

Nonsibilant Fricative Acquisition by Bilingual Guoyu-Taiwanese Southern Min Children

THESIS

Presented in Partial Fulfillment of the Requirements for the Degree Master of Arts in the  
Graduate School of The Ohio State University

By

Jennifer Qian Zhang

Graduate Program in Linguistics

The Ohio State University

2016

Master's Examination Committee:

Dr. Mary Beckman, Advisor

Dr. Micha Elsner

Copyright by  
Jennifer Qian Zhang  
2016

## Abstract

Phonological acquisition by children is strongly influenced by language-specific and socio-environmental factors, rather than being determined strictly by linguistic universals or biological constraints. Although early research, primarily on the acquisition by English-speaking children, supported the hypothesis of linguistic universals, evidence from cross-language studies show wide variation in the acquisition order of sounds. Looking specifically at the acquisition of the nonsibilant fricatives /f/, /x/, and /h/, this study examines acquisition patterns by bilingual Guoyu-Taiwanese Southern Min speaking children in Taiwan. Transcription results show that while children are able to articulate both [x] and [h] before the age of 2;5 (2 years and 5 months), /f/ is phonologically acquired first around the age of 5, while /x/ and /h/ are acquired after the age of 6. The late acquisition of /x/ and especially /h/ may result from the wide range of /x/ and /h/ realizations by adults, due to the relative statuses of the two languages and the linguistic history of Taiwan. The current study complements Shih's (2012) study on the acquisition of sibilants to provide a holistic account of fricative acquisition by children in Taiwan.

## Acknowledgments

First and foremost, I would like to express the utmost gratitude to Mary Beckman for her mentorship and support over the past few years. With her genuine enthusiasm for a wide range of linguistic curiosities and her immense dedication to her work, she has been an enormous inspiration to me as I grow in my capacity as a researcher, and I aspire to one day encourage others even half as much as she has encouraged me. I would also like to extend my thanks to Micha Elsner for being ever open to offering assistance and for expressing his faith in my abilities, thereby spurring me to reach my potential.

This thesis would not have been possible without the support of Ya-ting Shih. I am grateful to have worked with her as an undergraduate and to have her continued correspondence despite the changes in time and distance. I would also like to thank the members of Lacqueys for their insightful comments and suggestions on the present thesis, and I express my thanks to Cynthia Clopper and my classmates from her journal writing workshop for the valuable feedback on previous work with Ya-ting.

For moral support, I thank the members of my half-cohort, and in particular, David King, Martha Austen, and Ellen Dossey. I would also like to express my immense gratefulness toward Vi Le for steadfast companionship and treasured conversations. Finally, I would like to express special thanks to Toni Vesala for his patience and neverending encouragement through this entire journey.

## Vita

2008 ..... Hudson High School  
2012 ..... B.A. Linguistics, The Ohio State University  
2016 to present ..... Graduate Research Assistant, Department of  
Linguistics, The Ohio State University

## Publications

Shih, Y., Kallay, J., & Zhang, J. (2012). Sibilant production patterns in three generations of Guoyu-Taiwanese bilinguals [Abstract]. *Journal of Acoustical Society of America*, 132, 1938.

## Fields of Study

Major Field: Linguistics

## Table of Contents

Abstract .....	ii
Acknowledgments .....	iii
Vita .....	iv
Table of Contents .....	v
List of Tables.....	vii
List of Figures .....	viii
Chapter 1: Child Phonological Acquisition .....	1
1.1 Introduction.....	1
1.2 Fricatives and Acquisition .....	3
1.3 Acquisition by Monolingual English Children .....	5
1.4 Cross-linguistic Variation.....	7
Chapter 2: Language Background of Taiwan .....	14
2.1 Language History .....	14
2.2 Phonology of Guoyu .....	17
2.3 Phonology of Taiwanese Southern Min .....	20
2.4 Relationship among Nonsibilant Fricatives.....	22

Chapter 3: Research Methodology .....	27
3.1 Research Questions .....	27
3.2 Participants .....	27
3.3 Stimulus Materials .....	28
3.4 Procedure .....	29
3.5 Data Analysis .....	31
3.5.1 Transcription .....	31
3.5.2 Determining the Age of Acquisition.....	34
Chapter 4: Results.....	36
4.1 General Results .....	36
4.2 Phonetic Acquisition .....	39
4.3 Phonological Acquisition .....	39
4.4 Phonological Mastery.....	41
4.5 Errors and Error Rates .....	42
Chapter 5: Discussion.....	45
5.1 Discussion.....	45
5.2 Conclusion .....	48
References .....	50
Appendix A: Word Lists.....	58

## List of Tables

Table 1. Word-initial fricatives in English. ....	5
Table 2. Acquisition age of English fricatives by American English children. ....	6
Table 3. Age of fricative acquisition across various languages. ....	11
Table 4. Surface consonants of Guoyu. ....	18
Table 5. Surface vowels of Guoyu. ....	20
Table 6. Surface consonants of Taiwanese Southern Min. ....	20
Table 7. Surface vowels of Taiwanese Southern Min. ....	22
Table 8. Number of child participants. ....	28
Table 9. Percent accuracy (s.d.) of nonsibilant fricatives across age groups.....	36
Table 10. Phonetic acquisition of nonsibilant fricatives. ....	39
Table 11. Percent of children with 75% or greater accuracy. ....	40
Table 12. Percent of children with 90% or greater accuracy. ....	41
Table 13. Guoyu word list. ....	58
Table 14. Taiwanese Southern Min word list. ....	58



## List of Figures

Figure 1. Allophones of /f/ and /x/.	24
Figure 2. A screenshot of the "Show and Play" word repetition task.	30
Figure 3. A production of target /f/ by a 5 year old child.	32
Figure 4. A production of target /x/ by a 3 year old child.	33
Figure 5. A production of target /h/ by a 3 year old child.	33
Figure 6. Accuracy (s.d.) for nonsibilant fricatives across all age groups.	37
Figure 7. Generalized linear model of the acquisition of nonsibilant fricatives.	38
Figure 8. Phonological acquisition of nonsibilant fricatives.	40
Figure 9. Phonological mastery of nonsibilant fricatives.	42
Figure 10. Substitutions for /f/ across all age groups.	43
Figure 11. Substitutions for /x/ across all age groups.	43
Figure 12. Substitutions for /h/ across all age groups.	44
Figure 13. Stop substitutions for Taiwanese Southern Min /h/ and for Guoyu /x/ by children older than 6.	47

## Chapter 1: Child Phonological Acquisition

### *1.1 Introduction*

In his influential work on child language acquisition, Jakobson (1941/1968) argued that there were universal restrictions placed on the structure of the consonant and vowel inventories of languages, which are mirrored in the order in which sounds are added to a child's phonology. For example, languages with a back consonant /k/ must also have the front consonant /t/, though the opposite is not true; the predictability between /k/ and /t/ is unidirectional. These "laws of irreversible solidarity" also describe a specific acquisition order of speech sounds. Front consonants and stops would be acquired before back consonants and fricatives respectively. The acquisition of fricatives would imply the previous acquisition of stops, and in the early stages of acquisition, fricatives would be replaced by stops.

While Jakobson only sometimes described a phonetic basis for his "laws", some researchers who posit universal restrictions have emphasized the role of articulatory constraints due to anatomical and neurophysiological developments as a child matures. In his examination of infant babbling, Locke (1983) found no detectable differences in consonantal babbling across different language environments. Furthermore, he noted that most of the consonants produced by infants younger than 6 months old involved tongue body constrictions, which were later outnumbered by consonants that required tongue tip

and lip constrictions. Locke argued that the pattern of emergence in infant babbling could be linked to the physical maturation of the vocal tract and the maturation of speech motor control.

In evaluating claimed universals, other researchers have noted contradictory evidence showing that there can be wide variation in the acquisition order of different sounds, due to language-specific and socio-environmental factors. The remainder of this chapter describes the evidence for cross-linguistic variation in the order of fricatives. This is a class of sounds that includes both [h], a sound in English that is among the first consonants to be produced by children, and [ʃ], one of the last consonants to be acquired in English.

This thesis explores the relative roles of universal articulatory constraints and language-specific factors by investigating the acquisition patterns of children in Taiwan who are acquiring both Taiwanese Southern Min and Guoyu, the standard dialect of Mandarin spoken in Taiwan, in order to determine the acquisition order of the nonsibilant fricatives /f/, /x/, and /h/. Production data was collected from a population of children in Kaohsiung, Taiwan and transcribed for accuracy. The order of acquisition was found to be different from the patterns predicted by a linguistic universal or biological constraint account, in that /f/ was the first nonsibilant to be acquired around the age of 5, and /x/ and /h/ were acquired after the age of 6.

## *1.2 Fricatives and Acquisition*

Fricatives are produced by forcing air through a narrow channel, generating turbulence known as friction. They can be characterized in terms of four different attributes: amplitude, duration, spectral properties during the fricative, and transitions into and out of the surrounding vowels. The overall spectral shape of a fricative is determined by the size and shape of the oral cavity before the place of constriction (Reetz & Jongman, 2009). Fricatives may be further separated into two categories: sibilants and nonsibilants. Sibilant fricatives, such as [s, ʃ, ʂ, ʐ], have greater acoustic energy than nonsibilants like [ɸ, f, v, θ, x, χ], which have less acoustic noise and are therefore less audible (Ball & Rahilly, 1999).

This class of sounds may be more difficult overall, relative to stops which are generally acquired earlier. Finer tuned acoustic differences, e.g. differences between [f] and [θ] or between [s] and [ʃ], may be missed or ignored (Miller & Nicely, 1955). In addition, Nittrouer (2002) found that children of different ages attended to different aspects of the acoustic signal, and older children attended more to differences in the fricative spectrum, particularly along a continuum between [s] and [ʃ]. Younger children attended more to formant transitions, rather than fricative noise, suggesting that the way in which children perceive fricatives modifies with age and as they gain experience with a native language. Fricatives are also considered to be more complex and difficult to produce, or phonologically "marked", than stops, nasals, and glides. The production of fricatives requires more precise motor control and positioning of the tongue than earlier

acquired sounds, in tandem with the fine force regulation necessary to generate the turbulent noise characteristic of fricatives (Kent & Murray, 1982; Kent, 1992).

Many production studies on child acquisition (e.g. Prather et al., 1975; Smit et al., 1990) support the hypothesis that fricatives are generally acquired later than stops, but fewer studies (e.g. Ferguson, 1973; Ingram et al., 1980) have focused on the relative order of the acquisition of different fricatives within a language. Cross-linguistic studies, either on general acquisition of consonants or specifically fricatives (e.g. Li et al., 2009; Shih, 2012; Bernhardt et al., 2015) are even more rare.

The consonants examined in this study are the nonsibilant fricatives, Guoyu /f/ and /x/ and Taiwanese Southern Min /h/. Labiodental [f] is produced with the airstream directed through a narrow constriction against the upper lip. The energy of [f] and other labial fricatives is spread over a large frequency range and is characterized by a relatively flat spectrum. Velar [x] has energy concentrated at lower frequencies which will match the F2 at the onset of the following vowel (Reetz & Jongman, 2009). The spectrum of [x] is also characterized by well-defined striations, especially in comparison with [h], another fricative with compact low-to-mid frequency energy. The fricative [h] is a continuant characterized by low-amplitude aperiodic noise which arises at the vocal folds. There is no constriction in the oral cavity for the production of [h] and this sound is arguably less difficult to produce than other fricatives, as no precise positioning of the articulators is required to generate turbulence (Bernhardt, Másdóttir, Stemberger, Leonhardt & Hansson, 2015).

### *1.3 Acquisition by Monolingual English Children*

From the 1960s, especially after the English publication of Jakobson (1968), there has been an increase in research on child language acquisition and child phonology. Early research (Ferguson, 1973; Templin, 1957) showed that fricatives and affricates were among the most difficult class of sounds for English-speaking children, usually among the last sounds to be acquired. Table 1 lists the fricative inventory of English, with voiceless fricatives to the left of each cell and voiced fricatives to the right.

	Place of articulation								
	Labiodental		Dental	Alveolar	Postalveolar	Glottal			
Fricative	f	v	θ	ð	s	z	ʃ	ʒ	h

Table 1. Word-initial fricatives in English.

