

# AN ACOUSTIC STUDY OF ENGLISH AND THAI FRICATIVES PRODUCED BY THAI SPEAKERS

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## ABSTRACT

This paper explores the acoustic characteristics of English and Thai fricatives, uttered by native-Thai speakers. In the phonological systems, English has four pairs of voiceless-voiced fricatives, which appear initially, intervocalically, and finally. Thai, on the other hand, has only two initial voiceless fricatives. The results of this acoustic study revealed that the major acoustic cues of different English fricatives for L2 learners include (i) the shorter or longer frication durations, (ii) the variations in shapes and heights of the amplitude of fricatives due to different durations and positions of fricatives, (iii) the fundamental frequency (F0) of fricatives, and (iv) the voicing state. It is hoped that this study will shed light on to further acoustic and perceptual studies in L2 learning.

**Keywords:** fricatives, English, Thai, acoustic cues, production

## 1. INTRODUCTION

Fricatives, commonly found in many languages around the world, are classified as obstruents in the same class as stops [4]. However, unlike stops, the fricative production involves a close proximity between two articulators, and a turbulent airstream [5]. Fricatives can be differentiated into different types due to different places of articulation, voicing, and the velocity of airflow (sibilants and non-sibilants) [4, 5].

In second language (L2) learning, some questions arose of how L2 learners produce the L2 fricatives, when the L2 phonology (English) has more fricative phonemes than does the L1 sound system (Thai). Furthermore, what would be the acoustic cues for the L2 learners to produce L2 fricatives?

In the literature, English has four pairs of voiceless-voiced fricative phonemes /f, v/, /θ, ð/, /s, z/, and /ʃ, ʒ/ [4, 5], which do not include the phoneme /h/ [3]. These eight English fricatives can appear in the initial, intervocalic, and final

positions. Thai, on the other hand, has only two initial voiceless fricatives /f/, and /s/ [7].

Acoustically, the eight English fricatives have the acoustic cues such as the spectrum, amplitude, and duration of the frication noise [3, 4, 6]. Amongst the three positions, the acoustic analysis revealed that the amplitude of the high frequency noise of the coda fricatives was lower than the one of the initial fricatives [11]. Furthermore, based on the aerodynamic principles, voiced fricatives tend to become voiceless or to defricate [8, 9]. In L2 learning, some acoustic studies on fricatives uttered by non-native speakers reported that Chinese learners tended to substitute /s/ for /θ/ [10]. Previous impressionistic studies on English fricatives, produced by Thai learners, have been conducted, based on the data of the frequency occurrences of the phonemes which the researchers heard and identified as [1].

This paper has a focus on the acoustic studies of English and Thai fricatives to see the acoustic characteristics of the eight English fricatives and the two Thai fricatives, produced by native-Thai learners. An acoustic study was conducted.

## 2. METHODS

This acoustic study involves the measurements of English and Thai fricatives, uttered by native-Thai speakers. 67 English and 10 Thai words were selected. The English tokens had the structure of C1VC2 or the structure of C1VC2VC3. Initial English fricatives /f, v, θ, ð, s, z, ʃ, ʒ/ were C1 and final fricatives were C2 of the first structure: C1VC2. Those in the intervocalic position were C2 of the second structure: C1VC2VC3. The Thai tokens had the structure of C1V(:)(C2), where C1 was a fricative /f/ or /s/, V(:) was a short or long vowel /a, aa/, and C2 was a final nasal /n/ or a final stop /k/. All tokens were in citation form and in the framed sentences: “Say the word \_\_\_\_ twice” for the English tokens and /phûut kham wâa \_\_\_\_sǎŋ kr áŋ/ “Say the word that \_\_\_\_ two times.” There were a total of 924 tokens (77 tokens x 2

times x 2 contexts x 3 speakers). Three native-Thai female speakers, with English as their L2, participated in this study. Two were 19 years old, and the other was 18 years old. All were non-English-major freshmen in a state university in Thailand. All speakers had a normal speaking and hearing. They were asked to utter all the English and Thai tokens, which were digitally recorded in the Praat Sound Analysis program at a sample rate of 16 kHz. Each token was measured for (1) the amplitude at three temporal points (the amplitude onset (T1), 50% of the amplitude duration (T2), and the amplitude offset (T3)), (2) the fricative duration, (3) the vowel duration, (4) the fundamental frequency of voiced fricatives, (5) the voicing duration (if any), (6) the fundamental frequency of the vowel, and (7) the formant frequencies of the adjacent vowels (the vowel onset, the mid duration, and the vowel offset). The results and discussion are presented in Sections 3 and 4 below.

