SIBILANTS IN CHINESE IMMIGRANT SPANISH*

Tanya L. Flores

The present case study examines the acquisition and variation of peninsular Spanish /θ/ and /s/ by a naturalistic learner whose native language is Mandarin Chinese. It provides the first in-depth phonological analysis of Chinese Immigrant Spanish (CIS). The objective is to identify and describe the sibilant system of a CIS speaker by examining her interpretation of the interdental fricative /θ/, the apico-alveolar /s̲/, and allophonic variations of /s/. Results show that the learner relies on her L1 inventory in creating her L2 sibilant system, and is influenced by the frequency of the input at both the word and phonemic levels. These findings uphold the Distributional Bias Hypothesis and will be supported by a detailed acoustic analysis.

1. Introduction

Studies in the acquisition of Spanish phonology by second language learners have focused on English L1 learners receiving formal instruction in American classrooms or on study abroad programs. One such comparative study, Díaz-Campos (2004), found that while study abroad does provide an authentic L2 context, it does not by itself facilitate the acquisition of Spanish sounds. The English speaking university students used for the study did not show significant gains in the acquisition of voiceless plosives /p t k/, and only slight gains were made in the pronunciation of voiced initial stops /b d g/. The study concluded that the following factors had the greatest effect on acquisition: years of instruction, age the learner began instruction, and language use outside of the classroom. From these results one could predict more favorable gains in pronunciation for naturalistic L2 learners; however such studies are scarce, especially where Spanish is the target language.

The present case study examines the acquisition of one of the most recognizable characteristics of standard peninsular Spanish, the phonological contrast between /θ/ and /s/, with /θ/ occurring in words spelled with *z* (as in *zapato* [θapato] 'shoe') and in *ce, ci* (*centro* [θentro] 'center', *cien* [θien] 'hundred'). This contrast, known as "distinción" in Spanish, is exclusive to the standard peninsular variety; Andalusian and Latin American varieties pronounce all words containing *s*, *z*, and *ce, ci* as [s]. The current study is the first acquisition study on the peninsular contrast for a naturalistic learner of Spanish. The subject of this case study is a female adult native speaker of Mandarin Chinese, a language with a larger sibilant inventory than that of the target language. One of the difficulties the learner faces in acquiring "distinción" is that there is no exact phonemic overlap between Chinese and Spanish in regards to sibilants or the interdental fricative, as will be described below.

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Table 1 provides a complete consonant inventory for all standard varieties of Spanish. While the alveolar fricative /s/ is the only sibilant phoneme, /z/ exists in allophonic variation. In most Spanish varieties, including peninsular, voice assimilation of [s] to [z] can occur before a voiced stop, nasal, liquid, or glide in word internal positions or across word boundaries. (Hualde 2005) The following examples illustrate these contexts.

(1) *desde*	[dez.de]	'from'
(2) *asno*	[az.no]	'donkey'
(3) *las manos*	[laz.ma.nos]	'the hands'

Several of the phonemes shown, including the interdental fricative /θ/, do not occur in every variety; as mentioned above, it is unique to peninsular Spanish. Another characteristic of the peninsular variety, most audible in the word-final position, is that /s/ is generally realized as an apico-alveolar fricative, as in the examples below.

(4) *sapo*	[s̱a.po]	'toad'
(5) *menos*	[me.nos̱]	'less'

Table 1. Spanish consonantal sounds

	Bilabial		Labiodental		Dental		Interdental		Alveolar		Palatal		Velar	
	−	+	−	+	−	+	−	+	−	+	−	+	−	+
Stop	p	b			t	d							k	g
Affricate											tʃ	ɟ		
Fricative		β	f				θ	ð	s	z		ʝ	x	ɣ
Nasal		m		ɱ		n̪		ṇ		n		ɲ		ŋ
Lateral						l̪		ḷ		l		ʎ		
Trill										r				
Flap										ɾ				

Table 1. Spanish consonant inventory from Díaz Campos (2004)

Standard Mandarin has twelve fricatives illustrated in Table 2, including at least seven sibilants[1] /s z ʃ ts dz ts^h tʃ^h/ with voicing and aspiration contrasts (Peng et al. 2004). The following are examples of each of these, spelled in pinyin, a widely used romanized representation of the original Chinese characters. Given the multiple meanings of Chinese words based on tones, the English glosses given here correspond to a common meaning of the term.

[1] There are two other possible sibilant phonemes not included by Peng et al. (2004): Xia [szhia], Si [szʉ]. However, these only occur in dialectal variations of Mandarin.

(6) Mandarin sibilants

Sai	[sai]	‘match/contest’
Zong	[zong]	‘always’
Shang	[ʃang]	‘on top of’
Ci	[tsʉ]	‘next’
Zi	[dzʉ]	‘self’
Cu	[tsʰʉ]	‘vulgar’
Chi	[tʃʰʉ]	‘to eat’

Manner of Articulation	Aspiration	Bilabial −	Bilabial +	Labiodental −	Labiodental +	Alveolar −	Alveolar +	Postalveolar −	Postalveolar +	Palatal −	Palatal +	Velar −	Velar +
		Place of Articulation and Voicing (−/+)											
Plosive	−	p				t						k	
	+	pʰ				tʰ						kʰ	
Nasal			m				n						
Fricative				f		s		ʂ	ʐ	ɕ		x	
Affricate	−					ts		tʂ		tɕ			
	+					tsʰ		tʂʰ		tʰ			
Lateral approximant							l						

Table 2. Standard Mandarin Consonant Inventory (Peng et al. 2004).

Tables 1 and 2 help illustrate that the sibilant inventories of these two languages do not share many phonemes in general, including those that will be examined here. Mandarin Chinese does not have an interdental fricative in its phonological system, and five of the seven Chinese sibilants are completely foreign to Spanish. Though the sibilant phoneme /s/ is shared by both languages, the variety of Spanish spoken in Madrid produces it as an apico-alveolar fricative that is not phonetically equivalent to Mandarin /s/. While standard Spanish does allow for the voiced fricative /z/, one of the seven sibilants of Mandarin, it occurs only as an allophone of /s/ in the limited contexts noted above.

The differences between the two systems suggest considerable difficulty in phonological acquisition by speakers of Mandarin learning Spanish (and vice versa). This qualitative case study will provide a detailed analysis of sibilant productions by a speaker of Chinese Immigrant Spanish (CIS) and how these productions relate to both Mandarin, her native language, and peninsular Spanish, the target language in this contact situation. The main objective is to identify and describe the speaker’s sibilant system using acoustic analysis to examine her interpretation of the interdental fricative /θ/, the apico-alveolar /s̱/, and allophonic variations of /s/. The role of lexical and phonemic frequency on the construction of the CIS sibilant system will also be explored.