Wellman, Case, Mengert and Bradbury (1931), using a 75% accuracy criterion, found that the fricatives /h/ and /f/ were acquired by the age of 3 years, /s, v, z/ at the age of 5, /ʒ/ at the age of 6, and /θ/ sometime after the age of 6. Ingram et al. (1980) performed a cross-sectional study specifically on the acquisition of English fricatives with 73 children aged 1(year);10(months) - 5(years);11(months). Using a 70% accuracy criterion, they found that, of the fricatives studied, /f/ was acquired first by the age of 3;0, followed in order by /ʃ/, /s/, /v/, /z/, and /θ/. Table 2 summarizes the age of acquisition for word-initial English fricatives from studies by Templin (1957), Prather, Hedrick and Kern (1975), and Smit, Hand, Freilinger, Bernthal, and Bird (1990). Different criteria for acquisition of a sound were used among the three studies, with Templin and Prather et al.

assigning age of acquisition as when 75% of children within an age group were able to correctly produce the sound in initial and final position, and Smit et al. using a 75% and 90% by age group criteria. None of these studies tested /z/ as it does not occur in any picturable words that young children might know.

	Templin (1957)	Prather et al. (1975)	Smit et al. (1990)	Smit et al. (1990)
Fricative	75% age group	75% age group	75% accuracy	90% accuracy
h	<3;0	2;0 - 2;6	<3;0	3;0
f	<3;0	2;6 - 3;0	<3;0 - 3;6	3;6
s	4;6	3;0 - 3;6	3;0 - 5;0	7;0 - 9;0
ʃ	4;0	3;6 - 4;0	4;0 - 5;0	6;0 - 7;0
ð	7;0	4;0 - 4;6	4;0 - 5;6	4;6 - 7;0
v	6;0	> 4;6	4;0 - 4;6	5;6
θ	6;0	> 4;6	5;6 - 6;0	6;0 - 8;0
z	7;0	> 4;6	5;0 - 6;0	7;0 - 9;0

Table 2. Acquisition age of English fricatives by American English children.

In addition, the Goldman Fristoe Test of Articulation (Goldman, Fristoe, & Williams, 2000) offers guidelines for child speech pathologists to monitor the acquisition of consonants. For example, children should be able to accurately produce /h/ by the age of 2-2;6, /f/ by the age of 3;6-4;6, /s, ʃ/ by the ages 4;6-5;6, and /θ/ only by the age of 8-8+, with each of the voiced fricatives being produced accurately later than its voiceless counterpart.

Dodd, Holm, Zhu, and Crosbie (2003) also examined the phonetic acquisition of sounds, defined as when 90% of children in an age group were able to spontaneously

produce or imitate a sound, judged without consideration of whether it is the target sound. They found that the earliest phonetically acquired fricatives were /h, f, v, s, z/, all being produced at 3;0-3;5, the youngest age group in their study. In summary, specifically regarding the nonsibilant English fricatives /f/ and /h/, /h/ has been found to be acquired earlier or around the same age as /f/ for monolingual English-speaking children.

#### *1.4 Cross-linguistic Variation*

Slobin (1985) emphasizes the necessity to examine cross-linguistic patterns in development, as such studies can further illuminate universals as well as provide evidence for how the properties of different languages influence acquisition. By examining both developmental universals and patterns which are particular to a specific group of children or language, we can see how patterns of acquisition may vary across languages and whether there are any shared patterns that are determined or at least influenced by universals.

Evidence from cross-linguistic studies seem to refute claims about the role of strict universals in language acquisition. Macken and Barton (1980) showed that the acquisition of voicing contrast between English- and Spanish-speaking children varied, with English-speaking children acquiring the voiced initial stop contrast under the age of 1;10-2;8, while Spanish-speaking children did not acquire the voicing contrast until after the age of 4. These differences in order of acquisition correlated with a difference in the realization of the voicing contrast in word-initial context between the two languages and an associated difference in the distribution of voiced and voiceless stops in word-medial



context between the two languages, and as such, Macken and Ferguson (1981, 1983) suggest that acquisition patterns may be due to a child's individual experience with language, rather than universals.

Essentially, Macken and Ferguson argue that the regularities that may arise in child acquisition patterns are due to similarities in a child's categorization abilities and broad similarities between phonological systems of various languages, i.e. the phonemic inventory of a language characterizes a child's first phonemes (also argued by Ingram, 1992). Additionally, Vihman (1993), summarizing longitudinal studies of children acquiring English, French, Japanese, and Swedish, showed that even children acquiring the same language have different acquisition patterns. Overall, there are relatively few patterns present from the very initial stages of acquisition that provide evidence of innate linguistic universals, and therefore, a view that child language acquisition is shaped solely by innate or biological factors may be erroneous.

Studies of the acquisition patterns of children learning different languages have found varying results as well. For instance, Fox and Dodd (1999) studying German-acquiring children aged 1;6-5;11 found a more rapid acquisition rate compared to English-acquiring children, with phonemes such as /d, v, s, z/ acquired earlier. So and Dodd (1995), studying the acquisition of Cantonese consonants, have found that /h/ (2;7-3;0) is generally acquired earlier than /f/ (3;1-4;0), in keeping with the English pattern, but they also found a more rapid acquisition rate for /s/ in Cantonese and identified language-specific error patterns, such as the affrication of /s/ as [ts].

Edwards and Beckman (2008b) also found language-specific acquisition patterns with regard to within-language phoneme frequency in their study of coronal fricatives, stops, and affricates in monolingual children acquiring English, Cantonese, Greek, and Japanese. When comparing the acquisition of word-initial /s/ and /θ/ by English and Greek children, Edwards and Beckman found that although both groups of children had similarly high accuracy rates for /s/, English-acquiring children were much less accurate in their productions of /θ/, a sound that is less perceptually salient than /s/ and also less frequent in English than in Greek. In a parallel comparison of word-initial /t/ and /ts/ as acquired by Greek and Cantonese-speaking children, both groups of children acquired /t/ before /ts/. However, /ts/, which is much less frequent word-initially in Greek compared to Cantonese, was found to be significantly less likely to be transcribed as correct for children acquiring Greek than for those acquiring Cantonese. When comparing /t/ and /tʃ/ acquisition by English and Japanese children, while English children produced /t/ more accurately than /tʃ/ in all vowel contexts, the word-initial stop was not found to be more accurate than the affricate overall for Japanese-acquiring children. These results were attributed to differences in within-language frequency effects, along with universal factors of perceptual salience and relative articulatory ease or difficulty.

Pye, Ingram, and List (1987) studied the acquisition of a larger set of consonants of Quiché, a Mayan language, by children aged 1;7-3;0 over a 9 month period and found that their phonological acquisition pattern was different from that of English-speaking children. Quiché-speaking children acquired the fricative /x/ before English-speaking children acquired /f/, and notably, of the sounds shared by Quiché and English, /tʃ/ and /l/

appeared much earlier for Quiché-speaking children. Furthermore, Pye and colleagues found that /tʃ/ occurred much more frequently in Quiché words than in English words, and /l/ was nearly twice as frequent in the words that Quiché children used, compared with English children.

Amayrah and Dyson (1998) examined the acquisition patterns of Arabic-speaking children in Jordan, aged 2;0-6;4. Although the general acquisition order of Arabic consonants was found to be similar to that of English, some consonants (i.e. /t/ at 2;6, /f/ at 2;6, /l/ at 3;6) were acquired earlier than the corresponding English phonemes. Other sounds were acquired later, such as /h/ (5;0-5;4), /j/ (6;0-6;4), and /dʒ, ð/ (>6;0-6;4). Amayreh and Dyson also found a relatively early acquisition of voiceless uvular /χ/ at the age of 4;6-4;10, a sound which contrasts with many different consonants in Arabic. Additionally, children acquired the back fricatives /χ/, /ʁ/, /ħ/, and /h/ at widely different ages, with /h/ acquired at 2;6, /χ/ at 4;6-4;10, /ħ/ at 5;0-5;4, and /ʁ/ at 6;0.

MacLeod, Sutton, Trudeau, and Thórdardóttir (2011), looking at consonant acquisition by Québécois French-speaking children aged 1;8-4;5, found a similar age of mastery for many fricatives, although these children acquired /v/ and /z/ earlier than their English-speaking counterparts. Másdóttir (2008) found that Icelandic children acquired /h/ at 2;0-3;4, possibly earlier than English-speaking children. Icelandic children acquire /f/ at 3;4, slightly later than English-speaking children, and among the last fricatives to be acquired was /x/, word-finally, at the age of 6;0-6;11. Maphalala, Pascoe, and Smouse (2013) investigated phonological acquisition of isiXhosa by children in South Africa and found that children were able to produce [f] as well as the voiced glottal fricative [ɦ] at

3;0-3;6. Children acquired /f/, /x/, and the voiced glottal fricative at the age of 3;7-4;0, showing a rapid acquisition of /x/, as it was not found in children's earlier phonetic inventory.

The results regarding nonsibilant fricative acquisition by these and other cross-linguistic studies, including studies of Cantonese (So & Dodd, 1995), Dutch (Mennen et al., 2007), Greek (cited by Mennen & Okalidou, 2007: Papadopoulou, 2000), and Hebrew (cited by Ben-David & Berman, 2007), are summarized in Table 3. Maphalala et al. (2013) used a single 85% criterion, and to be on the more conservative side, their results are displayed under the 75% column. Although studies in several languages suggest, for example, that /h/ is generally acquired before /f/ and /x/, the variation of age of acquisition among these fricatives can be clearly seen.

Language	f		x		χ		h	
	75%	90%	75%	90%	75%	90%	75%	90%
Arabic	2;6-2;10	2;6-2;10			4;6-4;10	4;6-4;10	5;0-5;4	5;0-5;4
Cantonese		4;0						3;0
Dutch	2;3-2;5		2;0-2;2				2;0-2;2	
German	2;6-2;11	2;6-2;11	2;6-2;11	2;6-2;11			2;0-2;5	2;6-2;11
Greek	3;7-4;0	3;7-4;0	3;7-4;0	3;7-4;0				
Hebrew		3;0		3;0				> 5;0
Icelandic		3;4						2;0-3;4
isiXhosa	3;7-4;0		3;7-4;0					

Table 3. Age of fricative acquisition across various languages.

Zhu and Dodd (2000) studied the acquisition specifically of Putonghua, or standard Mandarin, by monolingual children in Beijing, aged 1;6-4;6. They found that 90% of children were able to articulate [x] at the age of 1;6-2;0, and [f] at the age of 2;1-2;6. These sounds were acquired phonologically both by 90% of children at the age of 2;7-3;0. Additionally, they found that there were phonemes, such as /f/, which were acquired relatively soon after the child was able to articulate them.

A longitudinal study by Jeng (1979) followed the acquisition of Guoyu, or the standard dialect of Mandarin spoken in Taiwan, by two Taiwanese boys aged 0;2-1;8 and 1;3-2;7. The earliest consonants to emerge were /p, t, k, ts/, followed in order by nasals, aspirated stops, fricatives (except /f/), and the approximant (not the alveolar trill) transcribed as /r/. The categorization of this approximant will be discussed in greater detail in section 2.2. In Jeng's study, the fricative /f/ was the last sound to emerge. Hsu (1987) performed a cross-sectional longitudinal study with 20 children aged 1;0-6;0, also acquiring Guoyu in Taiwan, and noted that children aged 4;4-6;0 still made errors with their productions of /f/.

As stated previously, this study seeks to build upon the results of Shih (2012), and as such, the acquisition of sibilant fricatives will be discussed here briefly. While Zhu & Dodd (2000) found that children acquiring Putonghua in Beijing acquired /ɕ/ first, followed by /s/, and finally /ʃ/, Li and Munson (2016) note that the elicitation of the voiceless sibilant fricatives was both sparse and unbalanced, in that /ɕ/ was elicited 8 times in word-initial position, /ʃ/ was elicited 4 times in word-initial position, and /s/ was elicited just once in word-medial position. Through transcription and acoustic analyses,

Li and Munson found a different sibilant acquisition order by monolingual Putonghua-speaking children in Songyuan. These children acquired /ɕ/ first, followed by /ʃ/, and finally /s/, and they argue that this pattern is influenced by both maturation of oral-motor control and language-specific phoneme frequency. Shih (2012) found a contrasting pattern in bilingual speakers of Guoyu and Taiwanese Southern Min, in that /s/ was acquired first, followed by /ɕ/, and then /ʃ/. Shih attributes the late acquisition of /ʃ/ to greater articulatory complexity and the relationship between /s/ and /ʃ/ in Guoyu, where some speakers have a clear contrast but others may produce [s] for /ʃ/, in keeping with a merger of /s/ and /ʃ/ that is wide-spread across many regional dialects of Mandarin Chinese outside of Beijing (see, e.g., Duanmu, 1970, and also the pronunciations recorded for words such as ‘watermelon’ and ‘stone’ in the 8 Mandarin dialects listed in Beijing University Chinese Department, 1964).

