AREСLS, 2012, Vol.9, 91-114.

THE EARLIEST STAGE OF VOICELESS FRICATIVE ACQUISITION AMONG THAI LEARNERS OF MANDARIN CHINESE

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Abstract

The aim of this study is to investigate whether sounds in Mandarin (L2) that are phonologically and/or phonetically similar to Thai (L1) sounds are easier to acquire by L2 learners than sounds that have no L1 counterparts. Mandarin voiceless fricatives are /f, s, ʂ, ɕ, x/ whereas Thai fricatives are /f, s, h/. Three Thai learners and two natives of Mandarin participated in a picture-naming task. Auditory analysis revealed that the participants produced labiodental and alveolar Mandarin fricatives with a 100% accuracy; the production of retroflex and alveolo-palatal fricatives, on the other hand, was variable; and all velar fricatives were realised as glottal fricatives. Acoustic results confirm that Thai learners have difficulty producing alveolo-palatal fricatives, but that the realisations of labiodental and retroflex fricatives were not significantly different between two groups. According to Contrastive Analysis Hypothesis (Lado, 1957), learners would find similar elements less difficult than different elements, which seems to be in agreement with our results since learners always produce labiodental and alveolar fricatives accurately.

Keywords: *Thai, Mandarin, phonological acquisition, second language acquisition, Contrastive Analysis hypothesis (CAH)*

1. Introduction

Two main hypotheses have been proposed in second language acquisition of phonology. According to the Contrastive Analysis hypothesis (CAH), L2 learners would assimilate similar sounds in L2 to their L1; thus similar sounds would be easier to acquire (Lado, 1957). However, this hypothesis is argued against by Flege (1995) who proposes the Speech Learning Model (SLM) that the more similar phonetic characteristics between L1 and L2, the more difficult L2 learners would find in acquiring new sounds; thus L2 learners would find different sounds easier to acquire than similar sounds.

2. Background

Most studies on the acquisition of Mandarin as a second language report on learners' difficulties in acquiring sounds that are not part of the phonemic system of L1, supporting the Contrastive Analysis Hypothesis (Lado, 1957). For instance, Guoyu-Taiwanese bilinguals find the alveolar vs. retroflex fricative contrast difficult to acquire because of the lack of retroflex fricatives in Taiwanese (Shih and Kong, 2011). Guangzhou Cantonese speakers have problems in differentiating some Mandarin contrasts, especially the alveolar vs. retroflex affricate and the aspirated alveolar vs. retroflex affricate contrasts, since they do not exist in Cantonese (Zhang et al., 2012). Besides, native speakers of English usually have the productions of Mandarin alveolo-palatal fricative as postalveolar fricative and Mandarin retroflex

fricative as alveolar fricative (Tutatchikova, 1995). However, several studies do support Flege's (1995) proposal that the smaller the phonetic differences between L1 and L2, the more difficulty learners would have when acquiring the target sounds. For example, native English speakers learning Mandarin as a foreign language can distinguish the retroflex and alveolo-palatal fricatives in Mandarin despite their non-existence in their L1 (Chang et al., 2009, Chang et al., 2011), and seem to produce alveolar fricative as postalveolar fricative despite their alveolar fricative existence in their native language (Tutatchikova, 1995).

Most of the literature on acquisition of fricatives by Thai learners has focused on English as a second language (Briere and Chiachanpong, 1980; Burkardt, 2008; Charmikorn, 1988; Chunsuvimol and Ronnakiat, 2000; Chunsuvimol and Ronnakiat, 2001; Pansottee, 1992; Roengpitya, 2011). However, to one author's knowledge, none of the above studies was conducted on the earliest stages of the acquisition of Mandarin fricatives by Thai native speakers. The objective of this study is to investigate the acquisition of Mandarin voiceless fricatives: /f, s, ʂ, ɕ, x/ by Thai learners, by conducting an auditory and acoustic analysis on the productions of Thai and Mandarin speakers.

