# LANGUAGE-SPECIFIC PITCH RANGES AMONG SIMULTANEOUS K'ICHEE'-SPANISH BILINGUALS

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## ABSTRACT

Twenty-four simultaneous bilinguals of K'ichee' (Mayan) and Spanish produced broad focus declaratives in both languages. Target words, taken from the middle of syntactically parallel phrases, were analyzed prosodically in terms of both pitch register and pitch span, and compared across both languages according to language dominance in order to determine if these bilinguals have language-specific pitch ranges.

Results demonstrate that the participants produce lower L tones in Spanish than in K'ichee' regardless of language dominance. However, the speakers produce higher H tones in their non-dominant language than in their dominant language and K'ichee'-dominant bilinguals produce larger between-language differences in pitch span than Spanish-dominant bilinguals. It is argued that these findings may correspond to the frequency code, in that a higher pitch may be a manifestation of the bilinguals' uncertainty or lower level of confidence when speaking their less-dominant language.

**Keywords**: Frequency code, bilingual language dominance, language-specific pitch ranges, K'ichee', Spanish.

## 1. INTRODUCTION

Aside from different phonemic inventories, one of the reasons that languages sound different from each other is that they are said to have different "phonetic settings", which "can be described as a tendency to make the vocal apparatus keep returning to a language-specific configuration" [19:14]. The notion of language-specific phonetic settings has been applied to both segmental and suprasegmental features [17].

Previous research has revealed that pitch range may demonstrate language-specific phonetic settings; some languages may be spoken with a higher pitch or larger pitch span than others [8, 9, 12, 20, 31, 33]. [1] Although between-speaker variables such as anatomical differences of individuals' vocal tracts hinder claims such as 'language A is always spoken at a higher pitch than language B' [30], there has been an increase in studies of pitch ranges with within-speaker designs, i.e., among bilingual speakers of the languages under comparison.

For example, Russian-English bilinguals speak Russian with a higher pitch than English [1], English-French bilinguals speak French with a higher pitch than English [30], and Spanish-Catalan bilinguals speak Catalan with a higher pitch [18]. However, other studies have demonstrated contrasting findings: [1] found no differences in pitch between the two languages of English-Cantonese bilinguals whereas [21] found that English-Cantonese bilinguals speak Cantonese at a lower pitch and [29] and [30] demonstrate contrasting findings of which language is spoken at a higher pitch among German-English bilinguals.

Though some of these studies propose different language-specific features as possible explanations for their results, language-specific pitch ranges among bilinguals are not always universal and may be due to particularities of the speakers. For instance, with Welsh-English bilinguals, most, but not all, females speak Welsh at a higher overall pitch than English but males do not demonstrate any differences in pitch range between languages [25]. Only female German-French bilinguals speak French with a higher pitch [34] and female Japanese-English bilinguals, but not males, speak Japanese with a higher pitch [13, 14]. Among German-Italian bilinguals, female bilinguals speak German with a higher pitch whereas males speak Italian with a higher pitch [34].

Furthermore, it should be noted that a bilingual population does not form a homogenous group as factors such as daily language use and language competence contribute to whether a bilingual is dominant in one language or the other [5]; even simultaneous bilinguals have a preferred language in which they tend to feel more comfortable [10]. Although language dominance has been shown to be a significant variable in the analysis of intonational contours produced by bilinguals [3, 4, 26, 32], few of the aforementioned studies on bilingual pitch ranges mention it as a possible factor in their analyses [21]. Thus, the objective of this study is to analyze the pitch ranges in both languages of K'ichee'-Spanish simultaneous bilinguals in Guatemala according to language dominance in order to ascertain if they demonstrate language-specific pitch ranges and how speaker particularities may effect these ranges.

## 2. METHODS

### 2.1. Materials and procedure

Many of the aforementioned studies have used data from different corpora in order to investigate the language-specific pitch ranges of bilinguals. However, as such a corpus is not available for the population under study in this analysis, a controlled production task was designed.