2. Background literature

2.1 Acquisition of L2 Spanish phonology

Acquisition studies on the Spanish sound system by non-native speakers are fairly recent and also generally limited to L1 English learners. The current literature on L2 Spanish phonology examines the following variables: voiceless stops /p, t, k/ (Díaz-Campos 2004; Díaz-Campos and Lazar 2003; González-Bueno 1997), voiced stops /b, d, g/ (González-Bueno 1997), rhotics /r, r/ (Face 2006; Face and Menke 2008; Reeder 1998; Rose 2008); lateral /l/ and palatal nasal /ɲ/ (Díaz-Campos 2004). Of particular interest to the current study are the contrastive /s/ and /θ/, which have not been examined together in the context of L2 acquisition. To date, there are only two studies on the L2 use of theta /θ/: Geeslin and Gudmestad (2008), and Willis et al. (2009). There is one current thesis, Schmidt (in preparation), on the acquisition of Spanish sibilants by second language learners. Geeslin and Gudmestad (2008) investigated the use of /θ/ with 130 college students across five proficiency levels. Results indicated that the few productions of theta occurred only among students at the 3 highest levels and was only categorical for two of the level five learners. The Willis et al. (2009) project examines the path of acquisition of /θ/ in León, Spain with nine advanced level high school students participating in a study abroad program. The study shows a statistically significant increase in theta usage for most of the participants, averaging from 20.9% at the beginning of the 7-week program to 59.4% by the end. The authors found a significant relationship between word position and use of /θ/, with word-initial increasing from 19.4% to 55.6% and word-medial from 22.2% to 62.7%. Based on individual variation and the follow-up survey from the 2008 study, it was determined that language attitude plays an important role in acquisition and continued usage of the peninsular variant.

Schmidt is currently investigating the acquisition of the s-aspiration (*manos* [manoh] 'hands') (in preparation) and voicing assimilation (2008) in Spanish by L1 English learners in words such as *mismo* [mizmo] 'same.' The English sibilant inventory includes a voiced alveolar sibilant /z/ that is usually non-contrastive in Spanish, it also has a palatal voiceless fricative /ʃ/ not found in standard Spanish varieties. Schmidt (2008) provides an acoustic analysis of the voicing assimilation by native Spanish speakers and then examines the acquisition of this contextual variation by English learners of Spanish. The preliminary results of the study are that some of the advanced undergraduate learners (3 of 14) do realize the contextual variation and exhibit cases of voicing assimilation of Spanish /s/ before a voiced consonant. Both the native and L2 learner groups also had varying degrees of voicing within the sibilant segment. These phasing differences can be explained as temporal overlap from both sides of the segment, in line with Browman and Goldstein's (1990) articulatory model, which will serve as the phonological framework for the current study.

2.2 Contact languages

Muysken's (1997) study on Media Lengua (a mixed language that combines Quechua grammatical structures with Spanish vocabulary) provides insights into the perception of Spanish /s/ by non-native speakers. Muysken found that Media Lengua speakers pronounce the intervocalic /s/ of Spanish words as a voiced variant [z], perhaps assimilating the voicing of the surrounding vowel context. They do not, however, voice intervocalic /s/ in Quechua words.

The study also found that before the phoneme /t/, speakers palatalize the /s/ of Spanish words producing the sound [ʃ], and the cluster "str" in words such as "nuestro" is pronounced as a rhotic with the voiced palatal [rzh]: [nurzhu]. Table 3 summarizes the sibilant system of the mixed language in comparison to Spanish and Quechua. All three sibilant variants, the voiced alveolar /z/, the voiceless palatal /ʃ/, and the voiced palatal /zh/, are phonemes in the Quechua consonant inventory that are also used in Media Lengua. These findings are relevant to the current study in that they demonstrate how non-native speakers of Spanish incorporate sibilants of their native inventory by attending to voicing and fronting cues from the surrounding contexts of the /s/ productions in Spanish words. In Quechua, voicing and fronting are used to create minimal pairs. Muysken's findings could suggest that speakers of Chinese Immigrant Spanish would also incorporate /z/, /ʃ/, and /zh/ from their L1 inventory into their Spanish. Predictions based on the DBH, however, do not necessarily substantiate this outcome, since none of these phonemes would be present in the Spanish input that the learners receive.

SPANISH	**MEDIA LENGUA**	**QUECHUA**
/s/, [z]* **allophone*	/s/, /z/, /ʃ/, /zh/	/s/, /z/, /ʃ/, /zh/, /ts/, /dz/

Table 3. Sibilant system of Media Lengua as it relates to its source language. (Muysken 1997)

A study on Chinese Pidgin English (Shi 1991) also provides insights into the phonemic system created by speakers in intense contact situations. This variety is a historic pidgin created on the eastern coast of China during the 18th and 19th centuries that allowed Cantonese speakers to communicate with English speaking traders for business purposes. In the absence of oral data of this variety, Shi's analysis is based on written sources. According to his corpus, CPE speakers regularly substituted the voiceless alveolar /s/ for English palatal /ʃ/, and occasionally vice versa, as in these examples[2]:

(7) *seep* 'sheep'
(8) *sheet tum* 'sit down'

The speakers also produced both /z/ and /zh/, as separate phonemes. Shi did not find any cases of the voiced alveolar /z/ replacing the voiced palatal /zh/. However, there were very few cases of English words with the [zh] sound in the corpus analyzed. Table 4 shows the sibilant system created by CPE speakers and how is relates to Cantonese and English.

CANTONESE CHINESE	**CPE**	**ENGLISH**
/s/, /ʃ/, /zh/, /ts/, /tsʰ/,/tʃ/, /tʃʰ/	/s/, /ʃ/, /z/, (/zh/)	/s/, /ʃ/,/z/

Table 4. Sibilant system of Chinese Pidgin English compared to its source languages. (Shi 1991)

[2] No phonetic transcriptions for examples 7 through 11 are provided because they come from written sources of a historic dialect. Oral pronunciation by CPE speakers is unknown.

Since the English consonant inventory also includes the interdental fricative /θ/, it is worth noting that speakers of CPE categorically replaced this phoneme with /t/, as in the following examples taken from Shi (1991).