3. The Sound Inventory of Thai and Mandarin Chinese

Table 1 illustrates the Mandarin consonant inventory (Guo, 1999); while Table 2 shows the Thai consonant inventory (Tingsabadh and Abramson, 1993).

		Bilabial	Labio-dental	Alveolar	Retroflex	Alveopalatal	Velar
Plosive	-aspirated	p		t			k
	+aspirated	pʰ		tʰ			kʰ
Affricate	-aspirated			ts	tʂ	tɕ	
	+aspirated			tsʰ	tʂʰ	tɕʰ	
Nasal		m		n			ŋ
Glide						j	w
Lateral				l			
Fricative	-voiced		f	s	ʂ	ɕ	x
	+voiced				ʐ		

Table 1: Mandarin Chinese Consonant Inventory

		Bilabial	Labio-dent.	Alveolar	Post-alveolar	Palatal	Velar	Glottal
Plosive	+voiced	b		d				ʔ
	-aspirated	p		t			k	
	+aspirated	pʰ		tʰ			kʰ	
Affricate	-aspirated				tɕ			
	+aspirated				tɕʰ			
Nasal		m		n			ŋ	
Glide						j	w	
Lateral				l				
Fricative			f	s				h
Trill				r				

Table 2: Thai Consonant Inventory

The literature on Thai fricatives is scarce but the description of Thai phonology by Tingsabadh and Abramson (1993) suggests that there are three fricatives in Thai: /f/ is labiodental; /s/ is articulated with the tip of the tongue making partial contact behind the upper teeth; and /h/ is glottal. According to Harris' (1972) study with about 60 Thai participants, each fricative has their own variants as follows: 1) the labiodental fricative has two variants: voiceless labio-dental fricative and voiceless labio-dental velarized fricative which usually occurs before close front vowels, e.g. [f̃ː] 'a boil'; 2) the voiceless lamino-alveolar grooved fricative has five variants: voiceless lamino-alveolar grooved fricative, voiceless lamino-dental flat fricative which is rare, occurring in the speech of a small number of people, e.g. [θ̪ŭəi] 'pretty', voiceless lamino-dental grooved fricative which is also rare, occurring with only one speaker [ʂ̪ŭəi] 'pretty', voiceless denti-alveolar grooved fricative which is

scarce, occurring before close front vowels occurring with only a few speakers, e.g. [ʂìː] ‘four’, and voiceless lamino-alveolar velarized grooved fricative which is common occurring before close front vowels in emphatic speech, e.g. [sʲìː] ‘four’; 3) the voiceless glottal fricative has four variants: voiceless glottal fricative, voiced glottal fricative occurring only between vowels, e.g. [ʔaɦăːn] ‘food’, voiceless nasalized glottal fricative occurring initially in [h̃ɦ̃ːˆ] ‘five’ and occurring everywhere for a few informants, and voiced nasalized glottal fricative occurring between vowels, e.g. [ʔaɦ̃ɦ̃ăːn] ‘food’. Even though no alveolo-palatal fricatives exist in Thai, Thai speakers produce sounds at this place of articulation in affricates: /tɕ, tɕʰ/.

In Mandarin Chinese, there are five fricatives: /f, s, ʂ, ɕ, x/. /f/ is reported as being labiodental. Even though Guo (1999) categorises /s/ as an alveolar fricative, Lee (2011) suggests that it is actually dental [s̪]. Compared to the retroflex fricative, the alveolo-palatal fricative is slightly more forward, going right up to the upper teeth, with a wider area of frication, expanding both sides into the molars and much inwards onto the hard palate. Therefore, the alveolo-palatal fricative has a smaller front cavity and a narrower channel area than the retroflex fricative (Chang et al., 2009). Moreover, although there are differences due to characteristics of each speaker, dental [s̪] makes contact close to the teeth (Ladefoged and Wu, 1984). Alveolar fricative is farther front than retroflex and alveolo-palatal fricatives, and alveolo-palatal fricative contrasts with alveolar and retroflex fricatives in the posture of the tongue due to its palatalisation (Li, 2008). The retroflex [ʂ] is made with the upper surface of tongue tip or blade against the post-alveolar area without curling the tongue tip (Lee and Zee, 2003, Toda and Honda, 2003). In addition, this sound has been called alveolo-palatal (Kratochvil, 1968), back apical (Zongji, 1992), or postalveolar (Lin, 2007). The velar fricative is more marked than glottal fricative – the occurrence of velar fricative is

