across both languages. Preliminary results support findings in previous research suggesting that anticipatory coarticulation and speech stability could be used as an index for assessing speech motor planning in bilingual and clinical populations (Barbier, Perrier, Ménard, Payan, Tiede, & Perkell, 2013; Frisch, Allen, Betancourt, & Maxfield, 2016; Frisch, Maxfield, & Belmont, 2016; Frisch & Wodzinski, 2014; Zharkova & Hewlett, 2009; Zharkova, Hewlett, & Hardcastle, 2011). Results additionally indicate that a young cochlear implant user who receives early intervention and is learning two languages can develop commensurate motor speech planning systems to that of a typical bilingual peer and that patterns of coarticulation and stability may be different in English and Spanish contexts.
Chapter One:
Introduction

Coarticulation and Speech Stability Measures

Co-articulation is described as the process by which consecutive sounds are produced with overlapping movements caused by anticipating and planning the succeeding sounds (Gick, Wilson, & Derrick, 2013). For example, when saying the word “suit” a speaker will round their lips during the production of /s/ in anticipation of the following /u/ phoneme. Previous research has suggested that measures of coarticulation can provide insight into the maturity of the motor speech planning system (Barbier, Perrier, Ménard, Payan, Tiede, & Perkell, 2013; Zharkova & Hewlett, 2009; Zharkova, Hewlett, & Hardcastle, 2011). Speech stability has also been suggested as an indicator of motor speech maturity in recent studies using ultrasound imaging of velar-vowel targets (Frisch, Maxfield, & Belmont, 2016; Frisch & Wodzinski, 2014). Specifically, it is suggested that there are two distinct closure locations (i.e., more front or more back) moving towards a virtual target point beyond the vocal tract depending on the upcoming vowel (Frisch et al., 2014).

The present study sought to extend previous research by Frisch, Maxfield, and Belmont (2016), which examined the degree of coarticulation as a measure of advanced speech planning processes, and speech stability as a measure of advanced motor execution of the articulators when producing planned sequences. Frisch and colleagues (2016) suggested that greater anticipatory coarticulation in the production of /k/ + velar vowel sequences are indicative of higher-level planning, meaning that more movement of the velar closure towards the anticipated
vowel (i.e., more front or more back) reflects more advanced sequence planning. Findings additionally suggested that stability of the articulators over multiple repetitions could be indicative of more consistent articulatory strategies or more accurate motor execution. It has been suggested in literature examining theories of motor planning that mature articulatory motions should be consistent and stable; however, more research is needed to create models that consider characteristics that might account for variations between languages and within and across different speaker groups (Gick et al., 2013).

Previous studies measuring coarticulation and speech stability in typical children and adults have begun to contribute to our understanding of how these measures can change over the course of speech and language development (Barbier et al., 2013; Zharkova & Hewlett, 2009; Zharkova et al., 2011). Barbier and colleagues (2013) concluded that with maturity of the speech motor systems comes greater stability and improved ability to anticipate and plan out sound sequences. Zharkova, Hewlett, and Hardcastle (2011) presented similar findings and additionally suggested that the reduced coarticulation and stability in children may be due to their rapid physiological development, leading to necessary articulatory adjustments in the speech motor systems. In clinical populations, physiological development may be reduced or delayed, potentially resulting in impairments of the speech motor planning system.

Few studies have examined coarticulation and speech stability in clinical populations (Frisch, Maxfield, & Belmont, 2016; Nijland et al., 2009, Ertmer & Goffman, 2011; Hardcastle & Tjaden, 2008). One study compared young adults who stutter to peers who do not stutter and found that patterns of coarticulation were consistent across participants, but that a subset of participants showed decreased stability in velar-vowel productions (Frisch et al., 2016). Another study by Ertmer and Goffman (2011) compared speech accuracy and variability in children who
wear cochlear implants and their normal hearing peers. Results of this study showed lower accuracy and greater variability in speech productions for children who wear cochlear implants, supporting the findings of Barbier et al., (2013) and Zharkova et al, (2011). Ertmer and Goffman (2011) indicate that differences in accuracy and variability are likely due to older and typically developing peers having been exposed to hearing and speech for a greater amount of time, but that the inconsistencies in speech production may rapidly decrease with continued CI experience. Studies that examined coarticulation in persons who are deaf and hard of hearing have generally concluded that hearing may play a significant role in regulating anticipatory coarticulation in adults and children (Rothman, 1976, 1977; Monsen, 1983; Waldstein & Baum, 1991). Together these findings raise questions about whether the use of cochlear implants would improve speech planning processes in children with hearing loss.

**Speech and Language Development of Cochlear Implant Users**

A growing number of researchers are investigating speech and language development in children who wear cochlear implants. Studies measuring consonant inventories of children with cochlear implants (Iyer, Jung, & Ertmer, 2017), grammatical abilities of cochlear implant (CI) recipients (Jung & Jongmin, 2018), and vocabulary and consonant accuracy of CI users (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006) suggest that children who wear cochlear implants can develop speech and language skills that are comparable to typically developing peers. Iyer, Jung, and Ertmer (2017) found that the children in their study who used cochlear implants showed larger, more diverse consonant inventories and faster consonant acquisition than their typically developing peers. Jung and Jongmin (2018) found that CI recipients achieved comparable results to normal hearing peers across four measures of grammatical ability. Another study examining phonological acquisition in Spanish-speaking CI users suggests that children
who use cochlear implants have difficulty learning auditory targets and that they show variability in long-term outcomes, which could be due to auditory motor integration deficits (Moreno-Torres & Moreno-Lopez, 2014). Studies investigating speech and language outcomes in CI populations suggest that this variability in long-term measures could be due to differences in environmental factors such as age of identification of hearing loss, age at cochlear implantation and intervention, and further indicate that that early identification and early interventions lead to positive outcomes in children who wear cochlear implants (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006; Moeller, 2009).

With the continuing development of new hearing technologies, and increased use of cochlear implants, it is important for Speech-Language Pathologists working with the hearing-impaired population to have current, reliable data regarding the speech development of these children in order to provide them with appropriate and effective speech and language services. Developing the understanding of how the articulatory patterns of children who wear cochlear implants can be affected by their hearing loss could lead to the development of a diagnostic tool that identifies these differences and provides implications for treatment.

**Bilingual Cochlear Implant Users**

Bilingual children also are part of an increasing number of candidates receiving cochlear implants and needing Speech-Language Pathology services (Mehra, Eavey, & Keamy, 2009). Bilingual children with cochlear implants have a unique set of characteristics that require consideration when assessing speech and language function. Previous research by Bunta, Goodin-Mayeda, Proctor, and Hernandez (2016) and Moeller (2009) suggests that bilingual and monolingual CI users can develop speech production patterns that are commensurate to normal hearing peers, with factors such as early identification of hearing loss, early activation and early
intervention leading to positive outcomes. However, these speech production patterns have been shown to be language specific, and there is limited evidence showing how speech patterns of bilingual children differ from those seen in monolingual children (Bunta et al., 2016; Moeller, 2000). A growing body of evidence suggests that there is an interaction of phonological information between the two languages of Spanish-English bilingual children, making their speech and language systems potentially different from their monolingual peers (Fabiano-Smith & Goldstein, 2010; Paradis & Genesee, 1996). To explain these differences, Fabiano-Smith and Goldstein (2010) examined phonological acquisition and dual language interaction of bilingual Spanish-English speaking children by measuring consonant inventories and consonant accuracy in single word samples and found evidence of transfer in bilingual children and differences in consonant accuracy between bilingual and monolingual children. Evidence of transfer and differences in accuracy were based on analysis of phonetically transcribed single word samples. Further objective measures of articulatory placement during speech targets may be useful in explaining how this transfer happens and what these differences look like.