### 3. RESULTS

The results are presented in terms of the values of the amplitude, different amplitude shapes, the fricative and vowel durations, the fundamental frequencies of the vowel onset, and the voicing state of English and Thai fricatives.

First, the results of the amplitude of English-Thai fricatives, in terms of the dB differences and various shapes, are shown in Figures 1-4 and Figures 5-7, respectively. Figures 1-4 present the dB differences of two different intervals of the English voiceless-voiced labiodental (Fig. 1), interdental (Fig. 2), alveolar (Fig. 3), and palatal (Fig. 4) fricatives, and the ones of the two voiceless Thai fricatives /f, s/ (Figs. 1 and 3).

It can be noted that, in each figure, T2-T1 is for the dB difference between the amplitude onset and the mid amplitude, and T3-T2 is for the dB difference between the amplitude offset and the mid amplitude. ‘TH’ means the Thai tokens for /f/ and /s/; otherwise, all are English tokens. ‘#x’ is a fricative in an initial position; ‘VxV’ is a fricative in an intervocalic position; ‘x#’ is a fricative in a final position; ‘sent’ is a fricative in connected speech (in a sentence); ‘th’ is a voiceless interdental /θ/; ‘thh’ is a voiced interdental /ð/; ‘sh’ is a voiceless palatal /ʃ/; and ‘zh’ is a voiced palatal /ʒ/.

Figure 1: The dB difference of /f, v/.

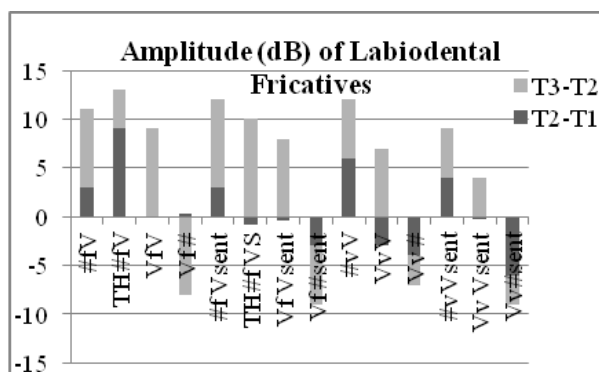


Figure 2: The dB difference of /θ, ð/.

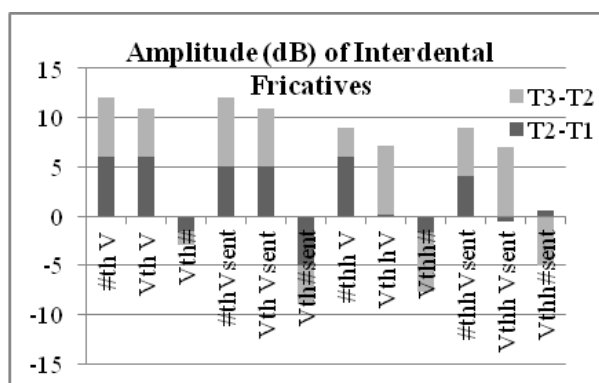


Figure 3: The dB difference of /s, z/.

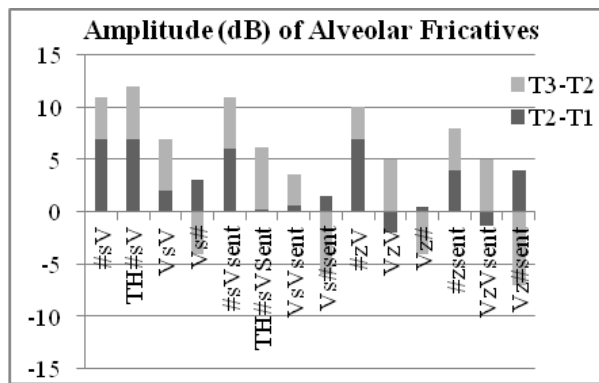
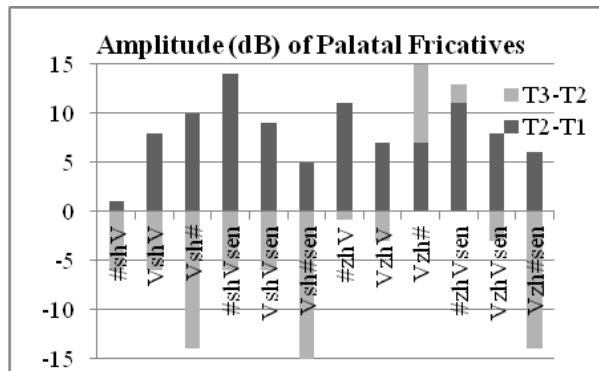
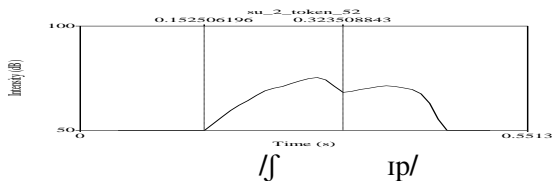


Figure 4: The dB difference of /ʃ, ʒ/.