rarer than glottal one; however, the velar fricative is often retracted before back vowels and perceptually sounds like glottal fricative (Hsiao, 2011). Furthermore, the velar fricative has two other allophones: uvular and glottal fricatives; however these two additional allophones are not considered as standard (Trísková, 2008). According to Lado (1957), we hypothesise that a positive transfer of Thai would occur in the production of Mandarin labiodental and alveolar fricatives by Thai participants. Besides, the results of this study would argue Flege's (1995) hypothesis since we assume that Thai learners would find alveolo-palatal, retroflex, and velar fricatives difficult to acquire in which their productions would be either non-target-like or variable.

4. Methodology

4.1 Participants

Three Thai participants – one male and two females – were recruited for the study along with two native speakers of Mandarin – one male and one female – as controls. The male Thai speaker was 27-year-old and was from Central Thailand and the female Thai speakers were: a 31-year-old from the Lower North of Thailand and a 35-year-old from Southern Thailand. The Thai participants had Thai as their mother-tongue, and had studied English as a foreign language for over twenty years as compulsory courses at school and university. None of them reported having knowledge of Mandarin. The native Mandarin speakers were a 25-year-old Mandarin male speaker from Beijing, and a 23-year old Mandarin female speaker from Northern China. All participants were postgraduate students who had been studying in the UK for over six months. None of them reported having hearing or speech impairments.

4.2 Data Collection and Analysis

4.2.1 The project of teaching Mandarin to Thai speakers

To investigate the earliest stages of L2 phonological acquisition of Mandarin, Thai learners were exposed to 14 hours teaching of Mandarin over a one-month project during which they received two hours of tuition, twice a week. The classes were taught by a female native speaker of Mandarin from Northern China who was one of the Mandarin participants. Both pinyin – a system of transcribing Chinese characters to Latin letters – and English as instruction languages were used. Thai learners were exposed to all the sounds in Mandarin, with no emphasis on fricatives by the teacher. The classes were run in a university room to ensure an appropriate atmosphere of instruction and learning. The teaching materials consisted of a Powerpoint presentation and a board to write words and sentences.

4.2.2 Procedure

After studying Mandarin for 14 hours, the participants were assessed on their productions of Mandarin words via a picture-naming task. The Powerpoint slides contained a picture accompanied by the pinyin word and the English translation. Learners were allowed to read their own Thai notes during the test to make them feel more confident. The task was composed of 60 words in total with only 25 with the target word starting with the following voiceless fricatives: /f, s, ʂ, ɕ, x/ (cf. appendix). They were instructed to produce each word embedded in the following carrier sentence: 'niàn _____, kāi shǐ' (Repeat _____, Go) at a normal rate. As participants were not told that only fricative productions in the target words would be assessed, they were semi-blind to the purpose of the study. All speakers' productions were

digitally recorded using an Edirol R-09 recorder at a sampling rate of 44,100 Hz in mono channel and 16 bit quantisation, which was placed 20 centimetres away from the speakers.

4.2.3 Transcription and auditory analyses

The transcription was done by trained phoneticians (with different levels of training) who were three native speakers of Mandarin and the first author who was native speaker of Thai. The transcribers were told what the target words were, and they were asked to phonetically transcribe the target words as they occurred in the reading sentences. If they were uncertain of what they heard, they were encouraged to transcribe the target words and to place it in separate 'not sure' column. For this study, the reliability for the transcription was 80%. It should be noted that the fricative tokens produced by two Mandarin natives were transcribed by only one Thai phonetician; thus, this transcription reliability was not included in the overall transcription reliability.