## Chapter 2: Language Background of Taiwan

### *2.1 Language History*

Taiwan has a population of roughly 23 million people of four different ethnolinguistic groups. The largest of these groups, Southern Min (73.3% of the population), migrated from Fujian province in the southeast of mainland China around the 17th century. This population speaks Taiwanese Southern Min (aka Taiwanese, Southern Min, Minnan, Hokkien, Amoy, Tai-gi). The Hakka people (12%), who speak Hakka, immigrated from Guangdong province shortly after, in the 18th century. Mainlanders (13%) are those who fled China after the Communist Party's victory over the Kuomintang (KMT) in 1949; this group speaks Guoyu, or Taiwanese Mandarin. The fourth group (1.7%) consists of the aborigines of the islands, who speak Austronesian languages (Huang, 2000; Sandel, 2003; Chen, 2010).

Taiwan experienced a period of Japanese colonization between 1895-1945. During this time, Japanese was made the official language. All other local languages were banned, although many people still spoke their native languages in the home. This pattern repeated when the KMT took over Taiwan, establishing a strict Mandarin-only policy. The standard Mandarin dialect was called *Guoyu* "national language" to contrast with *Putonghua* "common speech" in the mainland. Guoyu became the sole language of schooling, with many teachers who were still in the process of gaining fluency in Guoyu.

Beginning in 1958, all students had to pass a Guoyu proficiency exam as a prerequisite for graduation (Young, 1988). During this period, Guoyu was perceived to be the more prestigious language and Taiwanese Southern Min was considered to be lower class (Hsiau, 2000; Sandel, Chao & Liang, 2006).

In 2000, when the Democratic Progressive Party (DPP) took office, the government promoted Taiwanese nationalism, emphasized Taiwanese identity, and committed to improving the status of local languages, especially Taiwanese Southern Min. The Mother Tongue Language Policy, whose origins are linked to the establishment of the DPP, was formally implemented in 2001, incorporating Taiwanese ethnic language teaching (Taiwanese Southern Min, Hakka, Austronesian languages) into the formal curriculum of students from first to sixth grade (Chen, 2006, 2010). Public announcements on trains and subways are also now in both Guoyu and Taiwanese Southern Min, and sometimes Hakka as well, demonstrating the multilingual status quo of Taiwan (Shih, 2012). Although Taiwanese Southern Min may still not share the same language status as Guoyu, perceptions of Taiwanese Southern Min are not as negative as they were previously.

The language proficiencies of the present population vary greatly with age. Through a questionnaire survey with both urban and rural speech communities through Taiwan, Chen (2010) found that about 98% of all participants across age groups, home language, and other factors, rated themselves as being able to fluently speak Guoyu, while only 68% responded similarly for Taiwanese Southern Min. In addition, older people reported higher proficiencies in Southern Min or Hakka. Of the participants aged



60 and older, 100% reported that they spoke Taiwanese Southern Min fluently, followed by 93% of speakers aged 30-60, and 71% of 19-29 year olds. Conversely, only 67% of the 60+ age group rated themselves as fluent in Guoyu.

Sandel et al. (2006) examined the language use of extended families mostly from Taichung. Taichung, in the central part of Taiwan, acts almost as a dividing line between Guoyu and Taiwanese Southern Min, with those north of Taichung using more Guoyu and those south of Taichung using more Taiwanese Southern Min. These families included grandparents, parents, and children, and Sandel and colleagues found that the parents' generation would use Taiwanese to speak to the grandparents, but tended to use Guoyu when speaking to the children.

The oldest age group of speakers in Shih's (2012) study, or the grandparents, are Taiwanese Southern Min-dominant. They acquired Taiwanese Southern Min in the home as their L1 and learned Guoyu as an L2 from Guoyu L2 teachers when they began going to school at the age of 7. Speakers between the ages of 20-40 had more balanced access to Guoyu and Taiwanese Southern Min, and speakers are either Guoyu- or Taiwanese Southern Min- dominant depending on their families. Children in Taiwan are becoming more and more Guoyu-dominant, consistent with Sandel et al.'s (2006) findings that support the hypothesis that Taiwan is undergoing a language shift from Taiwanese Southern Min and other ethnic languages to Guoyu.

## *2.2 Phonology of Guoyu*

Putonghua, or the standard dialect of Mandarin spoken in China, has a series of retroflex consonants [ʂ, tʂ, tʂʰ] which are characteristic of speakers specifically from Beijing. Speakers in other regions often do not have the retroflex series in their native dialects and they often substitute dental [s, ts, tsʰ], or they may substitute retroflex [ʂ, tʂ, tʂʰ] for dentals in hypercorrection (Duanmu, 2007). The contrast between the dental and retroflex fricatives, although emphasized in primary education and through textbooks, is unstable, in that some speakers make the contrast while others do not (Lin, 2007). Regarding the surface palatal [ɕ], researchers disagree as to whether it should be considered a phoneme or an allophone. That discussion is beyond the scope of this thesis and as such, the palatal series is included as a surface consonant.

Standard Guoyu also demonstrates the common merger and fronting of the retroflex series (Zhu, 2002; Chung, 2006; Brubaker, 2012), and some researchers (cited in Lin, 2008; Dong, 1995) argue that this convergence is phonemic. Phonemes such as /f/ or /x/ which are not found in Taiwanese Southern Min may also be realized with several allophones. This variation in /f/ and /x/ will be discussed in greater detail in a following section. Table 4 shows the surface consonants of Guoyu, adapted from the surface consonants of standard Putonghua based on Cheng (1973), Duanmu (2007), and Lin (2007).

Manner of articulation	Place of articulation					
	Bilabial	Labio-dental	Dental	Retroflex	Palatal	Velar
Stop	p, p <sup>h</sup>		t, t <sup>h</sup>			k, k <sup>h</sup>
Affricate			ts, ts <sup>h</sup>	tʂ, tʂ <sup>h</sup>	tɕ, tɕ <sup>h</sup>	
Nasal	m		n			ŋ
Fricative		f	s	ʂ (z)	ɕ	x
Approximant	w, ɥ			ɻ	j, (ɥ)	(w)
Lateral approximant			l			

Table 4. Surface consonants of Guoyu. The doubly-articulated labiovelar and labiopatal semivowels are listed both in the “Bilabial” column and (in parentheses) in the column for the lingual place of articulation.

Duanmu discusses the transcription of [z] versus [ɻ] for the voiced retroflex onset consonant (as opposed to the clearly approximant retroflex coda consonant), stating that some researchers (including Duanmu (2000) in the first edition of the same text) have elected to use the latter, but Duanmu (2007) chooses voiced [z] due to the resulting symmetrical relationship with the voiceless [ʂ] that mirrors the relationship between [z] and [s]. This thesis follows Lin (2007) however, who chooses to categorize the sound as [ɻ]. This convention allows for an explanation of r-suffixation, also called *erhua*, commonly associated with speakers from Beijing, which is an allomorph of the nominalizing or diminutive suffix /tzi/. The phonetic realization of the suffix ranges from [r], [ɻ], [ʂ], and/or a retroflex feature on the preceding vowel. On the other hand, Lin notes that Guoyu speakers often replace onset [ɻ] with [z] or [l] (which is also the obstruent allophone of /n/ before oral rhymes), and they rarely have r-suffixation. Some

Guoyu speakers may pronounce *er* "son" as [əɪ], but others, especially those with a strong Taiwanese accent, pronounce the word instead as [ə] or [ɤ]. Thus, the argument for equating the voiced onset retroflex with the coda retroflex from the *erhua* allomorph may be less compelling for Guoyu than for Putonghua.

The three approximants (labiovelar [w], labiodental [ɸ], palatal [j]) are also called glides or semi-vowels, based on an analysis of these consonants as underlying high vowels, which are assigned to onset position when followed by mid or low vowels. By this analysis, the approximants [w], [ɸ] and [j] are the consonantal variants of the high vowels [u], [y], and [i]. The production of glides usually differ from vowels by having a slightly narrower channel between the tongue and top of the oral cavity (Lin, 2007).

The vowel inventory of Guoyu, adapted from Putonghua, is summarized in Table 5. There is some debate as to how to transcribe the mid vowel(s). For instance, Cheng (1973) does not distinguish between [ɛ] and [e] and writes [e] for both cases. Additionally, in some accounts, [e] and [o] are analyzed as not being contrastive in Putonghua, but instead as allophones of [ə] conditioned by the preceding and/or following consonantal context. However, these accounts posit sometimes very abstract contexts, and Duanmu (2007) argues for a more transparent surface representation.

	Front		Central	Back	
	unrounded	rounded		unrounded	rounded
High	i	y	ɨ		u
Mid	e ɛ		ə	ɤ	o
Low			a		

Table 5. Surface vowels of Guoyu.

### 2.3 Phonology of Taiwanese Southern Min

According to Chung (1996), Taiwanese Southern Min has twenty surface consonants and ten vowels. The twenty surface consonants of Southern Min are shown in Table 6.

Manner of articulation	Place of articulation					
	Bilabial	Labio-dental	Coronal	Palatal	Velar	Glottal
Stop	p, p <sup>h</sup> b		t, t <sup>h</sup> d		k, k <sup>h</sup> g	ʔ
Affricate			ts, ts <sup>h</sup>			
Nasal	m		n		ŋ	
Fricative			s z	ɕ		h
Approximant	w			j		

Table 6. Surface consonants of Taiwanese Southern Min.

Chung (1996) discusses the status of the sound that is listed in Table 6 as “/d/” as being both phonetically and phonologically ambiguous. First, in most descriptions of Taiwanese, this sound is transcribed phonetically not as [d] but rather as [l], and to an

English speaker, it might sound intermediate between [d] and [l]. Similarly, Japanese speakers assimilate it to the Japanese /r/, which is a laminal tap or approximant.

Phonologically, the sound patterns with /b/ and /g/ in being in complementary distribution with the nasals in onset and also with the voiceless unaspirated stops in coda position, suggesting that it is not a continuant (i.e., with the feature [-continuant] that is shared by nasals and stops). However, in some dialects, the sound has been merged with /z/, suggesting that it is a continuant. Evidence from speakers learning English further demonstrates that speakers may psychologically realize the sound as a continuant rather than as a non-continuant sound, supporting the more common transcription of the sound as [l]. Chung chooses to treat it as a voiced stop, due to its distribution with the voiced stops [b] and [g] in complementary distribution with the nasals [m, n, ŋ]. Subsequently, in Table 6, this sound has been listed as the stop /d/.

Only two sets of consonants (/p, t, k/ and /m, n, ŋ/) and the glottal stop can be found in coda position. In initial position, the glottal stop also occurs only in the onset of a vowel-initial syllable, in the so-called *zero-initial* or *zero-onset* position, i.e. no glottal stop is inserted in a compound where the second syllable begins with a vowel. A coda stop or nasal in the first syllable may also be resyllabified at the onset of a second syllable beginning with a vowel, resulting in a voiced onset consonant that is either a stop or a nasal depending on whether there is an oral or a nasalized vowel in the second syllable, respectively (Peng & Beckman, 2003). The vowels of Taiwanese Southern Min are summarized in Table 7. Nasalized vowels may occur independently as a syllable and they may be preceded by a non-nasal consonant other than a voiced stop.

	Front	Central	Back
	unrounded		rounded
High	i ĭ		u o
Mid	e ĕ		ɔ ǔ
Low		a ǎ	

Table 7. Surface vowels of Taiwanese Southern Min.

#### *2.4 Relationship among Nonsibilant Fricatives*

The phonetic realization of the nonsibilants may vary due to factors such as perceptions of language status. As Guoyu is still perceived to be the higher status language, hypercorrections may be expected in Guoyu speech. Hypercorrection may be defined as the use of linguistic forms, chosen due to their association with a prestige group, that exist within the language but that are applied in a context where the form does not belong. Hypercorrect forms are applied inconsistently and are more commonly produced in careful speech. The use of hypercorrections in Guoyu have been documented by researchers such as Kubler (1985), Peng (1993), and Chung (2006). Taiwanese speakers may mistakenly pronounce [f] for /x/ when they aim for the more prestigious standard, especially as the phonemes /x/ and /f/ from Putonghua and Guoyu are not found in Taiwanese Southern Min. Speakers of Taiwanese Southern Min must find their own way to produce these two unfamiliar phonemes if they are not able to reach the correct targets.