(9) *tinkee* ‘think’
(10) *teelee* ‘three’
(11) *etoo* ‘earth’

Like Cantonese, Mandarin also lacks the interdental fricative in its consonant inventory; therefore, Mandarin speakers would also be expected to replace /θ/ in Spanish. Considering the contextual variation between /θ/ and /s/ in Spanish, Chinese learners would be expected to select /s/ in replacing the interdental phoneme.

2.3 Chinese Immigrant Spanish (CIS)

The Chinese ethnic community in Madrid is a fairly isolated community, composed of immigrants from several provinces across the People’s Republic of China and also Taiwan. Clements reports that in 2000 there were as many as 60,000 Chinese living in Spain, mostly in Madrid. Chinese presence in Spain has been documented since the 1920s, but due to the strongly isolating tendency of this community, the majority are not fully integrated into Spanish society and few speak or read Spanish[3]. (Clements 2009) In terms of the language contact situation, Chinese immigrants generally maintain their native language; however, the few that do learn Spanish demonstrate a case of language shift.

After conducting several longitudinal interviews with CIS speakers, Clements (2003, 2009) described the contact situation of this group as one akin to language shift, as defined by Thomason and Kaufman (1988). CIS, as spoken by the informants interviewed, exhibits the following characteristics: (1) all Spanish lexicon with no Mandarin vocabulary incorporated[4] and (2) primarily Chinese morphosyntactic structures. Of the morphosyntactic traits that were identified in CIS, seven are attributed to Chinese sources, five are found in both Chinese and Spanish, and only two are exclusively Spanish traits. Table 5 is the complete list of traits examined in the Clements studies and the source language to which each is attributed.

Table 6 provides Clements’s general description of the CIS phonological system, where six of the seven main characteristics are attributed to Chinese phonology, and only one trait seems to have been acquired from Spanish. This description is based on a perceptual examination of CIS data; however, a complete acoustic analysis has not been conducted to confirm these results. The current study is an initial step toward filling this gap in the research of this language variety.

[3] Beltrán and García (2001, in Clements 2009) noted that in 1991, only 72 of the 264 Chinese immigrants who applied for citizenship could read or write Spanish.
[4] No Mandarin words appear in the data; however, there are some calques, such as “mamá-papá” for “padres.”

Morphological traits	
No case, number, gender, or person marking (except in pronouns)	(English), Chinese
No evidence of verbal inflection	Chinese
Syntactic traits	
SVO word order	English, Chinese
No passive voice	Other
Classifier *piece*	Chinese
N + N (with genitive or modifier relation)	English, Chinese
No prepositions as such	Other
Adv + Adj	English, Chinese
V + IO + DO order with no marking for IO or DO	English, Chinese
V + DO + IO with no marking is also found	Other
Adv + V + NP	Chinese
V + N + Adv	English, Chinese
Hab "have" completive	English, Chinese
Other than *hab*, there are no TMA markers	Other
Belong copula with Ns, absent with Adjs	Chinese
No articles (*the, an, a*); instead there are demonstratives	Chinese
In-situ and fronted *wh*-words	(English), Chinese
No equivalents of *yes* and *no*	Chinese
V + NEG + V (*savee, no savee* "do you understand?")	Chinese
Bimorphemic *wh*-words	Other
Negation: *no* before the predicate	Chinese
No relative clauses	Other
Abundant complement clauses	English, Chinese

Table 5. Morphological and syntactic traits of CIS as they relate to source languages. (Clements 2003)

Phonological traits	
$r \to l$	Chinese
[v] $\to$ [b]	Not present
b, d, g devoicing ($b \to p$)	Chinese
Occasional lack of fricative [β]	Other
$\delta \to d$	Not present
$\check{s} \to s$ (more common) and $s \to \check{s}$ (more rare)	Not present
Five types of syllabic simplification strategies	
vowel epenthesis	Chinese
cluster simplification	Chinese
both vowel epenthesis and cluster simplification	Chinese
deletion of syllable coda	Chinese
retention of closed syllables in *-s*	Spanish
Voicing	Not present

Table 6. Phonological traits of CIS as they relate to its source languages. (Clements 2003)

3. Theoretical models

Acquisition models for naturalistic learners historically fall under the category of contact linguistics, a field that studies the language produced when two or more languages (or varieties) interact for extended periods of time. Linguists such as Croft, Thomason and Kaufmann, and Klein and Perdue consider the contact setting and the emergent language system as a whole in order to determine the kind of contact language being produced, whether it is a pidgin, creole, mixed language, or a case of code switching, code mixing, or interlanguage. While the majority of Chinese speakers in Spain maintain their language, creators of Chinese Immigrant Spanish could be categorized as language shifters in Thomason and Kaufman's (1988) model. Previous research on CIS by Clements (2003, 2009) has contributed valuable insights into its morphological and syntactic systems. The concern of this project is to augment the work on CIS by analyzing sibilant productions acoustically in order to begin an in-depth phonological description of CIS and understand the factors influencing the creation of its phonemic inventory. Browman and Goldstein's (1990) articulatory model will provide the phonetic framework needed to describe the sibilant productions that make up her interlanguage inventory. Andersen's (1983) Distributional Bias Hypothesis (DBH) will be applied to explore the role of frequency on the speaker's phonemic selections.

According to Browman and Goldstein's (1990) articulatory model, voicing assimilations can be explained as a result of the temporal overlap of a consonant with a neighboring voiced consonant or vowel. For example, the /s/ in the Spanish word "desde" is pronounced as a [z] in most varieties because it is followed by a voiced consonant /d/. This model can also account for other assimilations, such as the palatalization of [s] to [ʃ] when the sibilant appears before a palatal consonant, front vowel, or /ie/ glide, as in the word "siempre". The following diagram (Figure 1) illustrates a theoretical phasing process of the consonant /t/ followed by the vowel /i/ in English words such as "vacation" [vei.kei.ʃən] explaining why the /t/ is palatalized. This phasing can occur in any proportion including full assimilation (100% overlap). The present study examines the sibilant productions of a CIS speaker and identifies any voicing and/or palatal assimilations that occur, using this model to account for them.