4.2.4 Acoustic analyses

Acoustic measurements were applied using Praat (Boersma and Weenink, 2012). The fricative was segmented from the first appearance of the aperiodic noise on the wave form, up to the first zero-crossing of the periodic waveform of the following vowels. Next, an FFT spectrum was made over a 40 ms Gaussian Window centred around the temporal mid-point of the fricative bit, which reflects the most stable portion of a fricative with the least influence of amplitude drops or coarticulatory effects from the preceding and/or following vowels (Li et al., 2009).

The peak location and the first four spectral moments: centroid, standard deviation, skewness and kurtosis, were computed to pinpoint the place of articulation of Mandarin fricatives (Behrens and Blumstein, 1988, Jongman et al., 2000). The peak location, centroid, and skewness are negatively correlated with the length of the front resonating cavity; thus, the higher the value, the more forward the place of articulation. The standard deviation and the kurtosis can distinguish the tongue posture between apical and laminal areas and the shape of the spectrum, i.e. diffuse or flat to distinguish between /s/ and /f/ (e.g., Li et al., 2009). When the distribution is more peaked, a higher Kurtosis is obtained. When the fricative is more sibilant, a lower standard deviation is obtained (Jongman et al., 2000).

5. Findings and Discussion

5.1 Auditory analyses

We present in Table 3 the percentages of target-like productions of Mandarin fricatives by Mandarin and Thai speakers. Thai learners produced both the voiceless labiodental fricative and voiceless alveolar fricative with a 100% accuracy. The retroflex and the alveolo-palatal fricatives were produced with only 40% accuracy.

Fricative	Mandarin speaker		Thai speaker		
	Female1	Male1	Female1	Female2	Male1
/f/	5(100)	5(100)	5(100)	5(100)	5(100)
/s/	5(100)	5(100)	5(100)	5(100)	5(100)
/ʂ/	5(100)	5(100)	0(0)	2(40)	2(40)
/ɕ/	5(100)	5(100)	2(40)	2(40)	2(40)
/x/	1(20)	1(20)	0(0)	0(0)	0(0)

Table 3: The target-like productions of Mandarin fricatives by Mandarin and Thai speakers (percentages in parentheses)

As demonstrated above, while Thai learners have stable target-like productions for both labiodental and alveolar fricatives, their productions exhibit

various realisations for retroflex and alveolo-palatal fricatives. First, two out of the three Thai speakers managed to produce retroflex fricatives mostly accurately. However, there are some errors in the productions of all Thai learners ranging between an alveolar fricative, an aspirated retroflex affricate, an aspirated alveolo-palatal affricate, and an unaspirated alveolo-palatal affricate. Second, all Thai learners have some target-like productions of the alveolo-palatal fricatives, with some substitutions as an alveolar fricative, a retroflex fricative, or an unaspirated alveolo-palatal affricate. The results are shown in Table 4.

Phoneme	Realisation	Female1	Female2	Male1
/ʂ/	[ʂ]	-	2(40)	2(40)
	[s]	-	1(20)	3(60)
	[tʂʰ]	1(20)	2(40)	-
	[tɕʰ]	2(40)	-	-
	[tɕ]	2(40)	-	-
/ɕ/	[ɕ]	2(40)	2(40)	1(20)
	[ʂ]	-	1(20)	1(20)
	[tɕ]	-	-	1(20)
	[s]	3(60)	2(40)	2(40)
/x/	[h]	5(100)	5(100)	5(100)

Table 4: The realisations of mispronounced sounds by Thai learners (percentages in parentheses)

The production of the voiceless velar fricative shows an interesting pattern for both Mandarin and Thai speakers. For Mandarin, the female speaker had two variants for this sound: velar and glottal fricatives; while there were three variants for the male speaker: velar, glottal and uvular fricatives. These variants are common for the voiceless velar fricative in certain varieties of Mandarin, though not the standard (Trísková, 2008). All three Thai speakers produced this sound as a voiceless glottal fricative. There are potentially three reasons why Thai learners produced only one variant for the voiceless velar fricative. First the pinyin character used to represent this voiceless velar fricative corresponds usually to the ‘h’ character. Second, both native speakers of Mandarin produced it as one of the variants. Finally, this might be

a direct transfer from L1 since the glottal fricative is part of the sound system in Thai. The results are shown in Table 4.

