Modern English Education

http://dx.doi.org/10.18095/meeso.2020.21.1.12

Temporal Organization of English Fricatives in the Speech of Korean Learners of English*

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ARTICLE INFO

Received: 15 December 2019
Revised: 15 January 2020
Accepted: 10 February 2020

Examples in: English
Applicable Languages: English
Applicable Levels: Elementary/Secondary/Tertiary

KEYWORDS

fricative/duration/voiceless/voiced/stress/
마찰음/길이/무성음/유성음/강세

ABSTRACT

Jeon, Yoon-Shil. (2020). Temporal organization of English fricatives in the speech of Korean learners of English. *Modern English Education, 21*(1), 12-21.

The present paper investigates the durational patterns of English fricatives /f, v, θ, ð, s, z/ produced by native English speakers and Korean learners of English. The contrasts of voiceless and voiced fricatives, fricative sequence across word boundary, stress placement, and place of articulation were taken into account to identify the durational changes and the durational patterns that are characteristic for Korean learners of English. Example phrases for the production experiment are "say foot" and "safe foot". The recorded speech was measured to get the durations of the target fricative intervals. The study results show that the variability of the durational patterns is smaller in magnitude and the mean durations in general are longer for Korean learners of English. The speech of Korean learners of English shows that the overlapping and shortening effect for the fricative sequence is greater and the lengthening effect of stress is smaller compared with those in native English speakers' data. The results of the study are discussed in relation to the phonological contrasts of English and Korean, and some pedagogical implications of the study are presented.

I. INTRODUCTION

Korean consonant system is different from English consonant system in that it doesn't have voiced obstruents, and it has very limited number of fricatives. For fricatives Korean only possesses alveolar lenis and fortis, /s/ and /s*/, which are both voiceless. Therefore, for Korean learners of English, English labio-dental, dental, voiced alveolar, and palato-alveolar fricatives, /f, v, θ, ð, z, ʃ, ʒ/ are new phonemes which have no counterparts in Korean, and English alveolar voiceless fricative /s/ is the only fricative phoneme which has a comparable one in Korean. The difference in fricative inventory of English and Korean suggests that Korean learners of English may have difficulty establishing the articulatory patterns needed to realize English fricatives.

Other than the inventory difference between English and Korean, one of the phonological differences between English and Korean language is that Korean is a syllable-timed language and a language without lexical stress. In Korean, syllables tend to be equal in length and the syllable structure is relatively simple. In contrast, English is classified as a stress-timed language. Stress-timed languages have a great variability of vowel and consonant duration, and they have vowel reduction and complex syllable structures (Dauer, 1983; Grabe & Low, 2002; Ramus, Nespor, & Mehler, 1999).

In view of the phonological differences, it is predicted that the temporal aspects of English speech produced by Korean learners of English will reflect the characteristics of Korean consonant inventory and the segment durational patterns as a syllable-timed language. The absence of voiceless and voiced contrast in obstruents, the English fricatives that have no counterpart in Korean, and the rhythmic difference between English and Korean might

* This work was supported by the Hyupsung University Research Grant of 2019.

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affect the durational pattern of the non-native English speech of Korean learners of English.

In this study, the durational pattern of fricatives in English speech produced by Korean learners of English is examined. The goal of this study is to identify the durational patterns of non-native fricatives which are affected by 1) stress placement, 2) segment sequence, 3) voicing contrast, and 4) place of articulation. In addition, pedagogical implications of the study results on the L2 English classroom will be suggested.

II. RESEARCH BACKGROUND

Korean fricative inventory is smaller than English fricative inventory. Table 1 shows fricatives that exist in English and Korean.