A preliminary study of velar-vowel coarticulation patterns in Spanish-English bilingual adult speakers utilized ultrasound imaging to analyze tongue positions during velar productions (Frisch, Allen, Betancourt, & Maxfield, 2016). Frisch and colleagues (2016) found differences in tongue positions between English and Spanish productions and suggested that bilingual speakers may change their coarticulation pattern for each language context. The use of ultrasound imaging to investigate speech patterns of bilingual populations could give further insight into the effects of language interactions and could prove to be a useful diagnostic tool for bilingual children, who are frequently over-identified as having a speech deficit or delay (Kohnert, 2010).
Ultrasound Measures

Measures of Ultrasound imaging have been used to observe and record tongue movements during speech because it allows the observer to see speech patterns and movements that could not otherwise be seen just looking at a person’s face. Zharkova, Gibbon, and Lee (2017) suggest that tongue ultrasound imaging can be effective at detecting small changes or differences in articulatory positions and movements. This could make ultrasound imaging a reliable instrument for measuring coarticulation and speech stability, as evidenced by its use in several studies examining these speech planning patterns (Frisch et al., 2016; Frisch, et al., 2014; Frisch & Wodzinski, 2006; Zharkova, Gibbon, & Lee, 2017; Zharkova, Hewlett & Hardcastle, 2011). Differences in patterns of coarticulation could indicate the need for developing phonologically-based approach to treatment, while similarities in coarticulation patterns could imply the need for emphasis on articulatory practice (Frisch et al., 2016). For example, a Spanish-English bilingual child demonstrating typical coarticulation in Spanish productions and reduced or lack of coarticulation in English productions may benefit from direct instruction in sound combinations in contexts unique to English. Conversely, if that same child demonstrates reduced coarticulation in both languages, they may benefit from targeting and practicing speech sounds that affect their intelligibility.

Purpose

The primary objective of this study was to measure anticipatory coarticulation and speech stability in children with cochlear implants and examine how these speech planning processes may be influenced by Spanish-English bilingual language acquisition. The following questions were addressed in this study:
**Question 1:** Can measures of coarticulation and stability be used to quantify maturity of the speech planning process?

**Hypothesis 1:** Results of this study will be consistent with previous research findings showing greater coarticulation and stability in a typical adult speaker when compared to children.

**Question 2:** Can a child who wears cochlear implants demonstrate similar coarticulation and stability to that of a typical child with no hearing loss?

**Hypothesis 2:** A child who wears cochlear implants can demonstrate coarticulation and stability results that are similar to a typical child with no hearing loss.

**Question 3:** Does coarticulation and stability differ between English and Spanish productions of velar/vowel sequences in bilingual speakers?

**Hypothesis 3:** Results of this study will be consistent with previous research findings, showing differences in measures of coarticulation and stability in bilingual speakers between English and Spanish productions of velar/vowel sequences.
Chapter Two:

Methods

Participants

The study was advertised via flyers in the Communication Sciences and Disorders building at the University of South Florida Tampa campus after IRB approval was received (see Appendix A). The first participant in this study (P1) was a 4-year 6-month old English-Spanish bilingual female with profound sensorineural hearing loss and a unilateral N6 cochlear implant. Her hearing loss was identified at 1 month and her age of cochlear implant activation was 14 months. She was clinically diagnosed with an expressive language delay resulting from her hearing loss. Results obtained from a receptive vocabulary assessment (ROWPVT-4; Martin, 2013) to P1, revealed a standard score that was more than one standard deviation above the mean score for similar age, normal hearing peers, indicating above average receptive vocabulary skills. Participant 1 started speaking English words at 18 months. P1 spoke English primarily with 90-100% of the day spent speaking English in the home and at school and 0-10% of the day spent using Spanish. It was reported that P1 is exposed to Spanish in the home and speaks a few Spanish words with her grandmother.

The second participant in this study (P2) was a 4-year 7-month old English-Spanish bilingual female with no hearing loss and typical language development. Participant 2 started speaking both English and Spanish words at 12 months. P2 spoke English primarily, with 90% of the day spent speaking English at school, in the home, and with friends and family, and 0-10% of the day spent speaking Spanish during short lessons at school and in the home with her mother,
father, and grandparents. The third participant (P3) was an English-Spanish bilingual adult female with no hearing loss and typical language development. Participant 3 started speaking Spanish words at 12 months and English words at 3 years. P3 spoke English primarily, with 90% of the day speaking English and 0-10% of the day spent speaking Spanish in the workplace and with family.

**Stimuli**

Fifteen English and fifteen Spanish bi-syllabic words were utilized in the present study. The words in both languages began with the voiced velar /k/ (as in Spanish *capa*), followed by a vowel, a labial plosive (i.e., /p/ or /b/), labiodental fricative (i.e. /f/ or /v/) or nasal (i.e. /m/) and a final vowel. Some of the English words also ended in a final consonant. The stimuli were recorded with a microphone using *Praat* speech analysis software. A female English-Spanish bilingual adult speaker was recorded repeating each word three times without rising or falling intonation. The recordings were then analyzed via *Praat* software, where a visual representation of each word is shown in a wave form and spectrogram using the “View & Edit” selection. The second repetition of each word was selected by dragging the cursor over the waveform, including approximately 500 milliseconds at the beginning and end of the word. The selected section was then extracted using the “Extract selected sound (time from zero)” file option. This added the recording to the Praat objects list, where it could then be renamed and saved as a .WAV file and loaded into the Articulate Assistant Advanced, 2.0 software (Articulate Instruments, 2012). The full list of words is presented in Appendix B.

**Procedure**

Parents of participants were asked to give consent (see Appendix C) to participate and complete a questionnaire (see Appendix E) containing basic demographic information (i.e. date
of birth, gender, nationality or country of origin), information about the child's language
development (i.e. babbling stage, monolingual vs. bilingual), and language use (i.e. languages
spoken in the home, age of language acquisition, and daily use of each language). Parents were
also asked to give consent to obtain hearing information including age of hearing loss
identification, age of cochlear implant activation, age at hearing access from other listening
devices, and medical or clinical diagnosis. Child participants were asked to give assent (see
Appendix D) to participate in the study and were given a small toy and book as compensation
upon completion of the study task. A listening check was conducted with child participant (P1)
who wears cochlear implants.

The stimulus words (see appendix B) were presented one at a time auditorily via speakers
and visually on a computer monitor, using Articulate Assistant Advanced, 2.0 software
(Articulate Instruments, 2012). The participant was seated in a chair in front of a monitor
approximately 20 inches from the speakers. The ultrasound used was an Aloka SSD1000 model
with a 90-degree convex with 10 cm depth, which was held under the chin of the participant by
trained study staff to generate the midsagittal ultrasound image. A microphone was positioned
approximately 12 inches from the participant to record acoustic data. Articulate Assistant
Advanced used the Sync Bright Up module to insert a synchronization marker in the audio and
video. Figure 1 shows the Aloka SSD1000 ultrasound machine with the placement of its probe
under the chin.

Three practice prompts were provided in English and Spanish to familiarize participants
with the word repetition procedure. Participants were asked to repeat each word three times
following one audio presentation of the word. A break in recording was taken between the
English and Spanish blocks. The order of presentation was counterbalanced across participants using two combinations of the stimuli, one starting with Spanish and one starting in English.