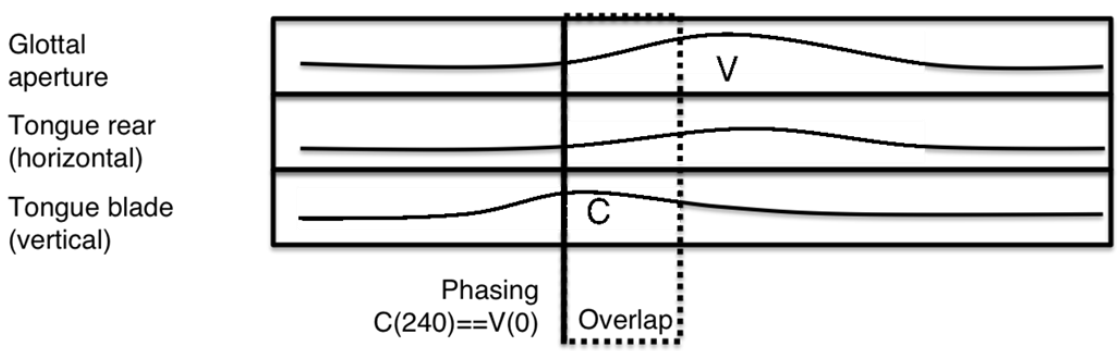

Figure 1. Representation of the Browman and Goldstein (1990) articulatory model.

The variety of Spanish spoken in Madrid has two sibilant phonemes /θ/ and /s/, however, these do not occur in equal distribution throughout the language. According to the oral data in the CREA database, /s/ is approximately three times more frequent than /θ/, based on average frequency counts of each token found in this corpus. The Distributional Bias Hypothesis (DBH) proposes that the more frequently used verb forms found in a language, and thus received by learners as input, will also be preferred by the learner (Andersen 1983). In examining the syntactical structures of the CIS variety, Clements (2009) finds the DBH to hold true for the morphological traits and verb paradigms used by these speakers. The DBH can account for the exclusive use of 3rd person singular verb forms, given that these are in most cases the most frequent conjugations produced by native speakers in written and oral data. For this project, the Distributional Bias Hypothesis is adapted to test the role of frequency in the production of phonemic variation. The use of the DBH to explain phonemic variation is innovative, yet it is the belief of this researcher that it will serve this data well. In the case of the CIS sibilant system, the DBH predicts that /s/ would be used exclusively or at least preferred over /θ/ for all words represented orthographically with the symbols *s, z,* and *ce, ci*, given the 3:1 frequency ratio.

The following research questions guide this study:

1. What are the phonemes and allophones that make up the sibilant system of Chinese Immigrant Spanish?

2. How does the CIS speaker interpret the interdental fricative /θ/, the apico-alveolar /s̲/, and allophonic variations of /s/?

3.What is the role of frequency, at both the phonemic level and word level, on the construction of the speaker's sibilant system?

4. Methodology

4.1 The informant

The CIS data used for this analysis comes from a private collection of interviews conducted by J. Clancy Clements (2000, 2000b), who shared his recordings with this researcher. The two interviews selected for this analysis were carried out with an adult female native speaker of Mandarin Chinese, currently living in Madrid, Spain, with no formal instruction in Spanish. The speaker, Jenny, is originally from Nanking, People's Republic of China, and moved to Spain in 1985 while in her late twenties. Between 1985 and 1994, she lived and worked with other ethnic Chinese in Madrid and used Spanish only a minimal amount. Since that time, Jenny has moved and changed jobs in order to become more integrated into Spanish society (Clements 2003, 2009). She has also learned Spanish and reported using it as her main form of communication at the time of her interviews. Jenny had lived in Madrid for 14 years at the time of the first interview with Clements in 2000, and was interviewed by him a second time in 2002. The data analyzed in this study consists of 200 sibilant tokens, divided equally between the two recordings. The interviews are sociolinguistic in nature; the participant was asked about familiar topics such as her job, family, background, and her life in Spain.

4.2 Acoustic analysis

The dependent variable used for this study has four fricative variants in peninsular Spanish: the interdental voiceless [θ], apico-alveolar voiceless [s̲], the voiceless alveolar [s], and the voiced alveolar allophone [z]. Since the purpose of this study is to examine the sibilant productions actually realized by the CIS speaker, the tokens were selected by orthographic correspondence to "c," "z," and "s," rather than acoustic correspondence to the standard variants.

Each of the 200 selected tokens was individually subjected to an acoustic analysis using the software program Praat (Boersma and Weenick 2008), designed for such purposes. Each sibilant segment was measured for duration, F2 values taken at 25%, 50%, and 75% of the segment, and frequency of formant energy at its peak also taken at 25%, 50%, and 75% of the segment using spectral slices, to determine place of articulation. The tokens were also coded for voicing, phonetic context, stress, word position, frequency within the corpus, and frequency in the CREA oral database for Spain.

According to Stevens (1989), F2 values will increase as the constriction (place of articulation) of a consonant moves further away from the glottis. Consistent with his configuration of natural frequencies for consonants, a palatal consonant (at 10 cm., indicated below by a blue arrow) should have F2 values of almost 2000 Hz for a male speaker and between 2600 and 3000 for a female. An alveolar consonant (at 12 cm., indicated by red arrow) should have an F2 value of about 1300 Hz for a male and about 2000 Hz for a female speaker. Figure 2 represents frequencies for an average male speaker with a 16 cm vocal tract.

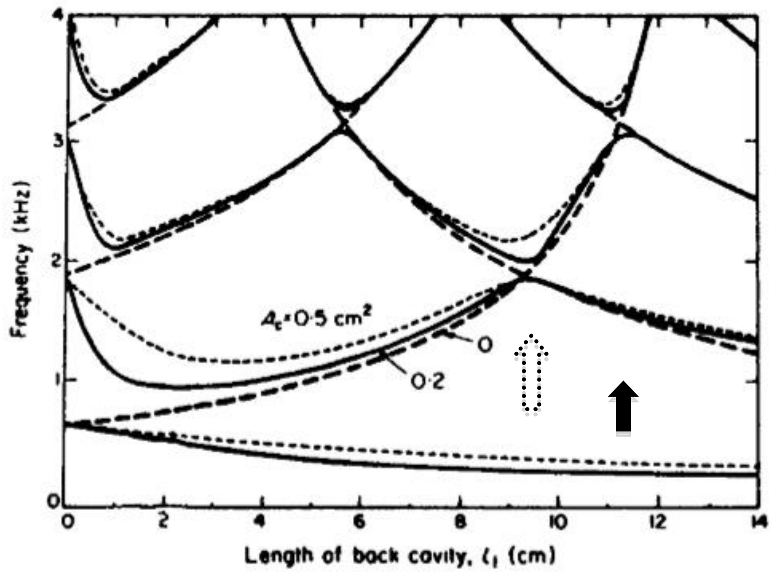

Figure 2. Configuration for consonants (Stevens 1989). Dotted arrow indicates palatal F2 estimate, black arrow indicates alveolar F2 estimate.