Peng (1991, 1993) found that adult male productions of /f/ and /x/ varied from native-like /f/ and /x/ to Taiwanese Southern Min /hw/ and /h/, respectively. Peng (1993) outlines that Taiwanese Southern Min speakers learning Guoyu may start by substituting [h] for both /x/ and /f/. Later, they may establish a new category for Guoyu [f], while a separate category for [x] is less likely to be established due to the perceived similarities between [x] and [h]. Peng recorded Guoyu monolinguals and Taiwanese Southern Min bilinguals of three different levels of Guoyu proficiency; the most proficient bilinguals were sometimes identified as Guoyu monolinguals by new acquaintances.

Proficient speakers were able to correctly produce [f] whereas less proficient speakers substituted [hw]. Examined through the analysis of formant frequencies, the productions of the least proficient group's Guoyu /fe/ and /fɤn/ were very similar to their productions of Taiwanese /hwe/ and /hwɤn/. Similarly, the least proficient group's productions of Guoyu /xe/ were very similar to their productions of Taiwanese /he/, showing that they substituted [h] for /x/. All other participants produced at least some [x] for target /x/ that showed the well-defined striations of a strong velar fricative, and the mean percentage of strong velar fricative productions by the most proficient group (37%) was close to that of monolinguals (43%) and higher than either of the other two groups' mean percentages. Peng notes that not all of the monolingual productions of [x] showed well-defined striations, and therefore, the absence of well-defined striations is not indicative of the absence of velar constriction when producing target Guoyu /x/. The highly proficient Guoyu-Taiwanese bilinguals also experienced some interference from Guoyu, as they pronounced some tokens of [h] that had the acoustic features of [x].



Overall, the [x] productions of intermediate and proficient speakers were intermediate between Taiwanese Southern Min [h] and Guoyu monolingual [x].

Another aspect of the commonly noted "Taiwanese accent" manifests in the substitution of initial /f/ with [hw], for example [hwan] for [fan] "meal" (Su, 2005). According to Dong (1995) and Tsao (2000), (as cited in Lin, 2008), the standard Putonghua phonemes /f/ and /x/ have several allophonic variants in Guoyu. The phoneme /f/ has three allophonic variants: [h], [hw], [ϕ]; and /x/ is also realized as [h] and [ϕ], in addition to [x]. Additionally, Kubler (1985) reported [ϕ] as a surface variant of both /f/ and /x/. Lin (2008) further proposes that [f] is an allophone of /f/ and /x/, and this overlap of surface variants is summarized in Figure 1.

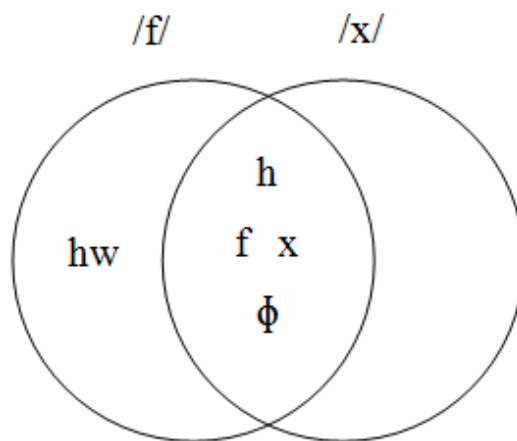


Figure 1. Allophones of /f/ and /x/.

The relationships between /x/ and [f], and /f/ and [x], were examined in more detail by Yang (2008) and Lin (2008). Yang studied a community in Taichung,

examining the speech of Taiwanese-speaking women who married Mandarin-speaking men from China. In particular, Yang focused on the productions of [hw] for /f/ and the hypercorrection of [f] for /xw/. In Yang's original work, there is not a distinction made between /hw/ and /xw/; Guoyu /xw/ is written as /hw/. This paper has elected to continue using previously established conventions by writing /xw/ when referring to Guoyu even while discussing Yang's work.

Examples of [hw] for /f/ productions include [hwa ʂəŋ] for *fa sheng* "happen" and [pi hu] for *pi fu* "skin". Guoyu speakers may also be influenced by native Hakka speakers and their accent, for example [fa] for /xwa/ "flower" (Tzeng, 2005). Yang (2008) found that Taiwanese women in the first generation of intermarriage who did not receive quality education tended to produce [hw] in place of /f/. Regarding the hypercorrection of [f] for /xw/, Yang noted that older women (>65 years old) and those with a higher level of education, as well as those with Hakka language backgrounds, tended to hypercorrect more.

Although Yang suggests that this phonological variation results from the intermarriage of two different populations, Lin (2008) notes that this phenomenon can be found in populations without intermarriage and is rather a result of the two languages being in contact with each other. In the case of Guoyu and Taiwanese Southern Min, Guoyu is perceived to be the more prestigious language and therefore it is not surprising that Southern Min speakers may hypercorrect when speaking in Guoyu, and Chung (2006) found that hypercorrection is more frequent in Taiwanese Southern Min speakers using Guoyu.

Lin (2008) examined the substitutions of [f] for /x/ by three groups speakers mostly toward the north of Taiwan. The older group, aged 65-92 ("grandparents"), were born during the Japanese colonization period. The middle group ("parents") was aged 38-60 and received their Guoyu education under the Mandarin-only policies of the KMT government. The younger group was aged 10-34, born after 1970. Lin (2008) found that hypercorrections of [f] for /x/ were most prevalent in the middle group, and argues that this phenomenon occurs because the middle group studied Guoyu under teachers who themselves were acquiring Guoyu as a second language; that is, the quality of their Guoyu education was lacking as the development of these programs was still in their early periods. Additionally, [f] for /x/ substitutions occurred before a high back rounded vowel (/u/) which was found by Yang (2008) as well.

In summary, children acquiring Guoyu in Taiwan receive a very wide range of /h/ and /x/ productions from their parents and their surroundings, ranging from [h, hw, x, f, φ]. This varying input could contribute to confusion about the two phonemic categories and result in delayed phonological acquisition. Therefore, this study seeks to examine the acquisition order of nonsibilant fricatives in order to determine possible influences on child phonological acquisition.

## Chapter 3: Research Methodology

### *3.1 Research Questions*

1) Do the acquisition patterns of these bilingual Guoyu-Taiwanese Southern Min children follow phonological universals or previously found patterns of nonsibilant acquisition?

2) How may child acquisition patterns be influenced by language-specific and/or socio-environmental factors?

### *3.2 Participants*

For this cross-sectional study, 58 children aged 2 to 6 were recruited from a day care center in Kaohsiung, the biggest city in southern Taiwan. As Taiwanese and Guoyu are both spoken in Kaohsiung, children in this city were more likely to have Taiwanese input, compared to other cities in Taiwan. The distribution of participants can be seen in Table 8. The small number of 2-year-old participants resulted from the limited availability of children within that age group at the day care center, but it was decided that their data might still provide valuable insight to the acquisition patterns of children. All child participants passed a hearing screening test using otoacoustic emissions at 2000, 3000, 4000, and 5000 Hz, indicating that their hearing was within the normal developmental range.

Age group	Number of participants	Sex Male, Female	Mean age, s.d. of age (in months)
2 years old	3	1, 2	30.4, 3.4
3 years old	15	9, 6	41.2, 3.6
4 years old	15	10, 5	51.2, 2.5
5 years old	14	7, 7	67.9, 3.5
6 years old	11	7, 4	76.0, 3.9

Table 8. Number of child participants.

### *3.3 Stimulus Materials*

Two word lists were created, one for Guoyu and one for Taiwanese. The nonsibilants were in word-initial position, controlled for vowel environment such that each nonsibilant appeared in each legal CV context. Two age-appropriate words were selected for each target CV per list, with the exception of Guoyu targets /fe/ and /xe/ and Taiwanese target /hu/ which only had one age-appropriate word each. Three words total were therefore repeated on the list, making for lists comprising a total of 18 Guoyu items (16 distinct words) and 10 Taiwanese items (9 distinct words). These word lists can be found in Appendix A.

Recordings of the word lists were produced by two bilingual native female speakers of Taiwanese and Guoyu. The Taiwanese-dominant bilingual was around the age of 50, and the Guoyu-dominant bilingual was of a younger generation, around the age of 30. Each speaker recorded each word five times, and then an independent group of two other native bilingual speakers listened to these productions and selected the best two based on clarity of speech and recording quality.

The productions selected from the two recordings of the word lists then became the stimuli for the test blocks, so that each speaker's productions were presented to

participants randomized within one of two test blocks. In this way, two productions of each Guoyu and Taiwanese word were elicited per participant, once in the block where the audio stimulus was the older speaker's production and once in the block where the audio stimulus was the younger speaker's productions.

### *3.4 Procedure*

These data were originally collected by Shih (2012). Participants were presented with an audio-picture prompted word repetition task, in which they heard the recorded productions from the bilingual speakers and saw corresponding, culturally appropriate pictures at the same time. The children were asked to repeat the target word after hearing the recorded production. This "Show and Play" approach (Edwards & Beckman, 2008a) included a sidebar of a duck climbing up a ladder, as seen in Figure 2; when the child repeated a word, the duck climbed up a step. Children were encouraged to complete the task by helping the duck reach the top of the ladder. Prior to testing, participants were given a practice session in order to familiarize them with the task.

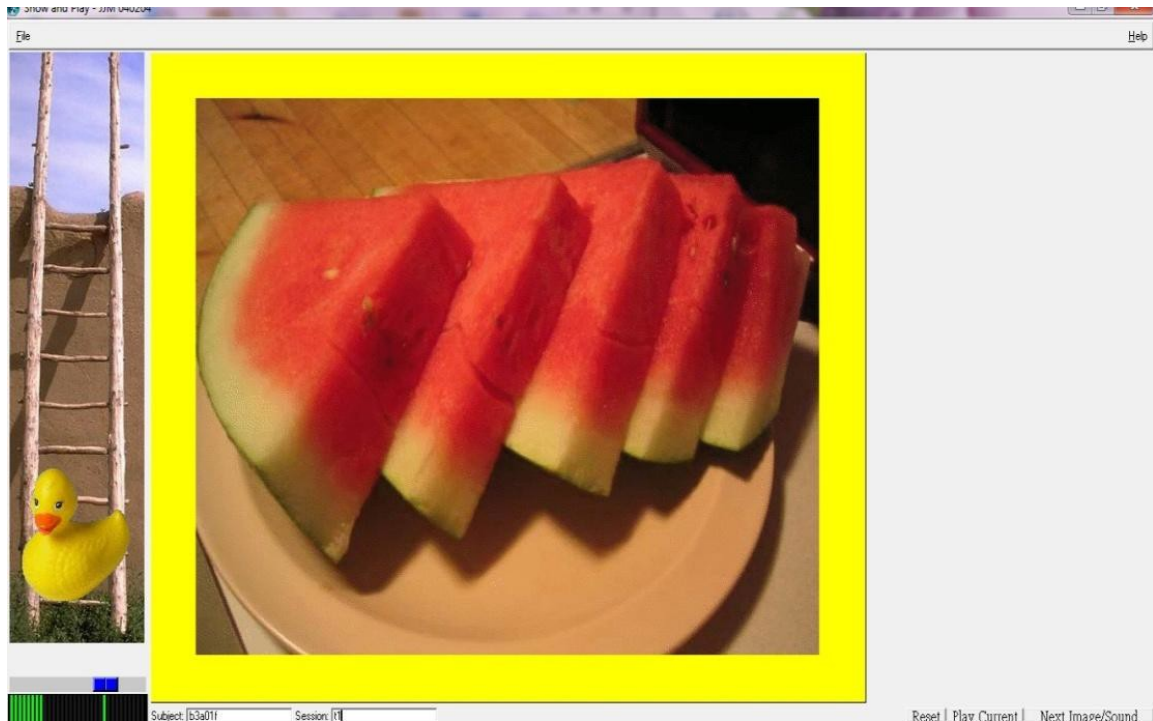


Figure 2. A screenshot of the "Show and Play" word repetition task.