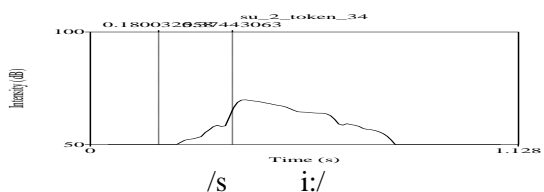


Figures 5-7 show three different types of the dB shapes of fricatives: the rising(-falling) shape of an initial fricative (Fig. 5), the step-rising shape of an initial fricative (Fig. 6), and the (rising-)falling shape of a final fricative (Fig. 7).

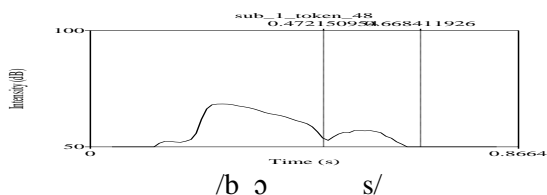
**Figure 5:** The dB rising-falling shape of the initial /ʃ/ the citation word ‘ship’ uttered by Speaker No.2.



**Figure 6:** The dB step-rising shape of the initial /s/ in the citation word ‘see’ uttered by Speaker No.2.

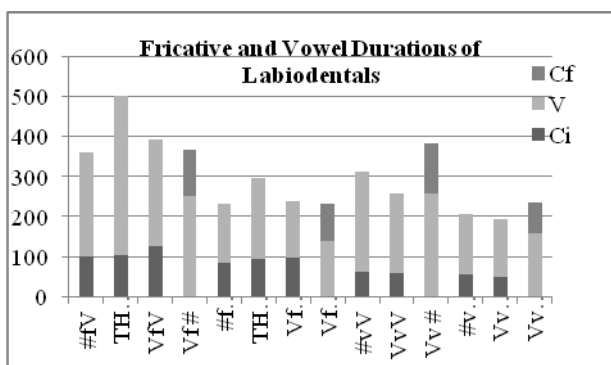


**Figure 7:** The dB rising-falling shape of the final /s/ in the citation word ‘boss’ uttered by Speaker No.1.

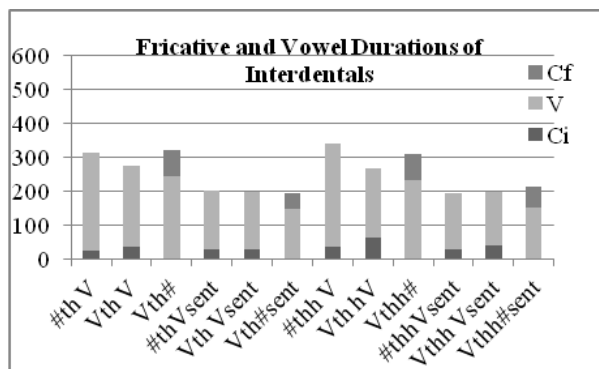


Second, the results of the fricative and the adjacent vowel durations are shown in Figures 8-11. In each figure, ‘Ci’ is an initial consonant, ‘V’ is a vowel, and ‘Cf’ is a final consonant. Figure 8 is for labiodentals, Fig. 9, for interdental, Fig. 10, for alveolars, and Fig. 11, for palatals. The results for Thai fricatives /f/ and /s/ are in Fig. 8 and Fig. 10, respectively.

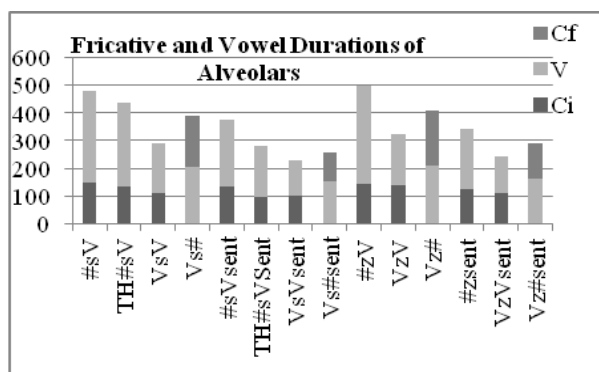
**Figure 8:** Fricative and vowel durations of /f, v/.