Based on Stevens model for relating formant values to place of articulation, 21 of the 200 total tokens were identified as palatal productions. The voicing bar on the spectrograms indicated that all of these palatal tokens were voiceless [ʃ], no cases were found of voiced palatal [zh] segments. The F2 measurements within each individual token did not show a significant change between the 25%, 50%, and 75% marks for the majority of tokens. According to these F2 measurements, 8 tokens suggested a change in place of articulation, occurring at the midway point, 4 of these showed a shift from the /s/ to /ʃ/ territory, and two followed the opposite pattern. Table 7 shows a sample of these tokens with the acoustic measurements.

Token	**Duration**	**F2 at 25%**	**F2 at 50%**	**Context**	**Production**
noveCiento-	0.137	2092	2517	e_ie	[s]-[ʃ]
soCio1	0.1196	1899	2499	o_io	[s]-[ʃ]
luneS	0.1872	2139	3094	e_u	[s]-[ʃ]
eScucha1	0.0776	1797	2645	e_k	[s]-[ʃ]
dice	0.0892	2745	2412	i_e	[ʃ]-[s]
dice	0.1043	2454	1891	i_e	[ʃ]-[s]

Table 7. Sample of tokens whose F2 values suggest change in place of articulation.

Spectral slices only confirmed one of these tokens as actually shifting from [ʃ] to [s]. The other two tokens that showed a change in place of articulation in F2 values were not confirmed by spectral slices either, one token shifted from [k] to [s] as the speaker cleared her throat (*solamente* [#kso.lo.men.te] 'only'), and the other seemed to shift from [s] to [z], but this was a result of the phonetic context in which the sibilant occurred: *lunes no* [lu.nes.ze.no] 'not Monday.'

For the remaining 192 tokens, the differences in F2 between the 25%, 50%, and 75% marks did not indicate a change in place of articulation. Based on these values, 22 tokens were identified as palatal productions (F2 range of 2416-3026 Hz with average of 2644 Hz). The remaining 175 tokens were identified as alveolar [s] (including 13 apico-alveolar tokens discussed later), with wide-ranging F2 values between 1720 and 2889 Hz, not including one outlier at either side of 1629 Hz (cosa [kosa] 'thing') and 3572 Hz (one of 3 tokens of 'Sang-hai'), respectively. These results are not unusual, particularly in running speech, since the model used can only account for ideal conditions. According to the Stevens model, the tokens measuring over 2500 Hz should be considered palatal productions. As all of these tokens were perceived as alveolar [s], the measurements of the formant energy peaks were used to confirm the alveolar place of articulation.

Examples of the spectrograms of two sibilant tokens in the words *sí* [si] 'yes' and *siempre* [ʃiem.pre] 'always', taken from the collected data, are provided below to illustrate the differences between average alveolar (Figure 3) and palatal (Figure 4) productions of the speaker.

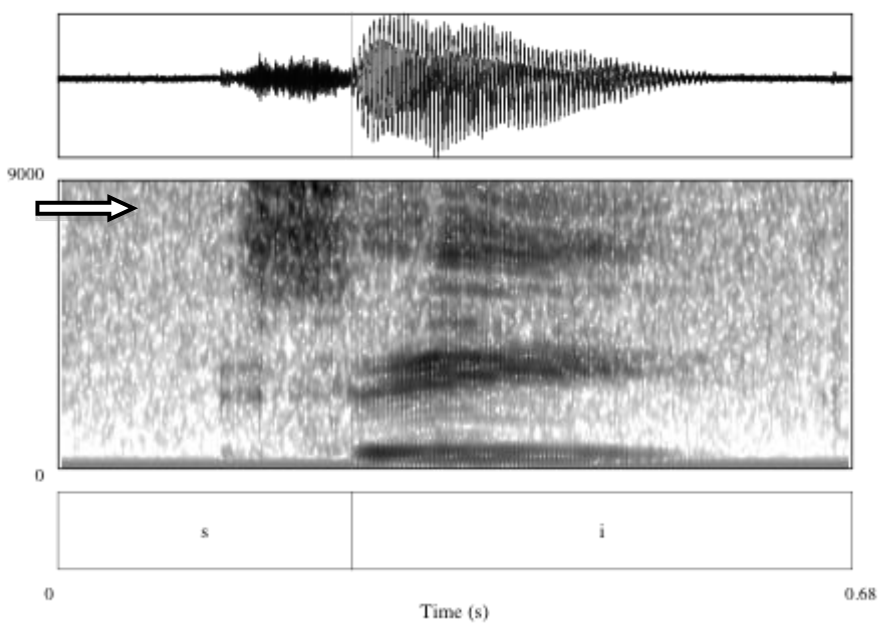

Figure 3. Alveolar production [s] in the word "sí." Arrow indicates formant energy peak.

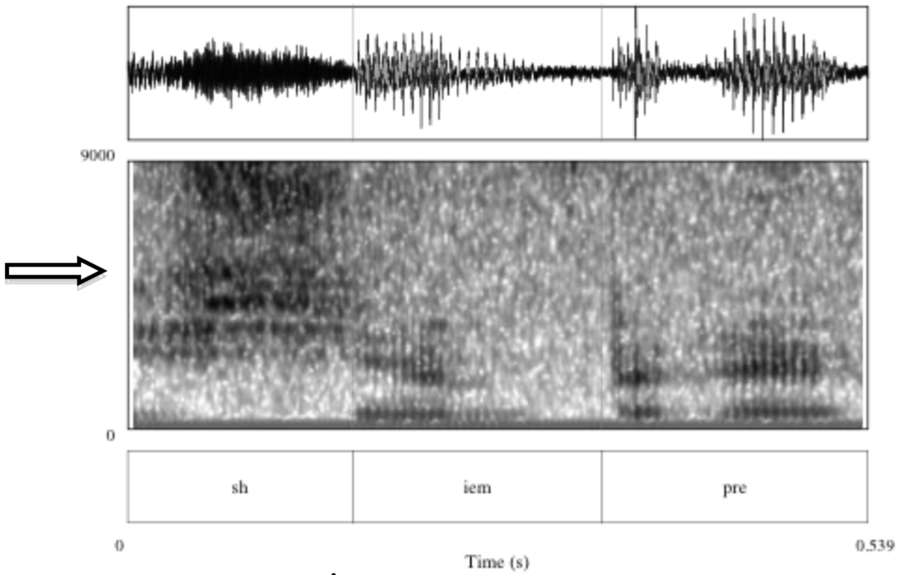

Figure 4. Palatal production /ʃ/ of the “s” in “siempre.” Arrow indicates formant energy peak.