In order to make the children more comfortable with their surroundings, Shih began by speaking with them in Taiwanese, as Taiwanese is the language that may be used with familiar people or within the home, whereas Guoyu is used in more formal settings (Sandel et al., 2006). Therefore, the first two test blocks used the two sets of Taiwanese word list productions, with the order of presentation of the two sets randomized for each participant. That is, some children heard the younger talker's stimulus set first, and some children the older talker's. Following a short break, the children were then presented with the two sets of randomized Guoyu word list productions in the third and fourth blocks. There were a total of 36 trials for the two Guoyu blocks and 20 trials for the two Taiwanese blocks.

The participants were presented with the task on an Asus 14 inch laptop. Their productions were recorded using a Marantz PMD 660 flash card recorder and an AKG C5900M condenser vocal microphone, which was placed approximately 30cm in front of the participant's mouth. All recordings were made at a sampling rate of 44,100 Hz.

### *3.5 Data Analysis*

#### *3.5.1 Transcription*

Each participant produced 4 tokens of the same target consonant and vowel combination found in each language, for a total of 56 tokens (16 tokens of Guoyu /f/, 20 tokens of Guoyu /x/, and 20 tokens of Taiwanese /h/) per participant. The phonetically trained author transcribed each token as correct or incorrect. If the production was marked as incorrect, the produced substitution was transcribed as either being from the target language (\$) or non-target language (+). For intermediate productions which could not be definitively categorized, the production was marked as intermediate, using a colon (:) between two sounds.

The primary transcriber was the author of this thesis, who is a second language learner of Putonghua with little experience with Guoyu or Taiwanese Southern Min. Since she was transcribing as a phonetician rather than as a native speaker, the transcriber also examined the spectrograms when transcribing, particularly to note the strength of striations and to examine how well the formant bands of productions of [h] and [x] aligned with the following vowel. The spectrograms for correct productions of target /f/, /x/, and /h/, in the same vowel context is shown in Figures Figure 3, Figure 4, and Figure



5. The markings shown in the bottom tier of the textgrids correspond to fricative start time (fst), seen through an increase of energy in both the waveform and the spectrum, and vowel start time (vst), defined as the first uprising zero-crossing after the first glottal pulse.

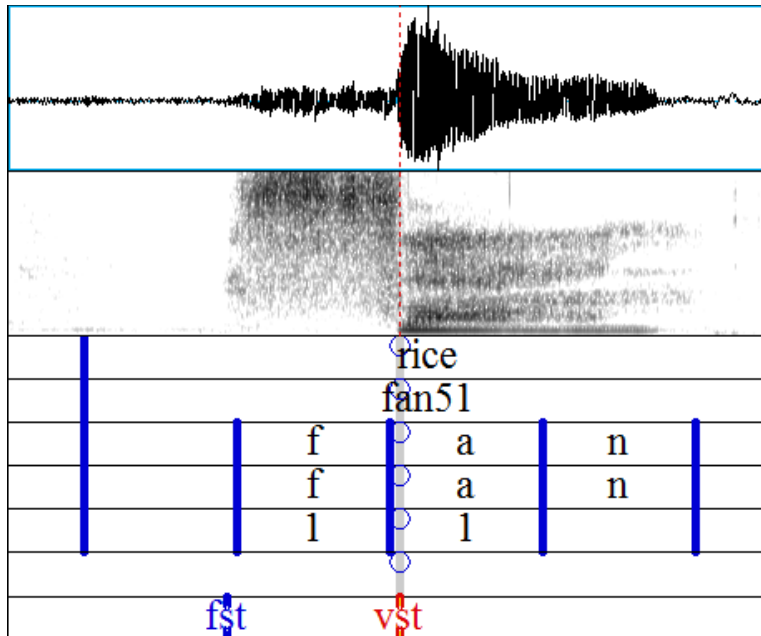


Figure 3. A production of target /f/ by a 5 year old child.

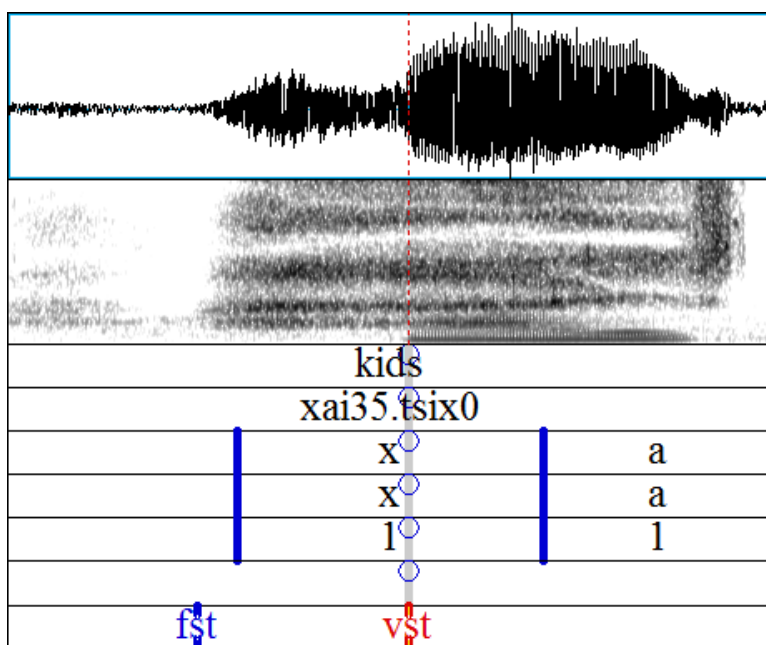


Figure 4. A production of target /x/ by a 3 year old child.

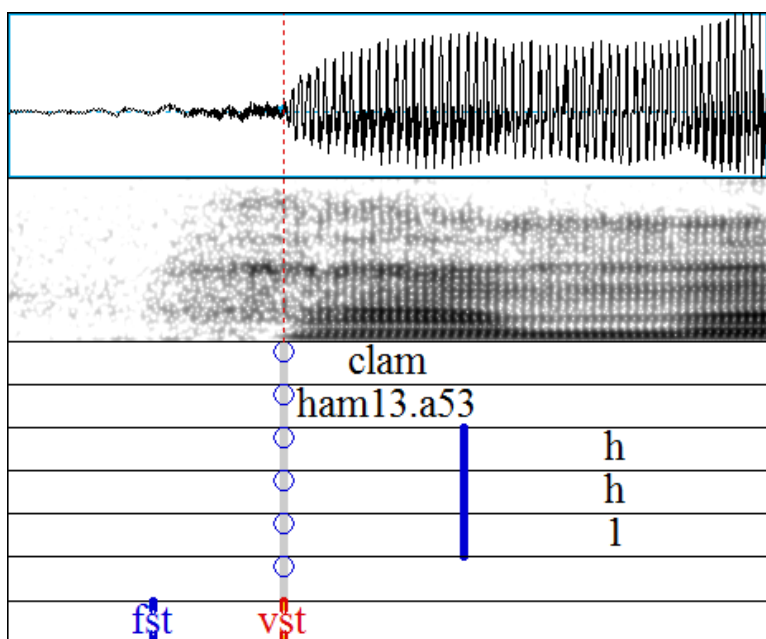


Figure 5. A production of target /h/ by a 3 year old child.

Approximately 5% of the nonsibilant data had been transcribed previously by a phonetically trained native Guoyu-Taiwanese bilingual speaker (the author of Shih, 2012). The inter-transcriber reliability between the two transcribers was 70% for target consonant transcription. A subset of the data (approximately 12%) was re-transcribed by the primary transcriber, and intra-transcriber reliability was found to be 85%.

### *3.5.2 Determining the Age of Acquisition*

Studies of child phonological acquisition have used various methods and criteria for determining the age and order of acquisition of different consonants, and many of these were applied in the current study, to be able to compare the results to other studies.

One method was to build generalized linear mixed effects model using the "lme4" R package (Bates, Maechler, Bolker & Walker, 2015). This was a logistic regression model with token-by-token accuracy as the dependent variable. Independent variables were age in months and phoneme as fixed effects and subject-level random intercepts, with the consonant /h/ as the referent in a treatments-style contrast for phoneme. The following R code was used:

```
model = glmer(accuracyC ~ age + targetC + gender + dominantLg +  
(1|child), nonsibilant, family="binomial")
```

Relative order of acquisition can then be evaluated by examining the effect of phoneme and comparing the sign of the coefficients for that fixed effect.

Furthermore, to evaluate age of acquisition, accuracy within each age group was analyzed in terms of three criteria for (1) age of phonetic acquisition, (2) age of phonological acquisition, and (3) age of mastery. Following Dodd et al. (2003), phonetic

acquisition was defined as the age of the youngest group in which 90% of children within the age group are shown to be able to articulate a sound, i.e. transcribed as saying the sound in some production, regardless of whether the sound matches the target phoneme as long as the production can be identified as an intended word. This is also referred to as "phoneme emergence" by Zhu (2002).

Age of phonological acquisition, as defined by Amayreh and Dyson (1998), is the age at which a target phoneme in an identifiable intended word is produced correctly 75% of the time. Following the criteria used by previous studies (Zhu & Dodd, 2000; Dodd et al., 2003; Li, 2008; Shih, 2012), the age of acquisition is determined as when 90% of children within an age group produce the correct sound with at least 75% accuracy. Similarly, age of mastery will be determined as when 90% of children within an age group produce the correct sound with at least 90% accuracy. Error rates and error patterns were also examined.

## Chapter 4: Results

### 4.1 General Results

Table 9 shows the percent accuracy of nonsibilant fricatives across all children in all age groups. For children under the age of 5, the large standard deviation shows that there is a wide range of productions, in that some children had many correct productions of /f/ while others had fewer. As seen in Figure 6, the accuracy of /x/ by 2 year olds appears to be higher than that of 3 year old children, but this irregularity is likely due to the small sample size; there is in fact no difference in accuracy across the age groups. Although the 6 year olds reach a 75% criterion of acquisition for /h/, none of the age groups achieved greater than 90% accuracy on /x/ or /h/.

	Age group				
	2 years old (N=3)	3 years old (N=15)	4 years old (N=14)	5 years old (N=14)	6 years old (N=11)
/f/	29.2% (28.2%)	52.1% (36.6%)	77.2% (38.9%)	96.4% (10.0%)	98.3% (2.9%)
/x/	53.3% (17.6%)	45.7% (16.2%)	47.9% (19.6%)	50.4% (14.6%)	65.0% (16.6%)
/h/	50.0% (20.0%)	63.0% (17.2%)	66.8% (15.0%)	69.6% (13.4%)	79.5% (11.1%)

Table 9. Percent accuracy (s.d.) of nonsibilant fricatives across age groups.

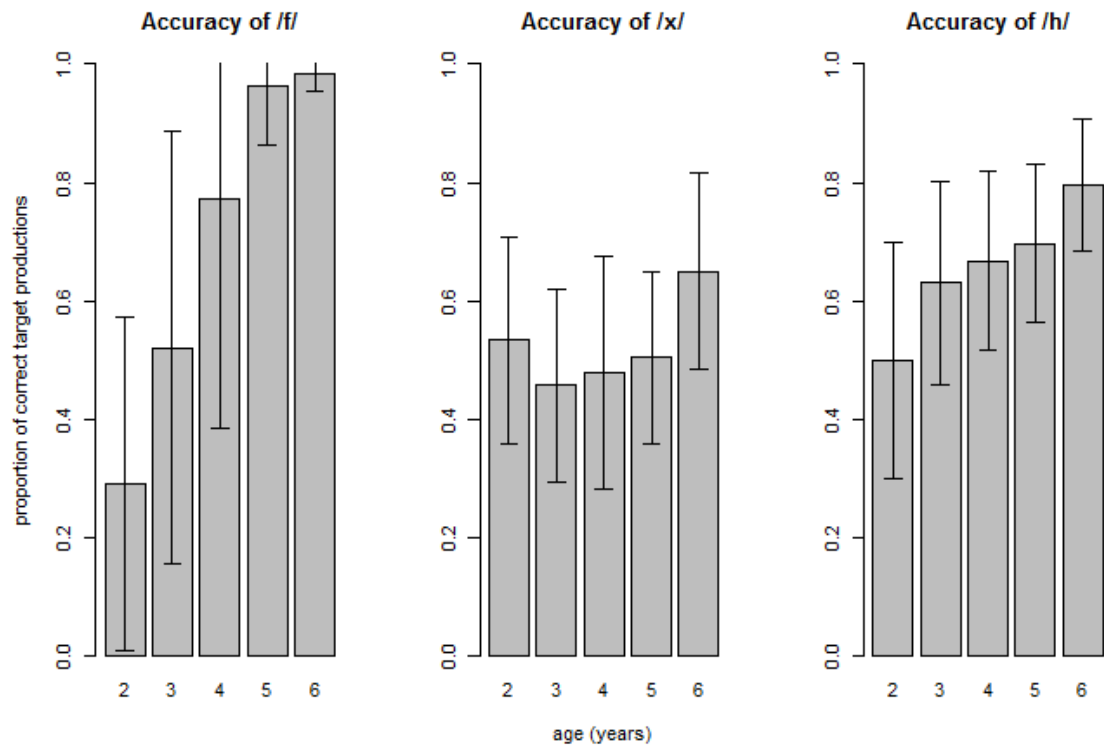


Figure 6. Accuracy (s.d.) for nonsibilant fricatives across all age groups.