![Figure 1](image)

**Figure 1.** Aloka SSD1000 ultrasound machine and view of probe placement. (a) Aloka SSD1000 ultrasound machine; (b) lateral view of probe placement under chin; (c) anterior view of probe placement under chin.

**Analysis**

**Coarticulation**

The ultrasound images of the tongue’s posture during production of the /k/ onset in each repetition were analyzed using Articulate Assistant Advanced. The researcher reviewed the recorded video ultrasound frames and identified the points of maximum velar closure, following the procedures of Wodzinski and Frisch (2006) to select the video frame containing a maximally raised tongue dorsum in contact with the palate. The identified frame was then used to create a spline following the contour of the upper surface of the tongue. Articulate Assistant Advanced generates a spline through a fixed fan of 42 measurement angles from the virtual probe center. The point of velar closure in each word was selected by identifying the position of peak...
displacement at the target word onset working backwards from the release of the /k/ onset. The
tongue at this position was manually traced and labeled with a phonetic transcription of the first
two phonemes (e.g. /ka/ for capa). The Articulate Assistant Advanced snap-to fit feature was
used to optimize the trace of the tongue’s surface. Each spline was manually trimmed to the
extent of the visible midsagittal tongue within the shadows created by the sublingual cavity and
the hyoid bone. The traces were then exported as a series of x,y coordinates for each production.
Figure 2 shows ultrasound tongue trace images of a typical bilingual adult speaker during the
position of highest velar displacement in the following velar consonant + vowel sequences:
Spanish: /ku/ (cupo), /ka/ (cabo), /ke/ (quema), /ko/ (coma), /ki/ (quimo), English: /kʌ/ (covey),
/kæ/ (comet), 8. /kæ/ (cabbie), /ko/ (coma).
Figure 2. Ultrasound tongue trace images of a typical bilingual adult speaker.
Speech Stability

An R script was used to compute the mean minimum point-to-point distance, which is considered a holistic measure of similarity between tongue contours (Zharkova & Hewlett 2009). Distance between successive splines within the same trial were measured. For example, for the three repetitions of capa, repetition 1 was compared to repetition 2, and repetition 2 was compared to repetition 3. Successive repetitions were analyzed to minimize the potential effect of probe movement on the tongue splines. The measure of speech stability for each stimulus word was the average of the mean minimum point-to-point distances for the trial containing that word. Speech stability measures were compared between participants, between languages within a participant, and between words within each language within a participant.
Chapter Three:

Results

Coarticulation

In comparing English and Spanish words, child participants P1 and P2 demonstrated increased coarticulation when producing Spanish words. Measures of coarticulation were relatively equal across P1 and P2, while P3 showed greater coarticulation across both languages. Average Tongue contours at the point of maximum velar closure by vowel context are shown for each participant in Figure 3. Each color represents a different vowel context (i.e. Red: English front vowels /æ/; Blue: English mid/back vowels /ʌ, ə, ɑ, o/; Green: Spanish mid/back vowels /u, ɑ, o/; Orange: Spanish front /i, e/), with the direction of the tongue tip facing right and tongue dorsum facing left. Around each collection of tongue contours is a boundary illustrating the space within the oral cavity with vowel markers representing where the tongue body is typically positioned during that the production of that vowel. Vowels are separated based on height and displacement of the tongue dorsum. Movement of the velar closure towards the anticipated vowel (i.e. front/back) indicates anticipatory coarticulation.
Figure 3. Average Tongue contours at the point of maximum velar closure: (top to bottom) P1 child CI user, P2 control child, and P3 control adult.
Speech Stability

In a comparison of English and Spanish words, participants showed decreased stability in Spanish productions (see Figure 4) as evidenced by greater average curve-to-curve distances between productions of the same velar-vowel target (difference for P1 = 0.31 mm; P2 = 0.23, P3 = 0.40). Adult participant P3 showed greater overall stability when compared to child participants P1 and P2, while the difference in overall stability for P1 and P2 were relatively minimal 0.01 mm across all productions, both English and Spanish.

Figure 4. Average curve-to-curve distances (mm); (P1) child CI user; (P2) control child; (P3) control adult
Chapter Four:

Discussion

The current study was a pilot analysis of anticipatory velar-vowel coarticulation and speech stability in bilingual children who wear cochlear implants. Three questions were addressed in this study:

**Question 1:** Can measures of coarticulation and stability be used to quantify maturity of the speech planning process?

**Question 2:** Can a child who wears cochlear implants demonstrate similar coarticulation and stability to that of a typical child with no hearing loss?

**Question 3:** Does coarticulation and stability differ between English and Spanish productions of velar/vowel sequences in bilingual speakers?

There is limited research that investigates speech motor planning and stability in bilingual and clinical populations. The present study seeks to extend previous research by Frisch and colleagues (2016) which examined the degree of coarticulation as a measure of advanced speech planning processes, and speech stability as a measure of advanced motor execution of the articulators using ultrasound imaging. Ultrasound images of the tongue’s posture during /k/ velar + vowel targets were analyzed using Articulate Assistant Advanced. Tongue contours were traced and examined for degree of coarticulation. It was hypothesized that greater coarticulation and stability would be found in a typical adult speaker when compared to the child participants. This hypothesis was supported by the results of this study, which showed greater overall stability.
productions and consistent coarticulation across both languages for the adult participant P3. These results contribute to findings in previous research suggesting that typical adult speakers coarticulate more and demonstrate more stable speech productions when compared to children. Therefore, with additional research and data, coarticulation and stability measures for typical adult speakers could serve as a standard of speech planning proficiency, which can then be used to assess speech planning abilities in children relative to the adult model and provide measurable data indicating level of proficiency.

Hearing may play a significant role in regulating anticipatory coarticulation in adults and children (Rothman, 1976, 1977; Monsen, 1983; Waldstein & Baum, 1991), but with the hearing restoration provided by cochlear implants, children with hearing loss could potentially show coarticulation patterns that are commensurate to normal hearing peers. The current study sought to examine this idea by measuring the degree and stability of anticipatory velar-vowel coarticulation over multiple repetitions in a four-year-old bilingual child who wears cochlear implants and comparing measures to that of a same-age peer with no hearing loss. It was hypothesized that this child (P1) could demonstrate coarticulation and stability results that were similar to her age-matched normal hearing peer (P2). Results showing relatively equal coarticulation and overall stability for P1 and P2 supported this hypothesis. These findings indicate that cochlear implants can provide children with speech sound access that is comparable to normal hearing peers, which then could lead to comparable speech production.

When considering the language development of children receiving cochlear implants, concerns that learning a second language may interfere with mastery of a primary language have persisted among families and professionals who provide care for this populations (Waltzman, Robbins, Green, & Cohen, 2003). Research examining dual language learning in children who
wear cochlear implants has suggested that competency in both languages can be attained by these children (Bunta & Douglas, 2013; Waltzman et al. 2003). Additional research addressing this issue could help inform decisions to promote bilingual language acquisition in young cochlear implant recipients.

Based on the finding of preliminary study of velar coarticulation and virtual targets in Spanish-English bilingual adult speakers (Frisch et al., 2016), it was hypothesized that measures of coarticulation and stability the bilingual speakers would differ between English and Spanish productions of velar/vowel sequences. Results showed evidence of increased coarticulation during repetitions of Spanish words for child participants P1 and P2. These findings create questions when considering coarticulation as an index for speech motor planning maturity because both children in this study were reported to be more proficient in the English language, and would therefore be expected to show increased coarticulation in English productions.