Since the F2 frequency range of an alveolar segment is often very close to the range of palatal segments, and in running speech may even overlap, the measurements taken of formant energy peaks were able to provide a more precise account of place of articulation. The fricatives [s] and [ʃ] have significantly different spectral peaks, visible on spectrograms and measurable with spectral slices. The alveolar fricative generally has two peaks, a smaller one at around 4000 Hz, and a larger one between 6000 and 8000 Hz, while the palatal fricative usually peaks only once between 3000 and 4000 Hz. (Johnson 2003: 130) Figures 5 and 6 demonstrate these differences respectively.

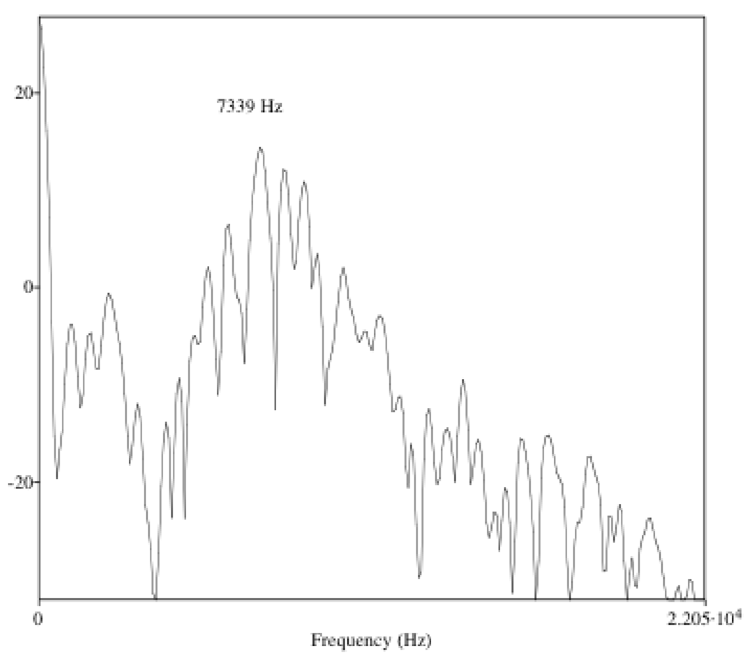

Fig 5. Spectral slice of alveolar [s] in “sí” at midpoint of segment, with energy peak of 7339 Hz.

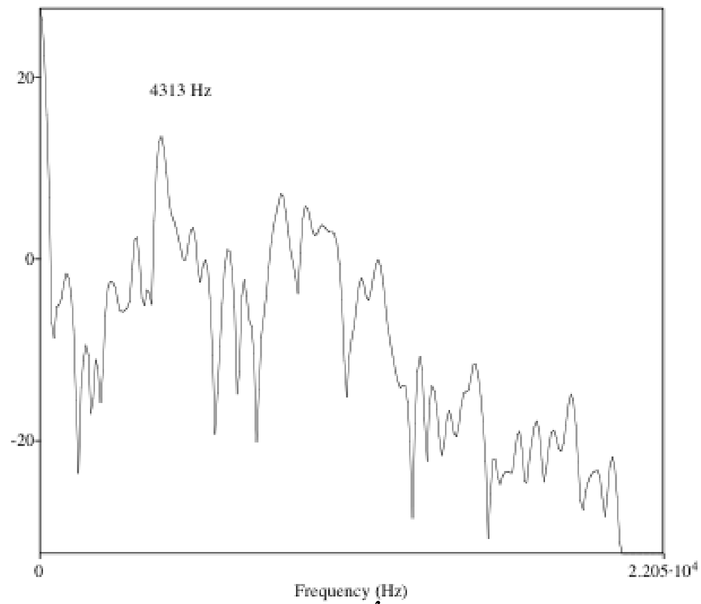

Fig 6. Spectral slice of palatal [ʃ] in "siempre" at midpoint of segment, with energy peak of 4313 Hz.

In addition to palatalization, this study is also interested in any voice assimilation of /s/, and acoustic evidence of interdental fricative [θ] or apico-alveolar [s] productions. The voicing bar in the spectrograms was used to identify a small voiced segment following word final /s/ in three tokens: *país* [pa.is.ə]'country,' *lunes* [lu.nes.ə] 'Monday,' and *a veces* [a.be.ses.ə] 'sometimes.' Although the speaker often added an epenthetic vowel after word final /s/ tokens, these three productions were unique because they were followed by words with word-initial sibilants. In running speech of native speakers, these conditions usually result in the combining of the shared phoneme as one segment. The voiced epenthetic in Jenny's productions seem to indicate that she maintains two separate alveolar sibilants across word boundaries as in the example, "a veces cenar," shown in Figure 7.

Aside from the 3 cases mentioned above, there were no tokens with a full voiced alveolar [z] or voiced palatal [zh] segment found in the Jenny's productions. However, she did produce 2 interdental fricative /θ/ tokens, both of the word "cinco," which appears a total of seven times.[5] These were difficult to identify because the [θ] portion did not replace any portion of an [s] segment, but rather always began immediately following it. Figure 8 shows the spectrograph of a token "cinco" that has the sibilant /s/ followed by the vowel /i/ without an additional fricative segment in between. In Figure 9, depicting one of the hybrid tokens, the spectrograph reveals the presence of a consonant between the /s/ and /i/ of a different token of the word "cinco." The interdental plus vowel segment is not easily perceived or distinguished from a vowel segment without the fricative, but spectrographic analysis illustrates a lowering of formants (consonants approach 0 Hz) followed by a rise to the vowel formant frequencies. Starting the audio after the [s] segment also facilitates auditory recognition of

[5] There was a token of the name "Alicia" that may also have an interdental /θ/ half-segment based on F2 values, but spectral slices could not confirm. The token is being coded as a palatal based on acoustic data.

the fricative. A comparison of the spectrographic images of Figures 8 and 9 illustrates this important finding.