Figure 7 shows the generalized linear model with child, age, and target consonant as predictor variables, in a graph of accuracy as a function of a child's age in months. This graph provides a clear representation of the relative accuracies of the three nonsibilants by age.

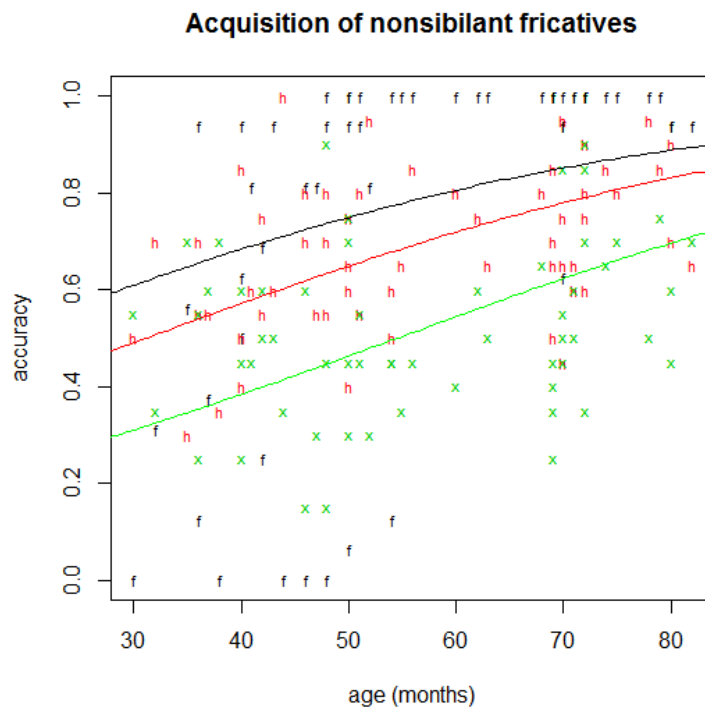


Figure 7. Generalized linear model of the acquisition of nonsibilant fricatives.

The generalized linear mixed effects model found significant effects of all target consonants ( $p < 0.01$ ) and of age ( $p < 0.05$ ). No significant effects of gender ( $p < 0.67$ ) or dominant language ( $p < 0.69$ ) were found.

#### 4.2 Phonetic Acquisition

All children in this study were able to articulate [x] and [h] before the age of 2;5. The children in this study began articulating [f] between the age of 3-4. Table 10 shows the percentage and number of children within each age group that were able to articulate each of the nonsibilant fricatives.

	Age group				
	2 years old (N=3)	3 years old (N=15)	4 years old (N=14)	5 years old (N=14)	6 years old (N=11)
[f]	66.7% (n=2)	80.0% (n=12)	92.9% (n=13)	100% (n=14)	100% (n=11)
[x]	100% (n=3)	100% (n=15)	100% (n=14)	100% (n=14)	100% (n=11)
[h]	100% (n=3)	100% (n=15)	100% (n=14)	100% (n=14)	100% (n=11)

Table 10. Phonetic acquisition of nonsibilant fricatives.

#### 4.3 Phonological Acquisition

Table 11 summarizes the results for age of acquisition of nonsibilants. Children acquire /f/ at the age of 4. Children are close to acquiring /h/ at the age of 6, but no groups were shown to have acquired the sound. The number of children who acquired /x/ was particularly low, with 5 children producing /x/ with 75% or greater accuracy. The graphed results can be seen in Figure 8.



	Age group				
	2 years old (N=3)	3 years old (N=15)	4 years old (N=14)	5 years old (N=14)	6 years old (N=11)
/f/	0% (n=0)	40.0% (n=6)	78.6% (n=11)	92.9% (n=13)	100% (n=11)
/x/	0% (n=0)	0% (n=0)	7.1% (n=1)	7.1% (n=1)	27.3% (n=3)
/h/	0% (n=0)	26.7% (n=4)	35.7% (n=5)	42.9% (n=6)	72.7% (n=8)

Table 11. Percent of children with 75% or greater accuracy.

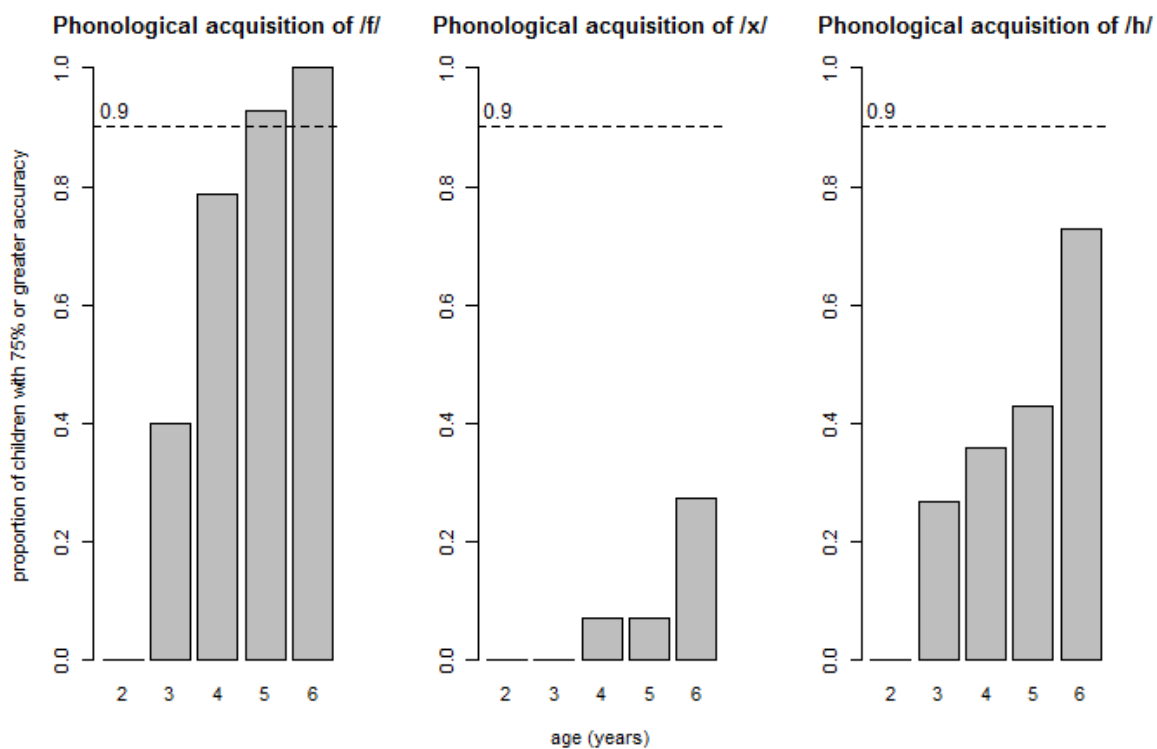


Figure 8. Phonological acquisition of nonsibilant fricatives.

#### 4.4 Phonological Mastery

Table 12 summarizes the results for age of mastery. Children master /f/ by the age of 5, showing that children acquired and mastered /f/ soon after being able to articulate [f]. No groups were shown to have mastered /h/. Only 5 children total produced target /h/ with 90% or greater accuracy. Only 1 child produced /x/ at 90% or greater accuracy. The graphed results can be seen in Figure 9.

	2 years old (N=3)	3 years old (N=15)	4 years old (N=14)	5 years old (N=14)	6 years old (N=11)
/f/	0% (n=0)	20.0% (n=3)	71.4% (n=10)	92.3% (n=13)	100% (n=11)
/x/	0% (n=0)	0% (n=0)	0% (n=0)	0% (n=0)	9.1% (n=1)
/h/	0% (n=0)	6.7% (n=1)	7.1% (n=1)	7.1% (n=1)	27.3% (n=3)

Table 12. Percent of children with 90% or greater accuracy.

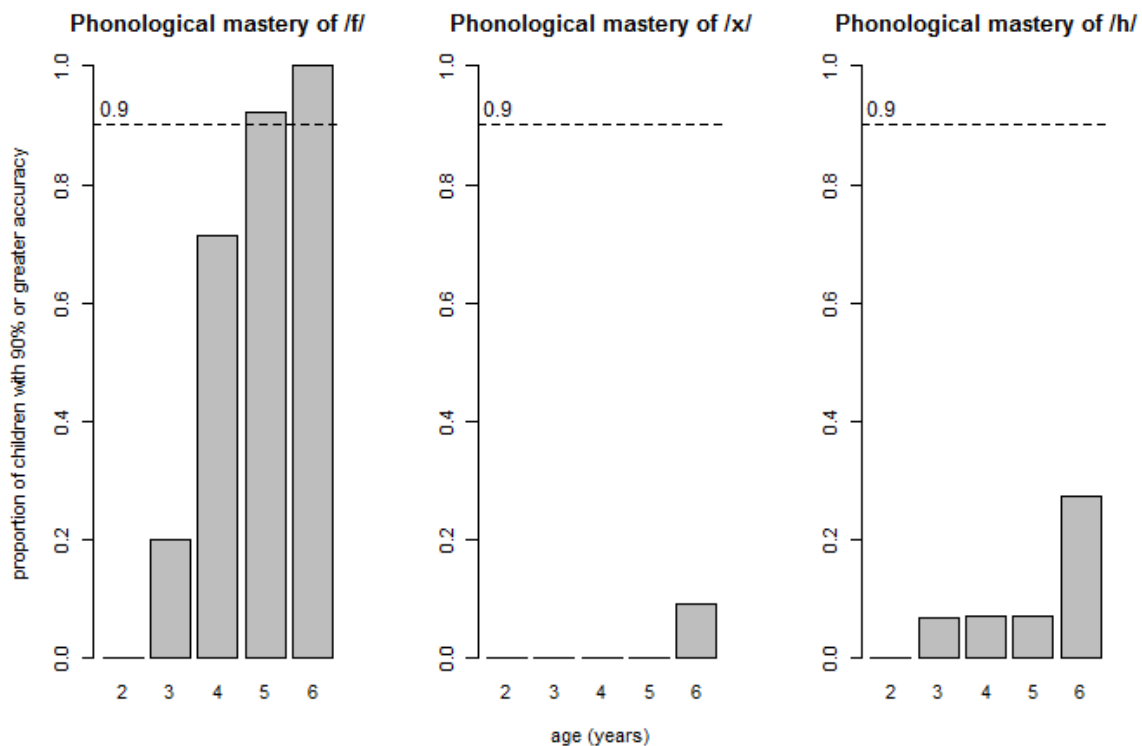


Figure 9. Phonological mastery of nonsibilant fricatives.

#### 4.5 Errors and Error Rates

The majority of substitution errors for target /f/ were stop substitutions. Of the 211 total errors, 92 were voiceless stop substitutions (81 front stops, 11 back stops) and 22 were voiced (all front). Additionally, there were 38 substitutions of [hw], 36 substitutions of [h] and 8 substitutions of [x] for target /f/. Of the [hw] for /f/ substitutions, 16 occurred before target /a/, 16 before target /e/, and 6 before target /ə/. Of the [h] for /f/ substitutions, 24 were before target high back rounded vowel /u/, and there were 7 substitutions of [h] for /f/ before target /ə/ and 5 substitutions of [h] for /f/ before target /e/. The proportion of substitution errors is shown in Figure 10.