TABLE 1
Fricative Inventory Comparison Between English and Korean

		Fricatives			
		Labio-dental	Dental	Alveolar	Palato-alveolar
English	voiceless	f	θ	s	ʃ
	voiced	v	ð	z	ʒ
Korean	voiceless			s (lenis) s*(fortis)	
	voiced				

As can be seen in Table 1, English has eight fricatives, which occur in voiceless and voiced pairs in three places of articulation. In contrast, Korean only has two alveolar fricatives, lenis /s/ and fortis /s*/, which are both voiceless. Korean does not have fricatives comparable to English /f/, /v/, /θ/, /ð/, /z/, /ʃ/, and /ʒ/. Therefore, it is predicted that Korean learners of English might have difficulty in producing those fricatives that are not present in their native language. As Korean does not possess voiced obstruents, it might be a challenge for Korean learners of English to pronounce English voiced fricatives. English fricative pronunciation errors produced by Malay learners of English are attributed to first language transfer in the study of Jehma and Phoocharoensil (2014). The previous studies on English fricatives produced by Korean learners of English present the cross-language differences between English and Korean fricative inventories and L1 transfer (H. Chung & A. Choi, 2007; H.-B. Lee, 2001; S. Lee, 2011).

Regarding phoneme distributions, Ruhlen (1975) surveyed 706 languages and showed that there are more languages with only voiceless fricatives than languages with only voiceless stops. It suggests that there is more probability of voicing being absent on fricatives than on stops. In articulation, voiced fricatives have more exacting aerodynamic requirements than do voiced stops (Ohala, 1983). Signorello, Hassid and Demolin (2018) reported the complex aerodynamic mechanism for voiced fricatives in comparison with voiceless ones. According to their study results, to provide the ideal aerodynamic conditions for sustaining both voicing and frication, a pressure difference across the glottis and the intraoral constriction should be maintained and kept as large as possible. These previous studies on phoneme distribution and speech mechanism suggest that there are probable difficulties of producing English voiced fricatives on the part of Korean learners of English.

In English, duration is used to distinguish between voiceless and voiced fricative. According to Klatt (1976), each phonetic segment has its own intrinsic or inherent phonological duration. Voiceless fricatives are about 40 ms longer in duration than the corresponding voiced fricatives. In terms of perception, native English subjects showed a significant increase in /z/ judgments as the duration of fricative noise was shortened (Flege & Hillenbrand, 1986). In the study of Flege and Hillenbrand, the Swedish and Finnish subjects, whose native languages do not possess an /s/ - /z/ contrast, differed from the English subjects in showing no significant effect of fricative duration.

Umeda (1977) also reported that the voiceless fricatives are longer than the voiced fricatives. In her study, the average duration of /f/ is 122ms, and the duration of /v/ is 78ms. /θ/ is 119ms, and /ð/ is 52ms. /s/ is 129ms, and /z/ is 85ms. She reported that in the word final position the fricatives are shorter than those in word initial position by 21ms to 39ms. In CVC monosyllabic word, the initial consonant is generally longer than the final consonant.

On overlapping of segment sequence, Umeda (1977) reported that two consecutive consonants often form one segment. Plenty of such examples are found at word boundaries. Similarly, the duration shortening occurs in consonant cluster (Klatt, 1976). Compared with /s/ and /p/ in the word 'sigh' and 'pie', consonant cluster /sp/ in the word 'spy' is shortened by as much as 20% - 30%.

Byrd and Tan (1996) conducted studies on the articulation of consonant sequence [d#d], [s#s], and [g#g]. They found differences in overlap and duration in consonant sequence spanning a word boundary as a function of speaking rate. Their study showed that stops are more likely to reduce than the fricative [s], and that coronals show greater reduction than the velar [g].

In English, the lexical stress pattern is a phonetic factor that can modify segmental durations. Oller (1973) observed that stressed vowels are longer in duration than unstressed vowels. Klatt (1976) listed durational cues that carry linguistic information. They include inherent phonological duration for segment types, phrase-boundary lengthening, effect of stress and emphasis. He reported that small differences in inherent duration were also observed as a function of place of articulation for consonants. Bilabial stops were typically slightly longer in duration than alveolars and velars. In this study, how fricative durations vary in relation with place of articulation is examined.

Consonants undergo lengthening in a stressed word initial and final position. In contrast, there is a shortening effect for consonant cluster and consonant sequence across word boundary. The two contrary effects were

examined in this present study, in which the lengthening effect of stress and the shortening effect of sequence were combined in the test conditions such as fricative sequence with stress on the first word (C_#C (W1F)) and fricative sequence with stress on the second word C#C_(W2F)) as well as the neutral condition without stress on the test words. In the test words, the consecutive fricatives across word boundary may be shortened due to overlapping, and on the other hand they may be lengthened because of the stress placed on the test words.