A study of the effects of familiarity and practiced productions on coarticulation during repetition fricative targets in nonsense words in children and adults offers a possible explanation for this (Siren & Wilcox, 1995). The study found their child participants, ages 5, 7, and 9, exhibited greater coarticulation than their adult participants. Results showed that when a word had no lexical meaning to the child, it produced a greater coarticulation effect on the preceding fricative. It was also found that vowels had a greater coarticulation effect on the preceding fricatives in repetitions of nonsense words. The coarticulation effects examined in this study could explain the increased coarticulation in Spanish productions of P1 and P2 because of the children’s limited Spanish proficiency, and therefore limited familiarity with the words. This limited familiarity could have the same effect as a nonsense word on coarticulation measures. It could also be posited that the increased coarticulation in Spanish is a result of transfer or
interaction of English to Spanish productions, as each participant reported greater proficiency in English. A speaker with more balanced proficiency may not show any differences in stability and coarticulation.

Overall, the findings of this study begin to show how clinical measures of coarticulation and stability may be an effective way of distinguishing between a language difference or disorder by providing information about typical patterns of speech productions in bilingual populations. These measures can additionally be useful in assessing progress of speech development and typical patterns of speech production in cochlear implant users which could be helpful in developing appropriate treatment plans that target the development of the speech motor planning system.

Limitations

Several limitations were found in this study due to the preliminary nature of the investigation. Firstly, the sample size does not adequately represent the target populations, making it difficult to draw any significant conclusions from the presented data. In addition, previous literature examining coarticulation and speech stability in bilingual cochlear implant populations does not currently exist, making it impossible to make comparisons between studies. And while not directly examined in this study due to limited sample size, factors affecting children who wear cochlear implants (i.e. pre vs. post lingual deafness, age of identification and activation, degree of hearing loss, concomitant disorders or delays) are difficult to control for, making it difficult to make comparisons within and across groups.

Future Directions
Future studies would benefit from collecting data from a larger sample size of CI users and controls to investigate the generalization of the current findings, as well as account for factors such as age of identification of hearing loss, age of activation, and age and frequency of speech and language intervention as early identification and early interventions have been shown to lead to positive outcomes in speech and language development (Connor, Craig, Raudenbush, Heavner, & Zwolan, 2006; Moeller, 2009). Collection of longitudinal data could also be beneficial in assessing different stages of speech planning maturity over the course of development. Additionally, it may be interesting to make comparisons between children or adults with varying levels of English and Spanish proficiency. The use of nonsense words as the targets for productions could be used, as nonsense words are thought to be a useful tool in assessing bilingual populations (Brea-Spahn, 2009; Dos Santos & Ferre, 2016, Gathercole & Baddeley, 1990) because they eliminate the effect of lexical knowledge of a word on the repetition and would, therefore, not be affected by language proficiency in the context of this study. Nonsense words have also been shown to have clinical utility in assessing cochlear implant users (Moreno-Torres & Moreno-Lopez, 2014; Nittrouer et al., 2014; Rodvik, et al., 2018). Finally, similar procedures could be applied to study additional clinical populations who struggle with speech production such as Childhood Apraxia of speech, Cleft palate, or Down Syndrome, to name a few.

Conclusion

In comparing English and Spanish words, child participants showed increased coarticulation during Spanish productions. All participants showed decreased stability in Spanish productions when compared to English. The adult participant showed greater overall stability
productions and consistent coarticulation across both languages. Measures of coarticulation and overall stability were relatively equal across the two children while the adult participant showed greater and more stable coarticulation across both languages.

Results of this study support previous research suggesting that a young bilingual cochlear implant user who receives early intervention can develop commensurate motor speech planning systems to that of a typical bilingual peer and that bilingual language acquisition in young cochlear implant recipients does not impair speech acquisition. Results additionally support literature proposing coarticulation and stability can be used as clinical measures of speech motor planning maturity. Clinical measures of coarticulation and stability may prove to be an effective way to assess progress of speech development and typical patterns of speech production in bilingual populations and cochlear implant users which could be helpful in developing appropriate treatment plans that target the development of the speech motor planning system.
References Cited

Edinburgh, UK: Articulate Instruments Ltd.


Connor, C. M., Craig, H. K., Raudenbush, S. W., Heavner, K., & Zwolan, T. A. (2006). The age at which young deaf children receive cochlear implants and their vocabulary and speech-


Appendix A: IRB Approval

11/29/2017

Katherine Javier
Communication Sciences and Disorders
4202 E Fowler Ave.
Tampa, FL 33620

RE: Expedited Approval for Initial Review
IRB#: Pro00032201
Title: Articulatory Patterns in Children who use Cochlear Implants: An Ultrasound Measure of Velar Stop Productions in Bilingual and Monolingual speakers

Study Approval Period: 11/28/2017 to 11/28/2018

Dear K. Javier:

On 11/28/2017, the Institutional Review Board (IRB) reviewed and APPROVED the above application and all documents contained within, including those outlined below.

Approved Item(s):
Protocol Document(s):
   Protocol

Consent/Assent Document(s)*:
   Assent Form_English.pdf
   Assent Form_Spanish.pdf
   Consent form_English.pdf
   Consent form_Spanish.pdf
   ****Script_Monolingual_English
   ****Script_Monolingual_Spanish

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent documents are valid until the consent document is amended and approved. ****Child verbal assents are not stamped forms.

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve
only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for nonresearch purposes (such as medical treatment or diagnosis).

(6) Collection of data from voice, video, digital, or image recordings made for research purposes.

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

This study involving child participants falls under the minimal risk category 45 CFR 46.404; Research not involving greater than minimal risk.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval via an amendment. Additionally, all unanticipated problems must be reported to the USF IRB within five (5) calendar days.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[Signature]

John Schinka, Ph.D., Chairperson
USF Institutional Review Board
Appendix B: List of Stimuli words

<table>
<thead>
<tr>
<th>Spanish Words</th>
<th>English Words</th>
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<tbody>
<tr>
<td>cupo</td>
<td>covet</td>
</tr>
<tr>
<td>cabo</td>
<td>comma</td>
</tr>
<tr>
<td>capa</td>
<td>caffeine</td>
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<tr>
<td>quema</td>
<td>coffin</td>
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<tr>
<td>quemo</td>
<td>coffee</td>
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<tr>
<td>cuba</td>
<td>comet</td>
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<td>coma</td>
<td>cabbie</td>
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<tr>
<td>campo</td>
<td>kabob</td>
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<td>quepa</td>
<td>caboose</td>
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<tr>
<td>cama</td>
<td>copy</td>
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<tr>
<td>quimo</td>
<td>combo</td>
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<tr>
<td>copo</td>
<td>covey</td>
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<tr>
<td>como</td>
<td>cobweb</td>
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<tr>
<td>copa</td>
<td>coma</td>
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<td>cubo</td>
<td>commit</td>
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</tbody>
</table>
Appendix C: Parental Consent Forms (English and Spanish)

Consent to Participate in Research & Parental Permission for my Child to Participate in Research and Authorization to Collect, Use and Share Your Health Information

Pro # _00032201_

The following information is being presented to help you and your child decide whether or not you would like to be a part of a research study. Please read this information carefully. If you have any questions or if you do not understand the information, we encourage you to ask the researcher.

We are asking you to take part, and to allow your child to take part, in a research study called: 
**Articulatory Patterns in Children who use Cochlear Implants: An Ultrasound Measure of Velar Stop Production in Bilingual and Monolingual Speakers**

The person who is in charge of this research study is Katherine Javier. This person is called the Principal Investigator. However, other research staff may be involved and can act on behalf of the person in charge. She is being guided in this research by Dr. Kyna Betancourt, Ph.D., CCC-SLP and Dr. Stefan Frisch, Ph.D.