The materials were designed to be syntactically parallel across both languages in order to perform a more viable cross-language comparison. As all segments except nasals devoice in word-final position in K'ichee' and stress is also fixed in word-final position [11], a target word composed of voiced segments and ending in a nasal was the third of four words in the phrase; the last word had an atonic-tonic stress pattern to avoid stress clash. Although Spanish does not demonstrate these same phonotactic restrictions, the Spanish material was also designed following this protocol. Ten phrases were created for each language (see Appendix in Section 6).

A question-answer task [4] was used to elicit the productions from the bilinguals. In this type of task, the participant is given information from a speaker and then asked the question "What happened?" by a second speaker. The participant then responds in a broad focus declarative to the second speaker, using the information received from the first.

Following the methods of previous phonetic studies in populations with low literacy rates [e.g., 11], the stimuli were presented to the participants via a video. 4 native bilingual speakers of K'ichee' and Spanish (2 male, 2 female) were recorded producing the stimuli on a Sony HDR-CX560 Handycam. The videos were created in *iMovie* software where the roles of speaker 1 and speaker 2 were randomized among the four speakers. The presentation of the stimuli to the participants is as follows: (i) speaker 1 appears on screen, presents the information to the participant, and the screen fades to black for 2.5 seconds; (ii) speaker 2 appears on screen and asks the question "What happened?" and the screen fades to black; and (iii) the participant responds to speaker 2. This methodological design also controls for other variables from speakers 1 and 2, such as question intonation or facial expressions. The 10 question-answer sets for each language were repeated 4 times to the participants and, along with distractor question-answer sets, were randomized 5 times and burnt unto different DVDs for each language.

Twenty-four simultaneous K'ichee'-Spanish bilinguals participated in this study (12 male, 12 female, ages 19-75, M: 40.25, SD: 14.5). The participants were analyzed for language dominance via the Bilingual Language Profile (BLP) [6], which assesses dominance on a continuum as opposed to more categorical interpretations [5]. The BLP was chosen because it has previously demonstrated correlations with intonational contours in both languages among this population [3, 4].

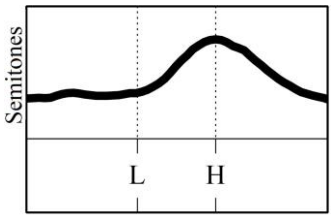
The participants were recorded via a Marantz PMD661 solid-state digital voice recorder digitized at 16 bits (44.1 kHz) with a Shure SM10A head-mounted microphone in quiet rooms in Guatemala. The order of the tasks, Spanish or K'ichee' first, was counter balanced among the participants and the DVDs were played for the participants via a Sony DVP-FX780 portable DVD player.

1,920 tokens (10 phrases x 4 repetitions x 2 languages x 24 participants) were elicited in the production task and 1,884 tokens were analyzed; 36 tokens were discarded due to recording errors.

### 2.2. Analysis

Pitch range is divided into two dimensions: register and span. Register, or level, refers to the overall pitch height of an intonational phrase whereas span refers to the size of the excursion of a contour [16]. Previous studies on uncontrolled speech have analyzed pitch range using various methods [e.g., 12, 33]. However, this analysis of controlled speech consisted in measuring the target words for F0 height at the L tone and H tone for pitch register and the difference in height between the H tone and the L tone for pitch span [16, 27]. These locations are summarized in Figure 1. Prior to the statistical analyses, the data were normalized to semitones (re 1 Hz) in Praat [7].

**Figure 1**: Schematic of the location of the measurements (st) made for each target word.



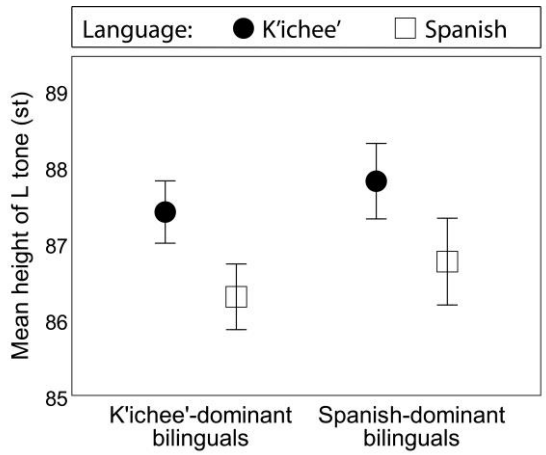

The data were analyzed via ANCOVAs with the specific acoustic measure as the within-speaker factor, Language as the between-speaker factor, Language Dominance (BLP score) as the continuous covariate, and speaker as the error term. Sex was included as a between-subjects factor but was never significant, aside from the expected between-sex differences in overall pitch height, and is not reported here. Although language dominance was analyzed as a continuous variable in this study, it is presented in the figures in Section 3 as categorical for clarity [5].