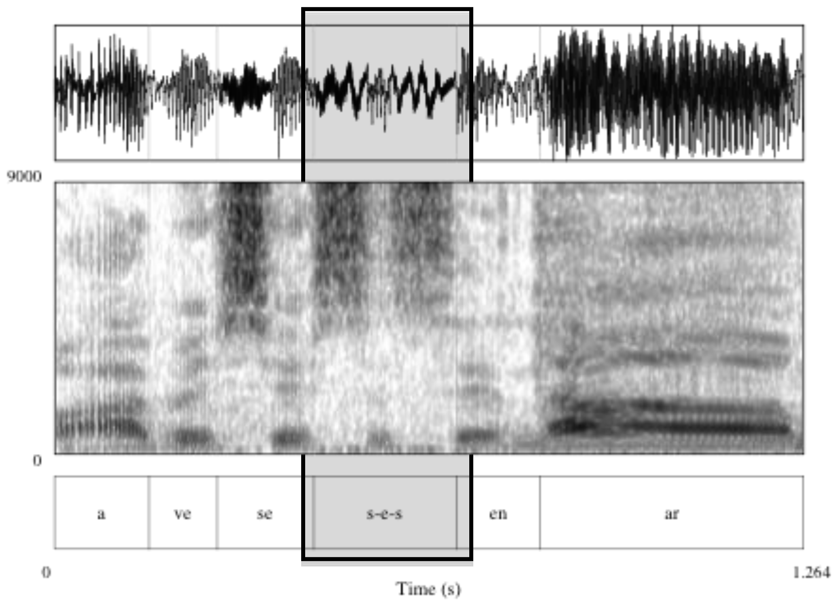

Figure 7. Spectrographic image of "a veces cenar" showing an epenthetic voiced segment between words.

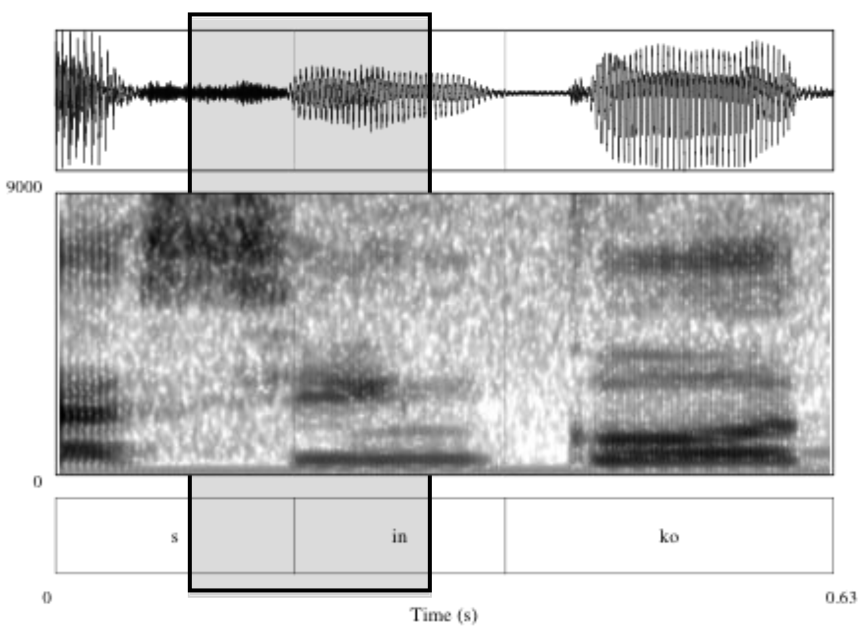

Figure 8. Image of "cinco" [sin.ko] without an interdental fricative production.

Perceptually, 13 tokens could be identified as apico-alveolar; however, acoustic software is not currently available to measure these productions. These tokens have an F2 range of 1809-2423 Hz, with an average of 2032 Hz. In the next step of this analysis, these tokens will be treated in two ways: first, as a separate category to give a preliminary account of the conditions that favor its use for future reference, and then combined with /s/ tokens for consistency within the corpus of the acoustic measurements.

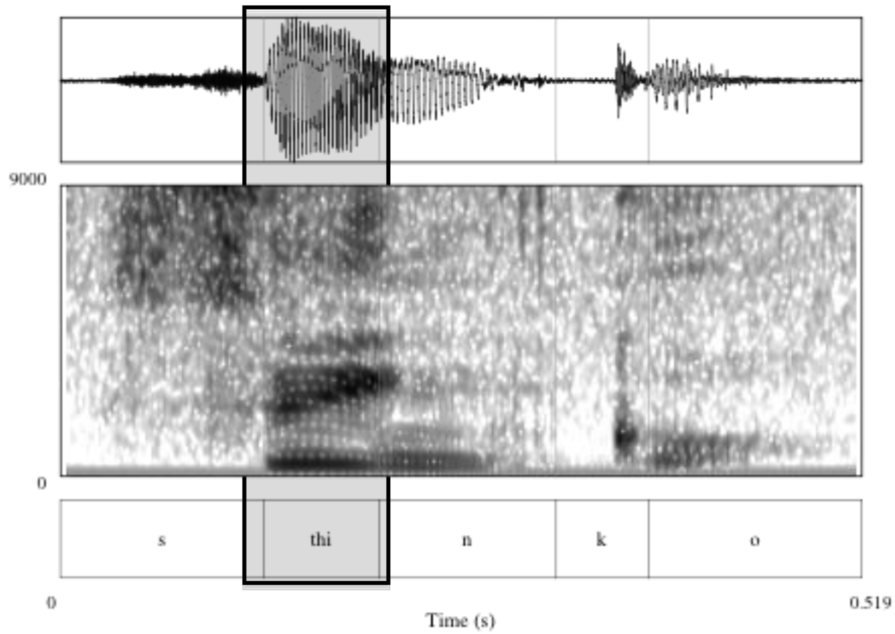

Figure 9. Image of "cinco" [sθin.ko] with interdental fricative between sibilant and vowel.

The duration measurements did not reveal a significant difference between alveolar and palatal sibilant productions. The average duration of all 200 tokens was 0.1158 seconds, where the average for alveolar productions was 0.1138 seconds, and the average duration for palatal productions was 0.1172. In terms of duration, the only average per token type found to be significant was the average duration of the perceived apico-alveolar [s] tokens, which was 0.1363 seconds. This can be explained by the fact that the majority of the latter tokens were produced in word-final position, which tend to be longer than word-initial or word-internal productions.[6] As for the difference between stressed and unstressed syllables, the average duration for sibilant segments inside an unstressed syllable was found to be slightly shorter (0.1115 seconds) than for stressed syllables (0.1222 seconds). However, this 11 ms difference was not considered significant.