The research will be conducted at Speech Science Lab in the Communication Sciences and Disorders Department at USF.

**Purpose of the study:**

The purpose of this study is to measure speech patterns in children with cochlear implants and examine how these patterns are influenced by Spanish-English bilingual language acquisition. Other objectives include examining how factors such as vocabulary knowledge, language proficiency and experiences, and age of hearing loss identification and cochlear implant activation relate to and influence these patterns.
**Why are you & your child being asked to take part?**

We are asking your child to take part in this research study because he/she is wears cochlear implants and is either Spanish-English bilingual or English monolingual. We want to find out more about how language influences their speech patterns. With the continuing development of new hearing technologies, and increased use of cochlear implants, it is important for Speech-Language Pathologists working with these populations to have current, reliable data regarding the speech development of these children in order to provide them with appropriate and effective speech and language services. There are a limited number of standardized assessments that reliably assess language and speech production in these populations. This is partially due to the sparsity of information about how this population develops and produces language. More quantitative data is needed to understand the speech processes and patterns of bilingual and monolingual children using cochlear implants.

**Study Procedures:**

If you and your child agree to participate in this study:

- You will be given a short questionnaire to determine your child’s language experience.
- If your child takes part in this study, s/he will be asked to complete one study session lasting about 30-45 minutes. During this session, your child will:
  - Complete a vocabulary assessment (*Receptive One-Word Picture Vocabulary Test-4: Spanish-Bilingual Edition*). The investigator will present a word with a group of four pictures and ask your child to identify which picture matches the word. (20 minutes).
  - Complete a word repetition task. An audio recorded list of words will be played through a speaker. Your child will be asked to repeat each word while the ultrasound probe is held under the chin. (15 minutes)
- An audio recording and a visual recording of the tongue images will be obtained during the repetition task. The recordings will not contain any identifiable information and will be stored on a password protected computer that only the study team members have access to. Recordings will be kept for at least 5 years after the final report is submitted to the IRB.
- After completing the task, your child will be rewarded with a toy and a book.
- The experiment will be conducted in the speech laboratory in the Department of Communication Sciences and Disorders

**Total Number of Participants**

Approximately 40 individuals will take part in this study at USF.

**Alternatives / Voluntary Participation / Withdrawal**

If you decide not to let your child take part in this study and you do not participate, that is okay. Instead of being in this research study you and your child can choose not to participate.

You and your child should only take part in this study if both of you want to. You or your child should not feel that there is any pressure to take part in the study to please the study investigator or the research staff.
If you or your child decide not to take part:

- You and your child will not be in trouble or lose any rights you would normally have.
- Your child will still get the same services he/she would normally have.
- Your child can still get regular treatments from his/her Speech-Language Pathologist.

You can decide after signing this informed consent form that you no longer want your child or yourself to take part in this study. We will keep you informed of any new developments which might affect your willingness to participate or allow your child to continue to participate in the study. However, you and your child can decide to stop taking part in the study for any reason at any time. If you and/or your child decide to stop taking part in the study, tell the study staff as soon as you can.

Benefits

Your child will receive no benefit(s) by participating in this study.

Risks or Discomfort

There are no known risks to those who are exposed to ultrasound imaging. There may be risks involved in using ultrasound gel, and alcohol wipes used to clean the ultrasound probe. Please inform the investigator if your child has any known allergies to these substances.

Compensation

Your child will be compensated with a book and a small toy if he/she completes the scheduled study visit.

Costs

It will not cost you anything to let your child take part in the study.

Privacy and Confidentiality

We will keep your child’s study records private and confidential. Certain people may need to see your child’s study records. Anyone who looks at your child’s records must keep them confidential. These individuals include:

- The research team, including the Principal Investigator and all other research staff.
- Certain government and university people who need to know more about the study, and individuals who provide oversight to ensure that we are doing the study in the right way.
- Any agency of the federal, state, or local government that regulates this research.
- The USF Institutional Review Board (IRB) and related staff who have oversight responsibilities for this study, including staff in USF Research Integrity and Compliance.

We may publish what we learn from this study. If we do, we will not include your child’s name. We will not publish anything that would let people know who your child is.
You can get the answers to your questions, concerns, or complaints.

If you have any questions, concerns or complaints about this study, call Katherine Javier at (561) 574-7094.

If you have questions about your child’s rights, or have complaints, concerns or issues you want to discuss with someone outside the research, call the USF IRB at (813) 974-5638 or contact by email at RSCH-IRB@usf.edu.

Authorization to Use and Disclose Protected Health Information (HIPAA Language)

The federal privacy regulations of the Health Insurance Portability & Accountability Act (HIPAA) protect your child’s identifiable health information. By signing this form, you are permitting the University of South Florida to use your child’s health information for research purposes. You are also allowing us to share your child’s health information with individuals or organizations other than USF who are also involved in the research and listed below.

The following groups of people may also be able to see your child’s health information and may use that information to conduct this research.

- The medical staff that takes care of your child and those who are part of this research study;
- The USF Institutional Review Board (IRB) and its related staff who have oversight responsibilities for this study, including staff in USF Research Integrity and Compliance and the USF Health Office of Clinical Research;
- Data Safety Monitoring Boards or others who monitor the data and safety of the study;

Anyone listed above may use consultants in this research study, and may share your child’s information with them. If you have questions about who they are, you should ask the study team. Individuals who receive your child’s health information for this research study may not be required by the HIPAA Privacy Rule to protect it and may share your child’s information with others without your permission. They can only do so if permitted by law. If your information is shared, it may no longer be protected by the HIPAA Privacy Rule.

By signing this form, you are giving your permission to use and/or share your child’s health information as described in this document. As part of this research, USF may collect, use, and share the following information.

- Age at identification of hearing impairment
- Age at cochlear implant activation
- Age at hearing access from another listening device
- Pure tone thresholds from most recent hearing evaluation
- Clinical Diagnosis
- Your child’s research record
• All of your child’s past, current, or future medical and other health records held by USF, other health care providers, or any other site affiliated with this study as they relate to this research project. This includes, but is not limited to records related to HIV/AIDS, mental health, substance abuse, and/or genetic information.

You can refuse to sign this form. If you do not sign this form your child will not be able to take part in this research study. However, your child’s care outside of this study and benefits will not change. Your authorization to use your child’s health information will not expire unless you revoke (withdraw) it in writing. You can revoke this form at any time by sending a letter clearly stating that you wish to withdraw your authorization to use your child’s health information in the research. If you revoke your permission:

• Your child will no longer be a participant in this research study;
• We will stop collecting new information about your child;
• We will use the information collected prior to the revocation of your authorization. This information may already have been used or shared with others, or we may need it to complete and protect the validity of the research; and
• Staff may need to follow-up with your child if there is a medical reason to do so.

To revoke this form, please write to:
Katherine Javier
For IRB Study # 00028371
4202 E Fowler Ave, PCD 1017, Tampa, FL 33612

While we are conducting the research study, we cannot let you see or copy the research information we have about your child. After the research is completed, you have a right to see the information about your child, as allowed by USF policies. You will receive a signed copy of this form.

Consent to Participate and Parental Permission for My Child to Participate in this Research Study and Authorization to Collect, Use and Share His/Her Health Information for Research

By signing this form:
• I confirm that I am either the parent of the child or a guardian with authority to provide consent on behalf of the child to general medical care.
• I freely give my consent take part and to let my child take part in this study and authorize that his/her health information as agreed above, be collected/disclosed in this study.
• I understand that by signing this form I am agreeing to take part in and to let my child take part in research.
• I have received a copy of this form to take with me.