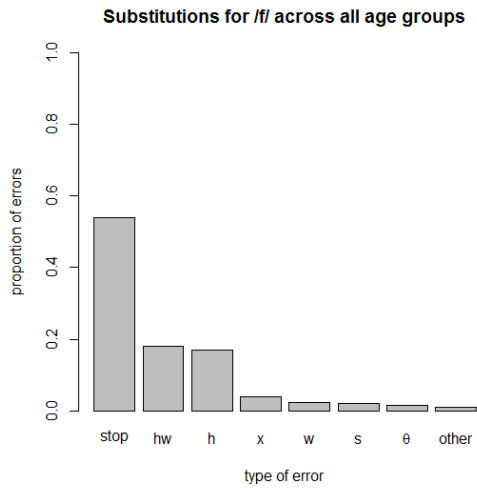


Figure 10. Substitutions for /f/ across all age groups.

There were 553 substitution errors for target /x/, although 427 (77.2%) of those errors were substitutions of [h]. There were 89 voiceless stop substitutions (19 front, 70 back) and 13 substitutions of [f] for /x/. The proportion of error types can be seen in Figure 11.

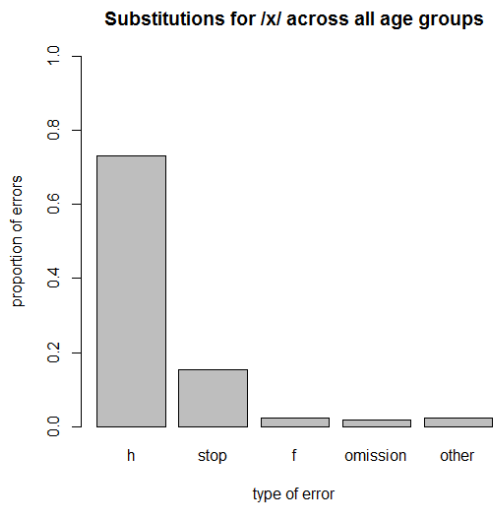


Figure 11. Substitutions for /x/ across all age groups

Of the 427 substitutions of [h] for /x/, 251 (58.8%) occurred before target /wV/, for example [hwa] for /xwa/ "flower". Before vowel /e/, there were 95 substitutions of [h]; before /a/, 49 substitutions; and before /ə/, 28 substitutions. Looking at the fewer substitutions of [f] for /x/, 11 of these substitutions occurred before target /wV/.

For target /h/, there were 364 substitution errors. Stop errors comprised 168 substitutions (34 voiceless front consonants, 2 voiced front consonants, 138 back consonants) and there were 155 substitutions of [x] for /h/. Of these [x] for /h/ substitutions, 71 were before /a/, 38 before /e/, 26 before /ə/, 10 before /wa/, and 7 before /we/. The proportion of error types is shown in Figure 12.

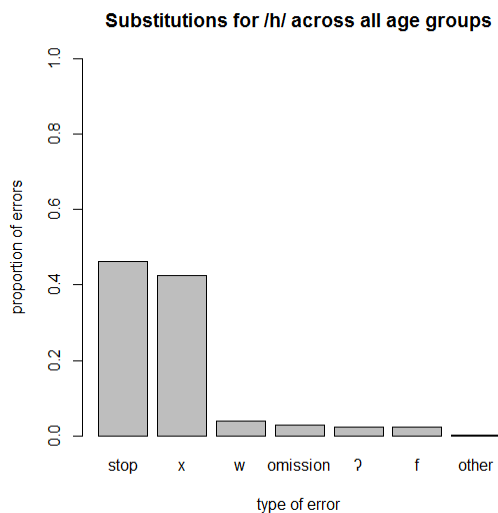


Figure 12. Substitutions for /h/ across all age groups.

## Chapter 5: Discussion

### *5.1 Discussion*

The transcription results show that children can articulate both [h] and [x] before 2;5, whereas children begin producing [f] between the ages of 3-4. After being able to articulate [f] correctly, these children rapidly acquired the phoneme /f/, which is similar to results found by Zhu and Dodd (2000). However, very few children can correctly produce the language-appropriate non-labial fricative in repeating Taiwanese words beginning with /h/ or Guoyu words beginning with /x/. This late acquisition of /h/ and /x/ does not match that of previous studies with monolingual Putonghua-speaking children, although it is important to note that speakers acquiring Putonghua do not need to acquire a contrast between /h/ and /x/, unlike speakers acquiring both Guoyu and Taiwanese.

Without such a contrast, native transcribers of Putonghua may also be more willing to accept variability within the productions of target /x/, including productions of [h] due to its phonetic similarities to [x]. Indeed, Peng (1993) discusses an earlier study by Yeh (1990) where Yeh found that native speakers of Taiwanese Southern Min were substituting Mandarin [x] (rather than Taiwanese [h]) for /f/, and comments that Yeh was identifying Taiwanese /h/ with Mandarin /x/ in "Mandarin mode". In languages such as Israeli Hebrew, German, and Dutch, which do have a contrast between /h/ and /x/, adult transcribers must be sensitive to the differences between the two phonemes. Although

Dutch and German children acquired the two sounds at similar ages, /h/ and /x/ were found to be acquired at vastly different ages by Israeli Hebrew children, who acquired /x/ first at 3;0, followed by /h/ at >5;0.

The late acquisition of /h/ and /x/ may also be influenced by the variation in the input that children receive from their parents and grandparents. Lin (2008) describes the wide range of possible allophones for /x/: [h, x, f,  $\phi$ ]. Children may hear different allophones, depending on the dominant languages or the quality of Guoyu education of their parents and grandparents. Furthermore, as Peng (1993) found, adult productions of target Taiwanese Southern Min /h/ may show interference from Guoyu [x] and vice versa, especially among more proficient bilinguals. This mixed input could contribute to the late acquisition of /h/ and /x/.

The frequent substitutions of [x] for Taiwanese /h/ and of [h] for Guoyu /x/ also support the explanation that children receive mixed input for the targets, although several children aged 6 and older were still making stop substitutions for both /h/ and /x/. The late acquisition of Taiwanese /h/ is especially notable, given its articulatory ease and frequent appearance in early infant babbling across languages (Vihman, 1992). Furthermore, despite better performance with target /h/ relative to /x/, children produce many more stop substitutions for /h/. Their stop substitutions are generally more emphatic as well, as seen in Figure 13. The reason for this is uncertain.

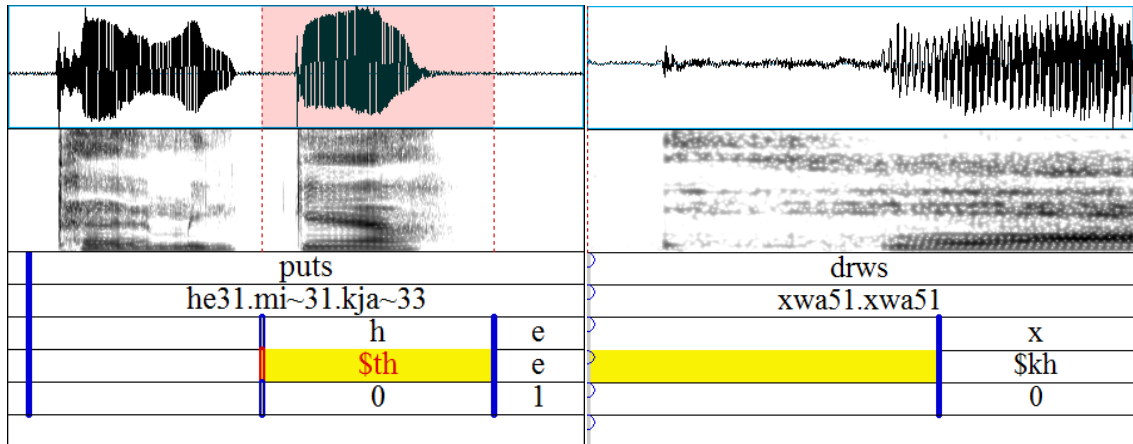


Figure 13. Stop substitutions for Taiwanese Southern Min /h/ and for Guoyu /x/ by children older than 6.

Some of the substitutions made by children for target /f/ were reflective of the relationship among [h], [hw], and /f/, as examined by Peng (1993) and Yang (2008). Approximately 18% of the errors for target /f/ were [hw] substitutions, e.g. [hwa] for /fa/, and 17% were [h] substitutions, e.g. [hu] for /fu/. Most of the [hw] for /f/ substitutions occurred before target /a/ and /e/, resulting in a production that matches the legal vocalic contexts /wa/ and /we/ found in Taiwanese. Additionally, about one-fourth of the [h] for /f/ substitutions occurred before high back rounded vowel /u/, another phenomenon noted by Yang (2008) and Lin (2008).

The large number of substitutions of [h] for /x/ before /w/ have not been previously discussed in the literature, other than the general discussion of the relationship between /h/ and /x/. However, a re-examination of the Guoyu and Taiwanese word lists shows that very similar cognate words (花 "flower") are used to elicit both Guoyu [xwa] and Taiwanese [hwe]; this may further cloud the distinction between /h/ and /x/,



specifically in the /w/ vocalic context. However, there are still many more substitutions of [h] for /x/ than [x] for /h/ in this context, though this may possibly be explained by a shift toward /h/ before /w/. An examination of adult production patterns may help illuminate the reasons behind this substitution pattern.

The late acquisition of /ʃ/ found by this same population was attributed in part to the lack of a strong contrast between /s/ and /ʃ/ (Shih, 2012). However, this does not result in late acquisition of /s/, as /ʃ/ appears to be merging with /s/ in a single direction. Although some adults may hypercorrect [ʃ] for /s/ when aiming for the standard, children receive many more productions of [s] for /ʃ/. On the other hand, the contrast between /x/ and /h/ appears to be much more uncertain, resulting in the late acquisition of both of these nonsibilants.

## *5.2 Conclusion*

This study on the acquisition of nonsibilant fricatives by Guoyu-Taiwanese Southern Min bilingual children found that the order of acquisition is as follows: Guoyu /f/ at the age of 5, followed by Taiwanese /h/ and Guoyu /x/ after the age of 6, despite the early appearance of [h] and even [x] relative to [f] in the children's phonetic inventory. Phonological mastery for /f/ is earlier than for either of the non-labial weak fricatives which demonstrate interference from L1 to L2 for older speakers and L2 to L1 in younger speakers. Children at the age of 6 also show higher rates of accuracy for /h/ than for /x/, a result that is reflective of the universal difficulty of the velar fricative relative to /h/, which requires no oral constriction or precise positioning of the articulators. Children may also

receive a greater frequency of [h] productions for both target /h/ and target /x/, although an examination of adult speech patterns would be necessary in order to support or refute this hypothesis. Compared to other cross-linguistic studies, these children pattern more similarly to Jordanian Arabic- and Israeli Hebrew-speaking children with the earlier acquisition of /f/ and later acquisition of /h/.

The results of this study agree with previous studies on Putonghua and Guoyu monolinguals in terms of phonetic acquisition, in that [f] emerged later than [h] and [x]. However, the phonological acquisition pattern differs in important ways, and this discrepancy may be due to the linguistic environment in which these bilingual children acquire their two languages. Children who receive mixed input for /h/ and /x/ may instead acquire /f/ earlier.

In tandem with Shih's (2012) results, this study demonstrates that a strict account of linguistic universals or biological constraints alone is not sufficient to describe the variation in phonological acquisition patterns across languages. Language-specific and socio-environmental factors must also be considered, as they have been shown to largely influence child phonological acquisition.

## References

- Amayreh, M.M., & Dyson, A.T. (1998). The acquisition of Arabic consonants. *Journal of Speech, Language, and Hearing Researcher*, 41, 642-653.
- Ball, M. J., & Rahilly, J. (1999). *Phonetics: The science of speech*. London: Arnold.
- Bates, D., Maechler, M., Bolker, B. & Walker, S. (2015). Fitting Linear Mixed-Effects Models Using lme4. *Journal of Statistical Software*, 67(1), 1-48.  
doi:10.18637/jss.v067.i01.
- Beijing University Chinese Department (1964). Hanyu Fangyan Cihui [Dictionary of Chinese regional varieties]. Beijing: Wenzhi Gaige Chubanshe.
- Ben-David, A. & Berman, R. A. (2007). Israeli Hebrew Speech Acquisition. In S. MacLeod (ed.), *The International Guide to Speech Acquisition*. Clifton Park, NY: Thomson Delmar Learning. 437-456.
- Bernhardt, B. M., Másdóttir, T., Stemberger, J.P., Leonhardt, L., & Hansson, G. (2015). Fricative acquisition in English- and Icelandic-speaking preschoolers with protracted phonological development. *Clinical Linguistics & Phonetics*, 29(8-10), 642-665.
- Brubaker, B.L. (2012). The normative standard of Mandarin in Taiwan: an analysis of variation in metapragmatic discourse. PhD Dissertation, University of Pittsburgh.
- Chen, S.-c. (2006). Simultaneous promotion of indigenisation and internationalisation: New language-in-education policy in Taiwan. *Language and Education: An International Journal*, 20(4). 322–337.