## 3. RESULTS

### 3.1. L tone height

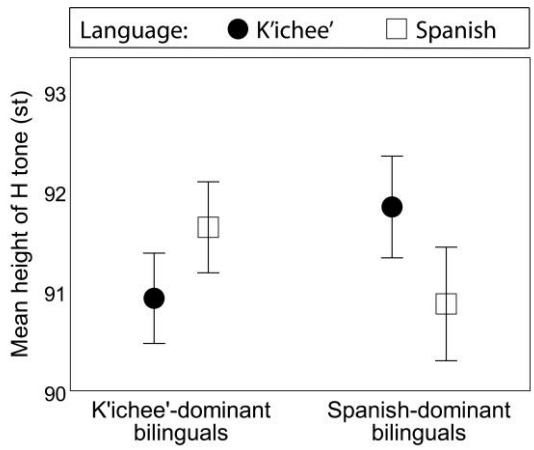
The ANCOVA of L tone height of the bilinguals demonstrates that there is a significant effect of Language [$F_{(1, 1882)} = 113.125$, $p < .001$]. However, there is no significant effect of Language Dominance [$F_{(23, 1882)} = .986$, $p = .325$] nor is there a significant Language x Language Dominance interaction [$F_{(22, 1882)} = 1.574$, $p = .116$]. As illustrated in Figure 2, the results indicate that the participants have a lower pitch at the L tone in Spanish than in K'ichee' regardless of language dominance.

**Figure 2**: L tone height (st) according to language spoken and bilingual language dominance.




### 3.2. H tone height

**Figure 3**: H tone height (st) according to language spoken and bilingual language dominance.

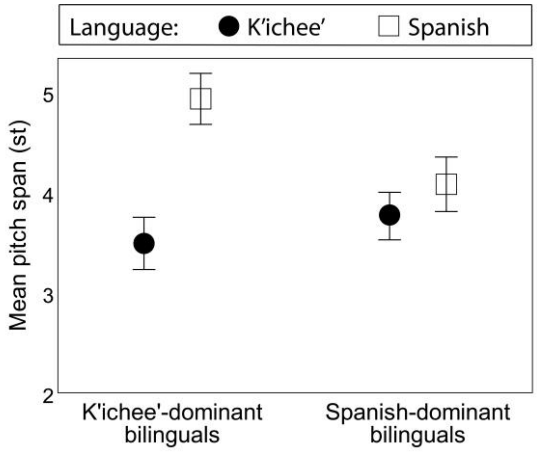



The ANCOVA of H tone height (Figure 3), does not yield a significant effect of Language [$F_{(1, 1882)} = 1.285$, $p = .257$], or an effect of Language Dominance [$F_{(23, 1882)} = .235$, $p = .815$]. However, there is a significant interaction between Language and Language Dominance [$F_{(22, 1882)} = 6.772$, $p < .001$]. Thus, the bilinguals in this study tend to have higher H tones in their non-dominant language.

### 3.3. Pitch span

Both Language [$F_{(1, 1882)} = 7.311$, $p < .001$] and Language Dominance [$F_{(23, 1882)} = 15.276$, $p < .001$] are significant in the ANCOVA of pitch span. The interaction between the two was also significant [$F_{(22, 1882)} = 3.361$, $p < .001$]. As seen in Figure 4, although all the bilinguals produce a larger pitch span in Spanish than in K'ichee', the difference between the language-specific pitch spans is greater among K'ichee'-dominant bilinguals than among Spanish-dominant bilinguals.

**Figure 4**: Pitch span (st) according to language spoken and bilingual language dominance.




## 4. GENERAL DISCUSSION

This study shows that, similar to the studies summarized in Section 1, these K'ichee'-Spanish bilinguals have different pitch ranges according to which language they are speaking. Following previous results among other bilingual populations [25, 34], it is also shown that these language-specific pitch ranges are influenced by social and cultural factors. Specifically, the pitch ranges of these bilinguals vary according to language dominance.