________________________________________________          __________________
Signature of Person and Parent of Child Taking Part in Study          Date
Statement of Person Obtaining Informed Consent

I have carefully explained to the person taking part in the study what he or she can expect from their participation. I confirm that this research subject speaks the language that was used to explain this research and is receiving an informed consent form in their primary language. This research subject has provided legally effective informed consent.

_________________________  _______________________
Signature of Person Obtaining Informed Consent  Date

_________________________
Printed Name of Person Obtaining Informed Consent
Consentimiento informado para participar en investigación, y permiso para que mi hijo participe en la investigación usar y compartir su información médica

Pro # _00032201_

La siguiente información se presenta para ayudarle a usted ya su hijo a decidir si desea o no participar en un estudio de investigación. Lea esta información cuidadosamente. Si tiene alguna pregunta o si no entiende la información, le recomendamos que consulte al investigador.

Le invitamos a participar de un estudio de investigación llamado:

Formas Articulatorios en Niños que usan Implantes Cocleares: Una Medida de Ultrasonido de Producción en Bilingües y Monolingües

(Articulatory Patterns in Children who use Cochlear Implant: An Ultrasound Measure of Velar Stop Production in Bilingual and Monolingual Speakers) en inglés.

La persona a cargo de este estudio es Katherine Javier. Esta persona se denomina el Investigador Principal. Sin embargo, otro personal del estudio también podrá participar y podrá actuar en nombre de la persona a cargo. Ella es dirigida/a en esta investigación por Dr. Kyna Betancourt, Ph.D., CCC-SLP and Dr. Stefan Frisch, Ph.D.

El estudio se llevará a cabo en el Speech Science Lab en el Departamento de Communication Sciences and Disorders de USF.

Propósito del estudio

El propósito de este estudio es investigar formas de habla en niños con implantes cocleares y examinar cómo estos modelos están influenciados por la adquisición del lenguaje bilingüe hispano-inglés. Otros objetivos incluyen examinar cómo factores como el conocimiento del vocabulario, la competencia experiencia lingüística, y la edad de la identificación de la pérdida auditiva y la activación del implante coclear se relacionan influyen las formas de habla.

¿Por qué se le pide a usted ya su hijo que participen?

Le pedimos a su hijo / a que participe en este estudio de investigación porque usa implantes cocleares y es bilingüe hispano-inglés o monolingüe inglés. Queremos saber más sobre cómo el lenguaje influye sus formas de habla. Con el desarrollo continuo de nuevas tecnologías auditivas
y un mayor uso de implantes cocleares, es importante que los Patólogos del Habla-Lenguaje que trabajan con estas poblaciones tengan datos actuales y confiables sobre el desarrollo del habla de estos niños con el fin de proveerles de manera apropiada y efectiva servicios de habla y lenguaje. Hay un número limitado de evaluaciones estandarizadas que evalúan de manera fiable la producción de lenguaje y habla en estas poblaciones. Esto se debe en parte a la escasez de información sobre cómo esta población se desarrolla y produce el lenguaje. Se necesitan más datos cuantitativos para entender los procesos y patrones de habla de niños bilingües y monolingües que usan implantes cocleares.

**Procedimientos del estudio:**

Si usted participa de este estudio, se le pedirá que:

- Se le dará un breve cuestionario para determinar experiencia de lenguaje de su hijo.
- Si su hijo participa en este estudio, se le pedirá que complete una sesión de estudio que dura aproximadamente 30-45 minutos. Durante esta sesión, su hijo /a va a:
  - Completar una evaluación de vocabulario (*Receptive One-Word Picture Vocabulary Test-4: Spanish-Bilingual Edition*). El investigador le va presentar una palabra con un grupo de cuatro imágenes y pedirá a su hijo que identifique qué imagen coincide con la palabra. (20 minutos).
  - Completar una actividad de repetición con palabras. Una lista grabada de audio de las palabras se va a presentar en un altavoz. Le van a pedir a su hijo que repita cada palabra mientras la sonda de ultrasonido se mantiene bajo del cuello. (15 minutos)
- Una grabación de audio y una grabación visual de las imágenes de la lengua se obtendrá durante la actividad de repetición. Las grabaciones no contendrán ninguna información identificable y serán almacenadas en una computadora protegida por contraseña a la que sólo los miembros del equipo del estudio tienen acceso. Las grabaciones se mantendrán por lo menos 5 años después de que el informe final sea presentado al IRB.
- Después de completar la sesión, su hijo será recompensado con un juguete pequeño y un libro.
- El experimento se hará en el laboratorio de habla en el Departamento de Ciencias de la Comunicación y Trastornos.

**Cantidad total de participantes**

Aproximadamente 40 personas participarán en este estudio en USF.

**Alternativas / Participación voluntaria / Retiro**

Si usted decide no permitir que su hijo participe en este estudio y no participa, está bien. En lugar de participar en este estudio de investigación, usted y su hijo pueden optar por no participar. Usted y su hijo solo deben participar de este estudio si desea ofrecerse en forma voluntaria. Usted o su hijo no deben sentir que hay alguna presión para participar en el estudio para complacer al investigador del estudio o al personal de investigación.

Si usted o su hijo (a) deciden no participar:

- No tendrá problemas o perderá los derechos que normalmente tendría.
• Su hijo seguirá recibiendo los mismos servicios que él / ella tendría normalmente.
• Su hijo todavía puede recibir tratamientos regulares.

Usted puede decidir después de firmar este formulario de consentimiento informado que ya no quiere que su hijo o usted participe en este estudio. Le mantendremos informado de cualquier novedad que pueda afectar su deseo de participar o permitir que su hijo continúe participando en el estudio. Sin embargo, usted y su hijo pueden decidir dejar de tomar parte en el estudio por cualquier motivo en cualquier momento. Si usted y / o su hijo (a) deciden dejar de tomar parte en el estudio, informe al personal del estudio tan pronto como pueda.

**Beneficios**

Su hijo no recibirá ningún beneficio al participar en este estudio

**Riesgos o molestias**

No existen riesgos conocidos para aquellos que están expuestos a la ecografía. Puede haber riesgos involucrados en el uso de gel de ultrasonido, y toallitas de alcohol utilizado para limpiar la sonda de ultrasonido. Informe al investigador si su hijo tiene alguna alergia conocida a estas sustancias.

**Compensación**

Su niño será compensado con un libro y un pequeño juguete si él / ella completa la visita de estudio programada.

**Costos**

No le costará nada dejar que su hijo participe en el estudio.

**Privacidad y confidencialidad**

Mantendremos los registros de su hijo privados y confidenciales. Ciertas personas pueden necesitar ver los registros de estudio de su hijo. Cualquier persona que observe los registros de su hijo debe mantenerlos confidenciales. Estos individuos incluyen:

• El equipo del estudio, incluido el Investigador Principal y otros miembros del equipo de investigación.

• Ciertas personas del gobierno y de la universidad que necesitan saber más sobre el estudio, y las personas que proporcionan la supervisión para asegurarse de que estamos haciendo el estudio de la manera correcta.

• Agencias del gobierno federal, estatal o local que regule esta investigación.

• La Comisión de Revisión Institucional (IRB, en inglés) de la USF y personal relacionado que tenga responsabilidades de supervisión para este estudio, incluido personal de Integridad y Conformidad de Investigaciones de la USF.
Podremos publicar lo que aprendamos con este estudio. Si lo hacemos, no incluiremos el nombre de su hijo/a. No publicaremos nada que permita a los demás saber quién es su hijo/a.