Our results seem to support both hypotheses. On the one hand, results for the labiodental and alveolar fricatives are in agreement with the Contrastive Analysis Hypothesis (Lado, 1957), and since the results show that Thai learners had difficulty producing alveolo-palatal, retroflex, and velar fricatives which are different sounds, thus the results argue against Speech Learning Model (Flege, 1995).

5.2 Acoustic analyses – Native speakers of Mandarin

Acoustic analyses were performed on the four Mandarin fricatives /f, s, ʂ, ɕ/ produced by native speakers with the exclusion of the velar fricative as its realisation was variable amongst native speakers. The aim here is to locate the place of articulation for these sounds as a comparison with those produced by Thai learners (cf. 5.3), followed by examining potential differences between the two Mandarin speakers and finally to determine which acoustic measurements are needed to distinguish between the four fricatives. The study assumes that there is no statistical difference between gender of Mandarin speakers and the values of acoustic measurements since the numbers of participants in both groups are too small to run statistical measure.

An independent t-test was performed on each of the five acoustic measures to determine influence of gender since Mandarin speakers were one female and one male. The results presented in Table 5 show under the significant level at 0.001 ($p < 0.001$), no acoustic measurements are significantly different between male and female speakers. This result indicates that fricatives produced by the male speaker seem to be similar to those by the female speaker.

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Peak Location	2.283	38	0.028	1436.253	629.0393	162.8299	2709.677
Centroid	1.232	38	0.225	641.3818	520.4534	-412.221	1694.985
Standard deviation	-0.38	38	0.706	-92.5357	243.7358	-585.953	400.8816
Skewness	0.146	38	0.884	0.03837	0.26199	-0.492	0.56875
Kurtosis	-0.238	38	0.813	-0.16488	0.69183	-1.56543	1.23566

Table 5: The independent t-test results for Mandarin speakers

In order to investigate which of the five acoustic measurements is needed to discriminate between the four fricatives in Mandarin, we performed a multinomial logistic regression with the four fricatives as dependent variables and the five acoustic measurements as predictors. The results are shown in Table 6.

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	62.716	62.716	3	0
Peak location	7.213a	7.213	3	0.065
Centroid	32.982	32.982	3	0
Standard Deviation	50.624	50.624	3	0
Skewness	.000b	0	3	1
Kurtosis	.000b	0	3	1

Table 6: Logistic regression results for Mandarin speakers

The results from the logistic regression suggest that Mandarin fricatives produced by native speakers were significantly differentiated with the centroid and the standard deviation, $\chi^2(3) = 32.98$, $p < 0.00$, and $\chi^2(3) = 50.62$, $p < 0.00$, respectively. The logistic regression results suggest that the peak location has no major effect (p=0.065) on distinguishing between the four Mandarin fricatives.

5.3 Acoustic analyses – Thai learners

Results obtained from native speakers of Mandarin showed that only the centroid and the standard deviation are necessary to distinguish between the four fricatives. In order to assess potential differences between the productions of the four Mandarin fricatives by the two groups, native speakers and Thai learners, we performed an independent t-test on each of the two acoustic measurements (centroid and standard deviation) of each fricative. The results are summarised in Table 7.

	t-test for Equality of Means						
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
Centroid - Labiodental	-1.959	23	0.062	-1006.57	513.9209	-2069.69	56.55816
Centroid - Alveolar	-1.782	13.585	0.097	-1006.57	564.7224	-2221.26	208.1217
Centroid - Retroflex	4.802	23	0	2052.675	427.5068	1168.309	2937.04
Centroid – Alveolo-palatal	0.383	23	0.705	184.0653	480.4512	-809.824	1177.954
SD - Labiodental	1.197	17.033	0.248	422.5561	352.9094	-321.907	1167.02
SD - Alveolar	-0.289	23	0.775	-126.654	438.1074	-1032.95	779.6406
SD - Retroflex	-3.496	23	0.002	-987.614	282.4948	-1572	-403.229
SD – Alveolo-palatal	-1.734	23	0.096	-448.701	258.824	-984.119	86.71695
	-2.485	18.621	0.023	-511.818	205.9754	-943.524	-80.1114

Table 7: The independent t-test results on comparable fricatives between Mandarin and Thai speakers

The positions of the four fricatives from both Mandarin speakers and Thai learners are presented as a function of their centroid and their standard deviation. These are presented in Figure 1.