Given the between-speaker variation within any bilingual population, the present study includes language dominance in the acoustic analysis of bilingual pitch ranges. Although the data demonstrate that these bilinguals have lower L tones in Spanish than in K'ichee', regardless of language dominance, both H tone height and pitch span were affected by language dominance.

The analysis of H tone height reveals that these bilinguals have higher pitch peaks in their non-

dominant language than in their dominant language. One manifestation of the frequency code [22, 23, 24], which is based on the correlation between larynx sizes and pitch, is that while lower pitch sounds more dominant and confident, higher pitch sounds vulnerable, uncertain, nervous, etc. Indeed, speaking with a higher pitch has been shown to be correlated with higher levels of uncertainty or nervousness and lower levels of confidence [2, 28]. Thus, the bilinguals in this study may be speaking their non-dominant language with higher pitch peaks than their dominant language due to lower levels of confidence or an increased level of nervousness that they may have while speaking their non-dominant language.

The results of pitch span can be interpreted as a function of the results of L and H tone height. As all speakers demonstrate lower L tones in Spanish, the greater differences between K'ichee' and Spanish pitch spans can be seen among the bilinguals that have higher H tones in Spanish: the K'ichee'-dominant bilinguals.

In conclusion, this study adds to our knowledge of language-specific pitch ranges among bilinguals, as it is one of the first to include language dominance in such an analysis. Following [34], this study provides further examples of how social and cultural factors may influence different aspects of bilinguals' pitch ranges in both of their languages. Although sex was not a significant factor in this study, this of course does not mean that it is not an important factor overall, as previous studies have demonstrated [14, 25, 34].

These findings have applications in fields such as forensic phonetics and speech-based technology. Previous work has shown that speaker perception needs to take into account factors such as the emotional state of and the language being spoken by the individual [28, 30], and this study indicates that the language dominance of bilingual individuals needs to be considered as well.

## 5. ACKNOWLEDGEMENTS

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## 6. APPENDIX

**K'ichee' Materials**

| Phrase (target word in bold) | Gloss |
|---|---|
| Xkam le **umam** iwir. | 'Her/his grandfather died yesterday.' |
| Xpe le **unan** kamik. | 'Her/his mother came today.' |
| Xwar le **uch'utinan** iwir. | 'Her/his aunt slept yesterday.' |
| Xtzaq le **rixnam** jela'. | 'His sister-in-law fell down over there.' |
| Xoq' le **unan** chaq'ab'. | 'Her/his mother cried at night.' |
| Xpe le **uch'utinan** ojer. | 'Her/his aunt came a while ago.' |
| Xul le **rixnam** waral. | 'His sister-in-law arrived here.' |
| Xel le **umam** chaq'ab'. | 'Her/his grandfather left at night.' |
| Xkos le **unan** iwir. | 'Her/his mother got tired yesterday.' |
| Xwa' le **rixnam** waral. | 'His sister-in-law ate here.' |

**Spanish Materials**

| Phrase (target word in bold) | Gloss |
|---|---|
| Juana la **mam** bailó. | 'Juana the Mam danced.'[2] |
| El señor **Adán** habló. | 'Mr. Adam spoke.' |
| El viejo **alemán** corrió. | 'The old German man ran.' |
| La señora **Guzmán** canto. | 'Mrs. Guzman sang.' |
| El viejo **mam** bebió. | 'The old Mam man drank.' |
| El señor **alemán** lloró. | 'The German man cried.' |
| La señora **Guzmán** gritó. | 'Mrs. Guzman yelled.' |
| El viejo **Adán** bailó. | 'The old(er) Adam danced.' |
| El viejo **Mam** comió. | 'The old Mam man ate.' |
| Juana la **Mam** habló. | 'Juana the mam spoke.' |

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[1] Although the terms F0 and pitch are not necessarily equivalent, as pitch is a perceptual property of frequency, these terms are used interchangeably here following previous studies [e.g., 25].

[2] *Mam* is used to refer to the Mayan language or as an ethnicity-denoting adjective in Guatemalan Spanish.