- Chen, S.-c. (2010). Multilingualism in Taiwan. *International Journal of the Sociology of Language*, 205, 79-104.
- Cheng, C.-C. (1973). *A Synchronic Phonology of Mandarin Chinese*. The Hague: Mouton.
- Chung, K.S. (2006) Hypercorrection in Taiwan Mandarin. *Journal of Asian Pacific Communication*, 16(2), 197-214.
- Chung, R. F. (1996). *The Segmental Phonology of Southern Min in Taiwan*. Taipei: The Crane Publishing Company.
- Dodd, B., Holm, A., Hua, Z. & Crosbie, S. (2003). Phonological development: A normative study of British-speaking children. *Clinical Linguistics and Phonetics*, 17, 617–643.
- Duanmu, S. (2007). *The Phonology of Standard Chinese, Second Edition*. Oxford: Oxford University Press.
- Edwards, J. & Beckman, M.E. (2008a). Methodological questions in studying consonant acquisition. *Clinical Linguistics and Phonetics*, 22, 937–956.
- Edwards, J. & Beckman, M. E. (2008b). Some cross-linguistic evidence for modulation of implicational universals by language-specific frequency effects in the acquisition of consonant phonemes. *Language Learning and Development*, 4, 122-156.
- Ferguson, C.A. (1973). Fricatives in Child Language Acquisition. *Papers and Reports on Child Language Development (Linguistics, Stanford University)* 6, 61-85.
- Fox, A.V. & Dodd, B. J. (1999). Der Erwerb des phonologischen Systems in der deutschen Sprache. *Sprache-Stimme und Gehör*, 23, 183–191.

- Goldman, R., Fristoe, M. & Williams, K. (2000). *Goldman-Fristoe Test of Articulation - Second Edition: Supplemental Developmental Norms*. Circle Pines, MN: American Guidance Service, Inc.
- Hsiau, A.-c. 2000. *Contemporary Taiwanese Cultural Nationalism*. New York: Routledge.
- Hsu, J. (1987). A study of the various stages of development and acquisition of Mandarin Chinese by children in Taiwan milieu. MA Thesis, Fu Jen Catholic University, New Taipei City.
- Huang, S. (2000). Language, identity and conflict: A Taiwanese study. *International Journal of the Sociology of Language*, 143, 139-149.
- Ingram, D. (1992). Early phonological acquisition: a crosslinguistic perspective. In C. Ferguson, L. Menn & C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*. Timonium, MD: York Press. 423-435.
- Ingram, D., Christensen, L., Veach, S. & Webster, B. (1980). The acquisition of word-initial fricatives and affricates in English by children between 2 and 6 years. In G. H. Yeni-Komshian, J. F. Kavanagh & C. A. Ferguson (eds.), *Child phonology, Vol. 1*. New York: Academic Press, 169-192
- Jakobson, R. (1968). *Child Language, Aphasia and Phonological Universals*. The Hague: Mouton.
- Jeng, H. (1979). The acquisition of Chinese phonology in relation to Jakobson's laws of irreversible Solidarity. *Proceedings of the 9th International Congress of Phonetic Sciences. University of Copenhagen*, 155-161.
- Kent, R. D. (1992). The biology of phonological development. In C. A. Ferguson, L. Menn, & C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*. Timonium, MD: York Press. 65-90.

- Kent, R. D., & Murray, A. D. (1982). Acoustic features of infant vocal utterances at 3, 6, and 9 months. *Journal of the Acoustical Society of America*, 72, 353–365.
- Li, F., Edwards, J., & Beckman, M. E. (2009). Contrast and covert contrast: The phonetic development of voiceless sibilant fricatives in English and Japanese toddlers. *Journal of Phonetics*, 37(1), 111-124.
- Li, F. & Munson, B. (2016). The Development of Voiceless Sibilant Fricatives in Putonghua-speaking Children. *Journal of Speech Language and Hearing Research*.
- Lin, C.-L. (2008). *A study of [f] as an allophone of /x/ in Taiwan Mandarin*. MA Thesis, Providence University, Taichung.
- Lin, Y. (2007). *The Sounds of Chinese*. Cambridge, UK: Cambridge University Press.
- Locke, J.L. (1983). *Phonological acquisition and change*. New York: Academic Press.
- Macken, M.A. & Barton, D. (1980). The acquisition of the voicing stop contrast in Spanish: a phonetic and phonological study of word-initial stop consonants. *Journal of Child Language*, 7(3), 433-458.
- Macken, M.A. & Ferguson, C.A. (1981). Phonological Universals in Language Acquisition. In H. Winitz (ed.), *Native Language and Foreign Language Acquisition*. New York: New York Academy of Sciences. 110-129.
- Macken, M.A. & Ferguson, C.A. (1983). Cognitive aspects of phonological development: Model, evidence, and issues. In K. E. Nelson (ed.), *Children's language (Vol. 4)*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- MacLeod, A., Sutton, A., Trudeau, N., & Thórdardóttir, E. (2011). The acquisition of consonants in Québec French: A cross-sectional study of preschool aged children. *International Journal of Speech-Language Pathology*, 13, 93–109.

- Maphalala, Z., Pascoe, M. & Smouse, M.R. (2013). Phonological development of first language isiXhosa-speaking children aged 3;0-6;0 years: A descriptive cross-sectional study. *Clinical Linguistics & Phonetics*, 28(3), 176-194.
- Másdóttir, T. (2008). Phonological development and disorders in Icelandic-speaking children. PhD Dissertation, Newcastle University.
- Mennen, I., Levelt, C. & Gerrits, E. (2007). Dutch Speech Acquisition. In S. MacLeod (ed.), *The International Guide to Speech Acquisition*. Clifton Park, NY: Thomson Delmar Learning. 325-399.
- Mennen, I. & Okalidou, A. (2007). Greek Speech Acquisition. In S. MacLeod (ed.), *The International Guide to Speech Acquisition*. Clifton Park, NY: Thomson Delmar Learning. 398-411.
- Miller, G.A. & Nicely, P. (1955). An Analysis of Perceptual Confusions Among Some English Consonants. *Journal of the Acoustical Society of America*, 27(2), 338-352.
- Nittrouer, S. (2002). Learning to perceive speech: How fricative perception changes, and how it stays the same. *Journal of Acoustical Society of America*, 112(2), 711–719.
- Peng, S.-h. (1991). The acquisition of a new phone: The production of Mandarin /f/ and /x/ by native speakers of Amoy (Taiwanese) [Abstract]. *Journal of the Acoustical Society of America*, 90(4).
- Peng, S.-h. (1993). Cross-Language Influence on the Production of Mandarin /f/ and /x/ and Taiwanese /h/ by Native Speakers of Taiwanese Amoy. *Phonetica*, 50(4), 245-260.
- Peng, S.-h. & Beckman, M. (2003). Annotation conventions and corpus design in the investigation of spontaneous speech prosody in Taiwanese. *Proceedings of the Spontaneous Speech Processing and Recognition Workshop*.

- Prather, E. M., Hedrick, D. L., & Kern, C. A. (1975). Articulation development in children aged two to four years. *Journal of Speech and Hearing Disorders*, 40, 179-191.
- Pye, C., Ingram, D. & List, H. (1987). A comparison of initial and final consonant acquisition in English and Quiché. In K.E. Nelson and A. Van Kleeck (Eds.) *Children's Language*, Vol 6. Hillsdale, NJ: Lawrence Erlbaum Associates. 174-190.
- Reetz, H. & Jongman, A. (2009). *Phonetics: Transcription, production, acoustics, and perception*. Chichester, UK: Blackwell.
- Sandel, T. L. (2003). Linguistic capital in Taiwan: The KMT's Mandarin language policy and its perceived impact on language practices of bilingual Mandarin and Tai-gi speakers. *Language in Society*, 32(4), 523-551.
- Sandel, T. L., Wen-Yu Chao, & Chung-Hui Liang. (2006). Language Shift and Language Accommodation across Family Generations in Taiwan. *Journal of Multilingual & Multicultural Development*, 27(2), 126-147.
- Shih, Y.-t. (2012). Taiwanese-Guoyu Bilingual Children and Adults' Sibilant Fricative Production Patterns. PhD Dissertation, The Ohio State University.
- Slobin, D. I. (1985). Why Study Acquisition Crosslinguistically? In D. Slobin (ed.) *Crosslinguistic Study of Language Acquisition*, Vol 1. Hillsdale, NJ: Lawrence Erlbaum Associates. 3-22.
- Smit, A. B. (2007). General American English speech acquisition. In S. McLeod (ed.), *The International Guide to Speech Acquisition*. Clifton Park, NY: Thomson Delmar Learning. 128-147.
- Smit, A., Hand, L., Freilinger, J., Bernthal, J., & Bird, A. (1990). The Iowa articulation norms project and its Nebraska replication. *Journal of Speech and Hearing Disorders*, 55, 779-798.



- So, L.K. & Dodd, B. J. (1995). The acquisition of phonology by Cantonese-speaking children. *Journal of Child Language*, 22(3), 473-495.
- Su, H.-Y. (2005). Language Styling and Switching in Speech and Online Contexts: Identity and Language Ideologies in Taiwan. PhD Dissertation, The University of Texas at Austin.
- Templin, M. (1957). Certain Language Skills in Children: Their Development and Inter-relationships. *Institute of Child Welfare Monograph 26*. Minneapolis, MN: University of Minnesota Press.
- Tzeng, Guo-Sheng (2005). *Sociolinguistic Variation of Mandarin Alveolopalatal Initials j-, q, x- in the Beipu Hakka Community, Taiwan*. MA Thesis, Providence University, Taichung.
- Vihman, M. M. (1992). Early syllables and the construction of phonology. In C. A. Ferguson, L. Menn, & C. Stoel-Gammon (eds.), *Phonological development: Models, research, implications*. Timonium, MD: York Press. 393-422.
- Vihman, M. M. (1993). Variable paths to early word production. *Journal of Phonetics*, 21, 61-82.
- Wellman, B. L., Case, I. M., Mengert, I. G., & Bradbury, D. E. (1931). *Speech sounds of young children*. Iowa City: The University.
- Yang, C.-Y. (2008). Sociolinguistic Variation of Mandarin Chinese /f/ and /hw/ in Taiwan. MA Thesis, Providence University.
- Young, R.L. (1988). Language maintenance and language shift in Taiwan. *Journal of Multilingual and Multicultural Development*, 9(4), 323-338.
- Zhu, H. (2002). *Phonological Development in Specific Contexts: Studies of Chinese-Speaking Children*. Clevedon: Multilingual Matters.

Zhu, H. & Dodd, B. (2000). The phonological acquisition of Putonghua (Modern Standard Chinese). *Journal of Child Language*, 27(1), 3-42.

## Appendix A: Word Lists

Target word	English gloss	Target nonsibilant	Vocalic context	IPA
飯	rice	f	a	[fan]
房子	house			[fan tsi]
飛機	airplane		e	[fei tei]
飛機	airplane			[fei tei]
粉紅色	pink		ə	[fən xon sə]
粉筆	chalk			[fən pi]
父親	father		u	[fu ts <sup>h</sup> iən]
父母	parents			[fu mu]
海邊	sea shore	x	a	[xai piən]
孩子	kids			[xai tsi]
黑色	black		e	[xe sə]
黑色	black			[xe sə]
很大	very big		ə	[xən ta]
很高	very tall			[xən k <sup>h</sup> ao]
花	flower		wa	[xwa]
畫畫	to draw			[xwa xwa]
灰色	grey		we	[xwe sə]
回家	go home			[xwe teia]

Table 13. Guoyu word list.

Target word	English gloss	Target nonsibilant	Vocalic context	IPA
學生	student	h	a	[haʔ siən]
蛤蜊	clam			[ham a]
放東西	to put things		e	[he mi kja]
蝦子	shrimp			[he a]
好吃	yummy		ə	[hə tsja]
好玩	fun			[hə səŋ]
玉米	corn		wa	[hwan me]
玉米	corn			[hwan me]
花	flower		we	[hwe]
火車	train			[hwe tsja]

Table 14. Taiwanese Southern Min word list.