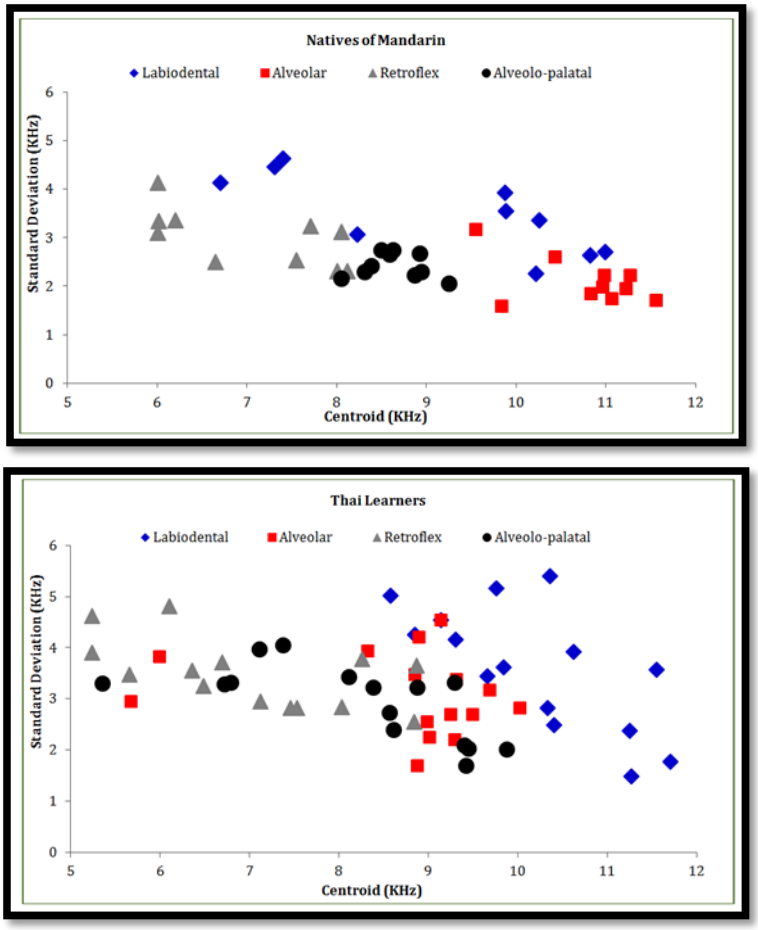

Figure 1: The position of the four Mandarin fricatives in a two dimensional space, centroid, by standard deviation, for Mandarin speakers (top) and Thai learners (bottom).

Results obtained from the independent t-tests and from the graphical display showed that the centroid of the alveolar fricative is significantly different between the two groups: Mandarin speakers produced significantly more forward alveolar fricative than Thai speakers, t(23)=4.80, p < 0.00 (Mandarin speakers: M=10775.66 Hz, SD=642.50, and Thai learners: M=8722.99 Hz, SD=1239.41). Results for the standard deviation of the alveolar fricative were also significantly different: Mandarin alveolar fricatives are more sibilant than Thai alveolar fricatives (cf. Jongman et al., 2000), t(23)=-3.50, p < 0.00 (Mandarin speakers: M=2104.81 Hz, SD=477.97, and Thai learners: M=3092.42 Hz, SD=799.85).

The standard deviation of the alveolo-palatal fricative was significantly different between the two groups: alveolo-palatal fricatives produced by Mandarin speakers are more sibilant than those produced by Thai learners, t(23)=-2.11, $p < 0.05$ (Mandarin speakers: M=2420.90 Hz, SD=256.13, and Thai learners: M=2932.72 Hz, SD=733.47).