**Usted puede recibir respuestas a sus preguntas, inquietudes o denuncias**

Si tiene preguntas, inquietudes o denuncias acerca del estudio, o experimenta algún problema imprevisto, llame a Katherine Javier at (561) 574-7094.

Si tiene preguntas acerca de sus derechos como participante de este estudio, o si desea realizar alguna denuncia, tiene problemas o inquietudes que desea discutir con alguien externo a la investigación, llame a la IRB de la USF al (813) 974-5638 o contáctese por correo electrónico RSCH-IRB@usf.edu.

**Autorización para usar y divulgar información protegida de la salud (lenguaje de HIPAA)**

Las regulaciones federales de privacidad de la Ley de Portabilidad y Responsabilidad del Seguro Médico (HIPAA, en inglés) protegen la información de la salud que permite identificar en forma personal. Al firmar este formulario, usted permite a la University of South Florida usar la información de su salud para fines científicos. También nos permite compartir la información de su salud con individuos y organizaciones diferentes de la USF también involucrados en la investigación que se listan a continuación.

Los siguientes grupos de personas también podrán ver la información de su salud y usar dicha información para llevar a cabo este estudio:

- El personal médico que cuida de usted y de quienes son parte de este estudio científico;
- La Comisión de Revisión Institucional (IRB) de la USF y su personal relacionado con responsabilidades de supervisión de este estudio, incluido el personal de Integridad y Conformidad de la Investigación de USF y la Oficina de Investigación Clínica de Salud de USF.
- Comités de control de seguridad de datos u otros que controlen los datos y la seguridad del estudio;

Las personas listadas anteriormente podrán usar consultores en este estudio, y podrán compartir su información con ellos. Si tiene preguntas acerca de quiénes son, debe consultar al equipo del estudio. Los individuos que reciben su información de la salud para esta investigación pueden no estar obligados por la Regla de Privacidad de la HIPAA a protegerla y podrán compartir su información con terceros sin su permiso. Sólo pueden hacerlo si lo permite la ley. En caso de que compartan su información, ésta podría ya no estar protegida por la Regla de Privacidad de la HIPAA.

Al firmar este formulario, usted otorga su permiso para usar y/o compartir su información de la salud descripta en este documento. Como parte de esta investigación, la USF podrá reunir, usar y compartir la siguiente información:

- Edad en la identificación de la deficiencia auditiva
- Edad en la activación del implante coclear
- Edad al escuchar el acceso desde otro dispositivo de escucha
- Umbrales de tonos puros de la evaluación auditiva más reciente
- Diagnóstico clínico
- El historial de investigación de su hijo
- Todos los registros médicos y de salud anteriores, actuales o futuros de su hijo en poder de USF, otros proveedores de atención médica o cualquier otro sitio afiliado a este estudio en relación con este proyecto de investigación. Esto incluye, entre otros, registros relacionados con el VIH / SIDA, salud mental, abuso de sustancias y / o información genética.

Puede negarse a firmar este formulario. Si no firma este formulario, su hijo no podrá participar en este estudio de investigación. Sin embargo, el cuidado de su hijo fuera de este estudio y los beneficios no cambiarán. Su autorización para usar la información de salud de su hijo no caducará a menos que la revoca (retire) por escrito. Puede revocar este formulario en cualquier momento enviando una carta indicando claramente que desea retirar su autorización para usar la información de salud de su hijo en la investigación. Si revoca su permiso:
- Su hijo ya no será un participante en este estudio de investigación;
- Dejaremos de recopilar nueva información sobre su hijo;
- Utilizaremos la información recopilada antes de la revocación de su autorización. Es posible que esta información ya haya sido utilizada o compartida con otros, o que podamos necesitarla para completar y proteger la validez de la investigación; y
- El personal puede necesitar un seguimiento con su hijo si hay una razón médica para hacerlo.

Para revocar este formulario, por favor, escriba a:
Investigador Principal: Katherine Javier
IRB Study # 00028371
4202 E Fowler Ave, PCD 1017, Tampa, FL 33612

Mientras realizamos el estudio científico, no podemos dejarle ver o copiar la investigación del estudio que tenemos acerca de su hijo/a. Una vez completado el estudio, usted tiene derecho a ver la información acerca de usted, según lo permitan las políticas de la USF. Usted recibirá una copia firmada de este formulario.

**Consentimiento informado para participar en investigación, y permiso para que mi hijo participe en la investigación usar y compartir su información médica para este estudio**

- Confirme que soy el padre del niño o un guardián con autoridad para dar consentimiento en nombre del niño a la atención médica general.
- Doy libremente mi consentimiento para participar y permitir que mi hijo participe en este estudio y autorizar que su información de salud como se acordó arriba sea recolectada / revelada en este estudio.
- Entiendo que al firmar este formulario estoy de acuerdo en participar y dejar que mi hijo
participe en la investigación.
- He recibido una copia de este formulario para llevar conmigo.

Firma de la persona y padre del niño participando en el estudio  Fecha

Nombre en imprenta

**Declaración de la persona que obtiene el consentimiento informado**

Le he explicado cuidadosamente a la persona que participa del estudio lo que puede esperar de su participación. Confirma que el sujeto del estudio habla el idioma que se usó para explicar la investigación y que recibe un formulario de consentimiento informado en su idioma principal. El sujeto de este estudio ha dado un consentimiento informado con validez legal.

Firma de la persona que obtiene el consentimiento informado  Fecha

Nombre en imprenta de la persona que obtiene el consentimiento informado
Appendix D: Child Assent Forms (English and Spanish)

Assent of Children to Participate in Research

Pro # 00032201

Title of study: Articulatory Patterns in Children who use Cochlear Implant: An Ultrasound Measure of Velar Stop Production in Bilingual and Monolingual Speakers

Why am I being asked to take part in this research?
You are being asked to take part in a research study about speech and language. You are being asked to take part in this research study because you have cochlear implants and you speak English, or speak both English and Spanish. If you take part in this study, you will be one of about 40 people at this site.

Who is doing this study?
The person who is in charge of this research study is Katherine Javier. This person is called the Principal Investigator. However, other research staff may be involved and can act on behalf of the person in charge. She is being guided in this research by Dr. Kyna Betancourt, Ph.D., CCC-SLP and Dr. Stefan Frisch, Ph.D.

What is the purpose of this study?
By doing this study, we hope to learn more about the speech and vocabulary of children with cochlear implants.

Where is the study going to take place and how long will it last?
The research will be conducted at Speech Science Lab in the Communication Sciences and Disorders Department at USF. You will be asked to participate in 1 visit which will take about 30-45 minutes.

What will you be asked to do?
First, I will show you some pictures and tell you which picture to point to. Then, you will be asked to say some words that I will play on a speaker while we take pictures of your tongue.

What things might happen if you participate?
To the best of our knowledge, your participation in this study will not harm you.
**Is there benefit to me for participating?**
We cannot promise that you will receive benefit from taking part in this research study.

**What other choices do I have if I do not participate?**
You do not have to participate in this research study.

**Do I have to take part in this study?**
You should talk with your parents or guardian and others about taking part in this research study. If you do not want to take part in the study, that is your decision. You should take part in this study because you want to volunteer.

**Will I receive any compensation for taking part in this study?**
You will receive a toy and a book for taking part in this study.

**Who will see the information about me?**
Your information will be added to the information from other people taking part in the study so no one will know who you are.

**Can I change my mind and quit?**
If you decide to take part in the study you still have the right to change your mind later. No one will think badly of you if you decide to stop participating. Also, the people who are running this study may need for you to stop. If this happens, they will tell you when to stop and why.