Each token was coded for frequency within the corpus and in the CREA database of oral occurrences for Spain. Based on standard peninsular Spanish pronunciation, 149 of the tokens in this corpus were considered to be /s/ input cases, and the other 51 tokens were coded as /θ/ input cases. According to CREA, the /s/ tokens ranged from 9-16,015 occurrences, with an average of 3,210. The /θ/ words had a range of 50-3,363 with an average of 1,231 occurrences.

[6] Average duration for word initial sibilants is 0.1248 seconds, for word internal 0.0997, and for word final 0.1412 seconds.

5. Results

Acoustic measurements did not confirm any voiced sibilant [z] productions in Jenny's Spanish. Formant energy peak measurements were more accurate than F2 values in determining place of articulation of the speaker's sibilant tokens. According to the measurements of frequency of formant energy peaks, 22 out of 200 tokens are voiceless palatals [ʃ] (11%), and 178 tokens (89%) had a full alveolar [s] production, including two tokens that were followed by an interdental fricative /sθ/ and 13 tokens that were perceived as apico-alveolar realizations, though acoustic analysis cannot confirm this result.

Seventeen of the 22 palatal sibilants occurred before a palatal segment, [i] or [ie]. Browman and Goldstein's articulatory model can explain the palatalization of these tokens, where a regressive temporal overlap occurs on at least 50% of the sibilant segment in one case and 100% in the other cases. There does not seem to be a pattern to account for the palatalization of the other 5 palatal segments listed below. In examples 14-16, the /s/ segment is followed by a voiceless stop. Since s-clusters do not exist in Chinese, Jenny may be using palatalization to resolve the foreign phonotactics.

(12)	*solo*	[ʃo.lo]	'alone, only'
(13)	*sube*	[ʃu.be]	'rise'
(14)	*escucha*	[eʃ.ku.tʃa]	'listen'
(15)	*español*	[eʃ.pa.ɲol]	'Spanish'
(16)	*revista*	[re.biʃ.ta]	'magazine'

Spectrographic analysis was used to reveal the productions of interdental fricative [θ] segments following full alveolar /s/ sibilant segments for two of the seven "cinco" tokens. Though the number of tokens is minimal, this finding is significant to the acquisition process of a low frequency but heavily marked phoneme of peninsular Spanish.

As for the apico-alveolar tokens perceived, 9 of the 13 occurred in word final position, where the sibilant segments were also found to be longest in duration. This observation may suggest that this peninsular variant is more perceptually salient in word final position, but once recognized, can be acquired even by learners whose L1 does not include it.

In line with the Muyksen (1997) and Shi (1991) studies, Mandarin sibilants such as /ʃ/ and /z/ were expected when the phonetic context allowed for palatalization (as in the word "siete") and voicing assimilation ("lune**s** **n**o"). In general, Jenny does not seem to transfer voicing cues in the surrounding phonetic contexts of segments that can be voiced by native speakers ("desde," "mismo") to her productions. She does, however, attend to palatal segments resulting in her palatalization of [s] to [ʃ].

I also predicted that high frequency words, such as "más," would have more native-like realizations than lower frequency words. While the analysis could not confirm the role of frequency in regards to Jenny's productions, the data does suggest that frequency plays a significant role in her [sθ] and apico-alveolar productions.

Based on the data gathered and analyzed for this project, the following table offers a summary of the informant's sibilant system. Her default sibilant production is the voiceless alveolar fricative [s].

6. Discussion

According to the Distributional Bias Hypothesis, learners tend to produce the most frequent variant of a given form, often at the expense of ever acquiring less frequent forms.

PENINSULAR SPANISH	JENNY'S SPANISH	MANDARIN CHINESE
/s̱/, /θ/, ([z])	/s/, /ʃ/, /sθ/, /s̱/[7]	/s/, /z/, /ʃ/, /ts/, /dz/, /tsʰ/, /tʃʰ/

Table 8. Jenny's sibilant system compared to her source languages

This hypothesis has been widely applied by acquisition studies on morphosyntactic traits, and while the use of the DBH to explain phonemic variation is innovative, it has served this data well. In the case of CIS sibilant productions, the DBH predicted that Jenny would acquire and produce apico-alveolar (or rather her perception of it) rather than /θ/, because as shown by the corpus and CREA data, /s/ productions outnumber /θ/ productions 3:1 in the input she receives.[8] These predictions were, in fact, borne out. Based on the results of this study, the DBH does account for the distribution pattern of Jenny's sibilant productions: 176 [s] and only 2 [sθ]. Of the words included in this corpus, the most frequent words in the CREA oral database (Spain only) are "más" with 16,015 occurrences, and "está" with 10,535. Jenny's productions of "más" were perceived to have the apical realization of native peninsular speakers. The most frequent words in this data where the interdental fricative is the target were the words "dice," with 3,363 oral occurrences in CREA, and "cinco," with 2,455. Jenny's productions of "dice" were not realized with the [θ] or [sθ], but spectrographic analysis revealed the production of [sθ] in 2 of her 7 cases of "cinco." While the frequency of this lexical item in this data is low, the 2,455 count it received in CREA is very high for a /θ/ word. This suggests that Jenny hears the word often enough to perceive the phoneme.

7. Conclusion

The discovery of [sθ] in this data has important implications for debates on the acquisition of phonological traits not found in a learner's native language after the critical period. Spanish L2 phonology studies would benefit from further research on this phenomenon.

One of the shortcomings of this project was the inability to acoustically confirm the presence of apico-alveolar productions, as current technology does not yet allow it. In the meantime, a perceptual component by native speakers of the peninsular variety would serve to corroborate or contradict the suppositions of this researcher.

Future studies on CIS would benefit from a larger corpus, including both male and female speakers of different age groups. A larger data set would allow for a regression analysis to test the influence of linguistic and social variables on the speaker's productions. Study abroad research has found that L2 learner's pronunciation is influenced by: years of instruc-

[7] The apico-alveolar [s̱] is based on perceptual not acoustic analysis.

[8] Only 50/200 words in the corpus contain a sibilant segment pronounced as the interdental fricative by speakers of standard peninsular Spanish. Even if Jenny were only exposed to this variety, the productions of alveolar or apico-alveolar are three times more frequent.

tion, age the learner began instruction, and language use outside the classroom. (Díaz-Campos 2004) These are variables that could be tested on naturalistic learners as well.

Future work on the CIS variety should also aim to provide a complete description of the phonological system, including an acoustic analysis of vowels, voiced and voiceless plosives, nasals, liquids, fricatives, and affricates. To that end, the analysis presented in this study will hopefully serve as an initial step for future studies.

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