The positions of each fricative production can be described as follows. For labiodental fricatives, the production of this segment is variable for both native speakers of Mandarin and Thai learners, and the independent sample t-test shows that there are no significant differences between these two groups; thus, this variation might occur due to the influence of the following vowels which are not controlled for in this study. Next, even though the auditory analysis shows that Thai learners have a 100% accurate productions of voiceless alveolar fricatives, the figures clearly illustrate that the alveolar fricatives of native speakers of Mandarin is on the right (with higher frequency), while those by Thai learners are in the middle of the figure. The higher frequency of centroid by native speakers of Mandarin suggests that an alveolar fricative is actually produced as a dental fricative in Mandarin while it is produced as an alveolar in Thai. The auditory analyses revealed that the two groups are different in their productions of the retroflex, with the native speakers of Mandarin being consistent in their production while Thai learners being variable. Acoustic analyses, however, revealed that the two groups are not different. Looking at the results in details suggests that Mandarin speakers are variable in their realisations of the retroflex fricative, with positions of centroid value ranging from 6003 to 11564 Hz, and SD value from 1713 to 4628 Hz. The value of centroid suggests that the retroflex position of Mandarin natives is between 6000-8000 Hz. Thai learners also seem to be variable with their centroid value ranging from 4824 to 11707 Hz, and SD

value from 1485 to 5396 Hz. This result seems not to be in accordance with the auditory analyses which revealed a more homogeneous group for Mandarin speakers and a more variable group for Thai learners. However, discrepancies obtained from the two analyses might suggest a different level of detail obtained from the two analyses, with auditory analyses being general, i.e. transcribers were aiming for transcribing a coarse phonetic category with minor details, while acoustic analyses is more detailed, i.e. results are suggesting the "real" position of the category. For the acoustic analysis for alveolo-palatal fricative, since the independent t-test shows that these two groups are significantly different, it supports the auditory analysis that Thai learners produced this sound with variable realisations.

6. Conclusion

At the earliest stage of the acquisition of Mandarin fricatives by Thai learners, one cannot reject the fact that the first language does play an important role. The Contrastive Analysis hypothesis (Lado, 1957) correctly predicts that learners will have less difficulty producing similar sounds rather than different sounds. This hypothesis is supported by the complete correctness in the production of the voiceless labiodental and alveolar fricatives which are also part of the Thai consonant inventory, with potential differences in places of articulation. Additionally, the suggestion from the Speech Learning Model (Flege, 1995) that sounds in the L2 that are different from those in the L1 are easier to acquire is also supported by our results; this was exhibited in the way Thai learners accurately pronounced some of the voiceless retroflex fricatives and the voiceless alveolo-palatal fricatives in the targeted words. Our analyses of error patterns found in this study showed that Thai learners do exhibit: fronting, backing, affrication and aspiration, and affrication. It is interesting to note that Thai learners might not be able to perceive the variations in the velar

fricative in Mandarin; hence, they only produced it as a glottal fricative. This might be due to the orthography misleading of pinyin (Bassetti, 2009), the negative transfer in their L1, or the variation in the pronunciation of the velar fricative by the Mandarin teacher. There are some limitations to study that should be noted. First, the number of participants is rather small - only three, and might not be sufficient to generalise the findings. Second, the teaching method using pinyin might mislead the perception and production of the learners as stated by Bassetti (2009). Therefore, for future research, a study with higher number of participants should be conducted, and the Mandarin classes and assessment might refrain from using pinyin as a medium of instruction - only pictures and English - to be able to prevent the influence of pinyin.