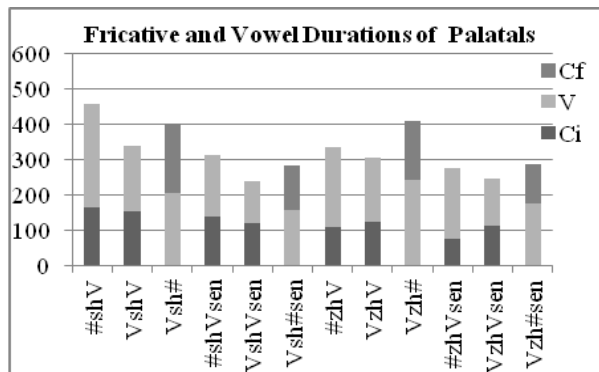
**Figure 9:** Fricative and vowel durations of /θ, ð/.



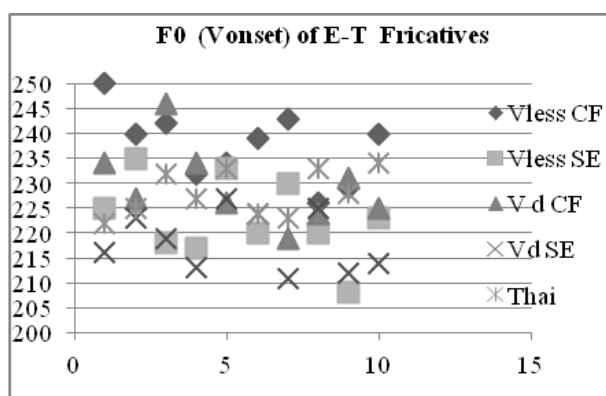
**Figure 10:** Fricative and vowel durations of /s, z/.



**Figure 11:** Fricative and vowel durations of /ʃ, ʒ/.



Third, the results of the F0 at the vowel onset of English and Thai fricatives are shown in Figure 12. In this figure, the diamonds are for the F0 values of the English voiceless fricatives in citation form (CE); the squares are for the ones of the English voiceless fricatives in sentences (SE); the triangular shapes are for the ones of the English voiced fricatives in citation form (CE); the exes (X) are for the ones of the English voiced fricatives in sentences (SE); and the asterisks (\*) are for the ones of the Thai voiceless fricatives.

**Figure 12:** F0 at the vowel onset of the E-T fricatives.

Fourth, for the results of the voicing, the results of this acoustic study revealed that native-Thai speakers uttered English voiceless fricatives as voiceless (without a voicing bar) for 80-100% for /f/, 60-100% for /θ/, 100% for /s/, and 55-78% for /ʃ/, and uttered English voiced fricatives as voiced (with a voicing bar) for 27-50% for /v/, 27-37% for /ð/, 11-27% for /z/, and 0% for /ʒ/. Moreover, speakers tended to substitute /w/ for /v/, /t<sup>h</sup>/ for /θ/, /ð/, and /c<sup>h</sup>/ for /ʃ, ʒ/.

#### 4. DISCUSSION AND CONCLUSION

The results of this acoustic study suggest that the acoustic cues of English fricatives for native-Thai learners who are acquiring English as their L2 are the amplitude of the fricatives, the fricative duration, the F0 values, and the voicing state.

The details of this study further illustrate that the frication duration greatly affects the shapes and heights of the amplitude of fricatives. In other words, the amplitude of a fricative tends to be higher when a fricative is in an initial position, but lower, in a final position, as what Solé [11] found. Furthermore, the results of this study show that the dB shapes of fricatives can vary. When compared to the dB shapes of longer fricatives in citation form, the dB shapes of shorter fricatives in connected speech have an increased rate of change or have a beginning or end truncation. This correlates with the shorter-longer F0 shapes of Erikson and Alstermark [2]. In terms of dB and F0 heights, the dB and F0 values at the vowel onset of the voiced fricatives tend to be lower than the ones of voiceless counterparts. Though many L2 voiced fricatives uttered by Thai speakers are voiceless, the devoiced fricatives have lower dB and F0 values at the vowel onset. Thus, it can be implied that, while acquiring the L2 voiced fricatives,

native-Thai speakers use lower dB and F0 as acoustic cues for L2 voiced fricatives, which do not exist in their L1, though the actual voiced fricatives that they utter are devoiced or defricated. The finding of this study supports the aerodynamic principles about the devoicing and defrication of voiced fricatives of Ohala [8], and Ohala and Solé [9].

It is hoped that this study will shed light on to other acoustic and perceptual studies of L2 learning of other languages.

#### 5. ACKNOWLEDGMENTS

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