**What if I have questions?**
You can ask questions about this study at any time. You can talk with your parents, guardian or other adults about this study. You can talk with the person who is asking you to volunteer by calling Katherine Javier at (561) 574-7094. If you think of other questions later, you can ask them. If you have questions about your rights as a research participant you can also call the USF IRB at (813) 974-5638 or contact by email at R SCH-IRB@usf.edu.

**Assent to Participate**
I understand what the person conducting this study is asking me to do. I have thought about this and agree to take part in this study. I have been given a copy of this form.

__________________________________________  _______________________
Name of person agreeing to take part in the study  Date

__________________________________________
Signature (if applicable; ages 13+)

__________________________________________  _______________________
Printed name person providing information (assent) to subject  Date

__________________________________________
Signature
Aceptación de los niños para participar en la investigación

Pro # 00032201

Título del estudio: Articulatory Patterns in Children who use Cochlear Implant: An Ultrasound Measure of Velar Stop Production in Bilingual and Monolingual Speakers

¿Por qué se me pide que participe en esta investigación?
Se le pide que participe en un estudio de investigación sobre el habla y el lenguaje. Se le pide que participe en este estudio de investigación porque tiene implantes cocleares y habla inglés, o habla inglés y español. Si participas en este estudio, serás una de unas 40 personas en este sitio.

¿Quién está haciendo este estudio?
La persona que está a cargo de este estudio de investigación es Katherine Javier. Esta persona se llama el Investigador Principal. Sin embargo, otro personal de investigación puede estar involucrado y puede actuar en nombre de la persona a cargo. Ella está siendo guiada en esta investigación por el Dr. Kyna Betancourt, Ph.D., CCC-SLP y el Dr. Stefan Frisch, Ph.D.

¿Cuál es el propósito de este estudio?
Al hacer este estudio, esperamos aprender más sobre el habla y el vocabulario de los niños con implantes cocleares.

¿Dónde se llevará a cabo el estudio y cuánto durará?
La investigación se llevará a cabo en Speech Science Lab en el Departamento de Ciencias de la Comunicación y Trastornos de la USF. Se le pedirá que participe en 1 visita que demorará unos 30-45 minutos.

¿Qué se le pedirá que haga?
Primero, te mostraré algunas fotos y te diré a qué imagen apuntar. Luego, se te pedirá que digas algunas palabras que tocaré en un altavoz mientras tomamos fotos de tu lengua.

**¿Qué cosas pueden pasar si participas?**  
A nuestro leal saber y entender, su participación en este estudio no le hará daño.

**¿Hay beneficios para mí para participar?**  
No podemos prometer que usted recibirá beneficios de participar en este estudio de investigación.

**¿Qué otras opciones tengo si no participo?**  
Usted no tiene que participar en este estudio de investigación.

**¿Tengo que participar en este estudio?**  
Usted debe hablar con sus padres o tutor y otros sobre participar en este estudio de investigación. Si usted no quiere participar en el estudio, esa es su decisión. Usted debe participar en este estudio porque quiere ser voluntario.

**¿Recibiré alguna compensación por participar en este estudio?**  
Recibirá un juguete y un libro por participar en este estudio.

**¿Quién verá la información sobre mí?**  
Su información se agregará a la información de otras personas que participaron en el estudio para que nadie sepa quién es usted.

**¿Puedo cambiar de opinión y dejar de fumar?**  
Si decide participar en el estudio, todavía tiene el derecho de cambiar de opinión más tarde. Nadie pensará mal de usted si decide dejar de participar. Además, las personas que están ejecutando este estudio pueden necesitar para que usted deje de hacerlo. Si esto sucede, le dirán cuándo parar y por qué.

**¿Qué pasa si tengo preguntas?**  
Puede hacer preguntas sobre este estudio en cualquier momento. Puede hablar con sus padres, tutores u otros adultos sobre este estudio. Usted puede hablar con la persona que le pide ser voluntario llamando a Katherine Javier al (561) 574-7094. Si piensa en otras preguntas más adelante, puede preguntarles. Si tiene preguntas sobre sus derechos como participante en la investigación, también puede llamar al USF IRB al (813) 974-5638 o contactar por correo electrónico a RSCH-IRB@usf.edu.
Asentimiento para participar

Entiendo lo que la persona que dirige este estudio me pide que haga. He pensado en esto y estoy de acuerdo en participar en este estudio. Me han dado una copia de este formulario.

__________________________________________________________________________  ______________
Nombre de la persona que acepta participar en el estudio                              Fecha

__________________________________________________________________________________
Firma (si es aplicable; edad 13+)

__________________________________________________________________________  ______________
Nombre impreso de la persona que proporciona                                         Fecha
la información (asentimiento) al sujeto

__________________________________________________________________________
Firma
Appendix E: Questionnaires (English and Spanish)

Parent Questionnaire

Part I. Demographic Information
1. Date of birth (month/year): ___________________
2. Gender: M___ F___
3. What is your nationality or country of origin? ________________________________

Part II. Language Development
1. Did your child go through a babbling stage before speaking words? (i.e. babababa, mamama)
2. Is your child: Monolingual _____ Bilingual ____ Multilingual _____
   a. If monolingual, what language does your child speak? _______________________
   b. If bilingual or multilingual, what languages does your child use?
      ______________________

If you answered Spanish above, please move on to the following language use questions.

Part III. Language Use
1. What language(s) do family members at home speak to each other?___________
2. With whom does your child speak Spanish? _________________________________
3. With whom does your child speak English? ________________________________
4. How old was your child when s/he started saying words in Spanish?___________
5. How old was your child when s/he started saying words in English?___________

6. How much of the day does your child spend speaking English? (Circle one)
   0-10%  20-30%  40-60%  70-80%  90-100%
   a. In what situations? ____________________________________________________

7. How much of the day does your child spend speaking Spanish? (Circle one)
   0-10%  20-30%  40-60%  70-80%  90-100%
   a. In what situations? ____________________________________________________
Cuestionario de Padres

Parte I. Información Demográfica
1. Fecha de nacimiento (mes / año): _________________________
2. Género niño___ niña___
3. ¿Cuál es su nacionalidad o país de origen? ________________________________

Parte II. Desarrollo del Lenguaje
1. ¿Su hijo tuvo una etapa de balbuceo? (es decir, “babababa”, “mamama”, “papapa”)
2. Si hijo es: monolingüe _____ bilingüe _____ plurilingüe _____
   a. Si es monolingüe, ¿Qué idioma habla su hijo? ___________________________
   b. Si es multilingüe, ¿Qué idiomas usa su hijo? ___________________________

Si respondió Español arriba, pase a las siguientes preguntas sobre el uso del idioma.

Parte III. Uso del Lenguaje
1. ¿Qué idioma(s) hablan los miembros de la familia en el hogar? _________________
2. ¿Con quién habla su hijo español? ________________________________
3. ¿Con quién habla su hijo inglés? ________________________________
4. ¿Qué edad tenía su hijo cuando empezó a decir palabras en español? _________________
5. ¿Qué edad tenía su hijo cuando empezó a decir palabras en inglés? _________________
6. ¿Cuánto tiempo por día dedica su hijo a hablar inglés? (Seleccione uno con círculo)
   0-10%  20-30%  40-60%  70-80%  90-100%
   a. ¿En qué situaciones? ________________________________________________
7. ¿Cuánto tiempo por día dedica su hijo a hablar español? (Seleccione uno con círculo)
   0-10%  20-30%  40-60%  70-80%  90-100%
   b. ¿En qué situaciones? ________________________________________________

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