As many researchers agree that auditory analysis might be subjective due to the perception and background of transcribers, acoustic analysis is often proven to be beneficial in terms of finding some contrast and covert contrast of speech productions (e.g., Li et al., 2009). In this study, the acoustic study reveals three coherent and one contrastive results to the auditory study. In terms of coherent results, first, the auditory analyses showed that the labiodental fricative was realised as a labiodental fricative by Thai learners and the acoustic results showed no significant difference in the production of this consonant by both groups. Second, the production of the alveolo-palatal fricative by Thai learners was shown to be variable in both the auditory and the acoustic analyses. This finding confirms that the alveolo-palatal fricative category is in the learning process by Thai learners as this was not fully acquired. Last, the result linked to the realisation of the retroflex fricative showed that from an auditory analysis point of view, Thai learners produced the retroflex with many realisations with different manners and places of articulations, ranging from fricatives to affricates, and from alveolar to, alveolo-palatal to retroflex. This result shows that

Thai learners have not acquired this sound yet and thus their productions are variable. From an acoustic analysis point of view, results revealed that in both Mandarin and Thai, the position of this sound is quite variable, with centroid frequencies ranging from the alveolar place of articulation going backward to the post-alveolar place of articulation. Moreover, results from the independent t-test suggested that there are no significant differences between the two groups of speakers. It might be possible that some productions of this sound by Thai learners has gained some positive influence from their L2 since retroflex fricatives in Mandarin are not produced with tongue curling, thus might be similar to postalveolar fricatives in English. The only contrastive result between the auditory and the acoustic analyses is linked to the alveolar fricatives. The realisation of the alveolar fricative by Thai learners was judged as being auditorily 100% accurate, but is in fact significantly different between native speakers of Mandarin and Thai learners based on the acoustic analyses. The independent t-test results and the graphical display showed that the production of the alveolar fricative by Mandarin speakers is more fronted and possibly uses a different part of the tongue or being possibly more sibilant than the alveolar fricative produced by Thai learners. These results seem to be in concordance with the description provided on Mandarin and Thai on the alveolar fricative being dental for the former and alveolar for the latter. Since the dental versus alveolar contrast is not relevant for Mandarin, the alveolar fricative by Thai learners were judged as accurate because to the perception of Mandarin listeners, it was close enough to what they would identify as /s/.

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Appendix: Items Used in Picture-naming Task

No.	*English*	*Pinyin*	*IPA*
1	rice	chī fàn	tʂʰi55.fan51
2	house	fáng wū	fɑŋ35.u55
3	airplane	fēi jī	feɪ55.teɪ55
4	windy	dà fēng	ta51.fəŋ55
5	father	fù qīn	fu51.teɪn55
6	pickles	suān cài	suan55.tʂʰaɪ51
7	broom	sào zhou	sao214.tʂou214
8	accommodation	sù shè	su51.ʂɤ51
9	three	sān kāi	san55
10	forest	sēn lín	sən55.lin35
11	read books	kàn shū	kʰan51.ʂu55
12	oil	shí yóu	ʂi35.jou35
13	mobile phone	shǒu jī	ʂou214.teɪ55
14	gentleman	shēn shì	ʂən55.ʂi51
15	mountain and water	shān shuǐ	ʂan55.ʂueɪ214
16	games	yóu xì	jou35.ɕi51
17	prawn	xiā kāi	ɕɪa51
18	shoes	xié zǐ	ɕɪɛ35.tsi214
19	missing	xiǎng niàn	ɕɪɑŋ214.nɪɛn51
20	snowy	dà xuě	ta51.ɕyɛ214
21	seafood	hǎi xiān	xaɪ214.ɕɪɛn55
22	red tea	hóng chá	xɔŋ35.tʂʰa35
23	kids	hái zi	xaɪ35.tsi214
24	oyster sauce	háo yóu	xau35.jou35
25	flower	huā duǒ	xua55.tuɔ214

Notes: Pinyin is Chinese romanisation system. The dots between words in the last column represent syllable break. The number used in IPA transcription indicates Mandarin tones: 55 – high level, 35 – rising, 214 – falling-rising, and 51 – high falling tones respectively.

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Acknowledgement

The authors are very grateful to Dr. Ghada Khattab, Prof. Martha Young-Scholten, and anonymous reviewers. In addition, we would like to thank Mr. Hou, Miss Nuatip, Miss Kanida, and Mr. Sarun for their participation.