This present study compares the native English speech and non-native English speech produced by Korean learners of English, focusing on the non-native durational pattern of fricatives. Native English speech is expected to have durational changes affected by each factor listed above and have its own regular pattern. In contrast, non-native English speech of Korean learners of English might show different durational patterns due to the cross-language differences of consonant inventory and rhythm in English and Korean. This study may help to resolve the question of whether Korean learners of English can produce the overlapping of consecutive identical fricatives, the durational contrasts of English voiceless and voiced fricatives, and the proper durational change with regard to stress placement.

III. RESEARCH METHOD

1. Participants

Four native speakers of English and four Korean learners of English participated in the production experiment. The English speakers were American female university students in their twenties, all of whom were speakers of Western American English. The Korean learners of English were female university graduates and Seoul Korean speakers in their twenties and thirties. All the Korean subjects had been in the U.S. for less than a year, and they rated their English speaking as low intermediate level.

2. Materials and Procedures

A set of two word phrases was constructed for the production experiment. Example phrases are “say foot” and “safe foot”. The target consonants were one fricative of word initial position such as /#f/ in the phrase “say foot” and a sequence of two identical fricatives across a word boundary such as /f#f/ in the phrase “safe foot”. The test phrases were put in carrier sentences, and preceding sentences were used to make context in which one of the two words comes to have an emphasis. Three types of stress placement, which are the neutral condition without stress (N), the condition of stress on the first word (W1F), and the condition of stress on the second word (W2F), were tested in the target material. Example phrases are “safe foot” (N), “SAFE foot” (W1F), and “safe FOOT” (W2F). The material phrases are listed in Appendix.

The test words are three for each fricative, and the words were produced in two conditions concerning sequence and three conditions of stress placement. Therefore, the words produced by each subject were 108 (3×6×2×3). As four native English speakers and four Korean learners of English participated the production experiment, 864 tokens (108×8) were collected and analyzed.

The experiment stimuli were presented on the computer screen in random order. The subjects were asked to read a pair of consecutive sentences, in which the first context sentence induce the subjects to place an emphasis on a certain target word in the second carrier sentence. The task was to read the presented sentences including target words at a normal speed of conversation. They were told to read the sentences again when they mispronounced the sentences presented. When they finished each frame, they pushed any key to continue to the next frame.

3. Measurements and Analysis

The recorded speech containing test words was measured manually, using Praat, a speech analysis software program to get the durations of fricative intervals. The example of segmentation and labelling is shown in Figure 1.

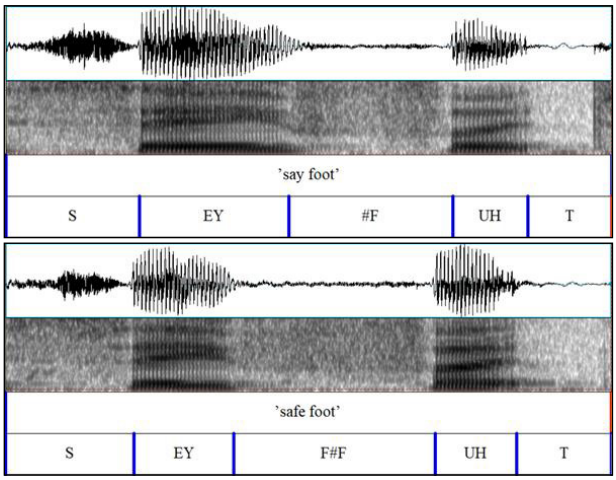

FIGURE 1 Segmentation and Labeling of Fricative Intervals in Speech Waveforms and Spectrograms

The onset and offset of frication energy was the criterion for fricative segmentation. When the onset or offset of frication noise was gradual, the onset and offset of vowel formant energy (F2) and corresponding dips and rises in overall amplitude were also used to identify fricative interval. A short silent gap that sometimes precedes or follows frication noise was considered to be part of the fricative interval. Paired sample t-tests were conducted testing the effect of stress placement, voicing contrast, fricative sequence, and place of articulation on target fricative duration. Criterial significance was set at $p < 0.05$.

IV. RESULTS AND DISCUSSION

1. Effect of Stress in Single Fricative and Fricative Sequence

The effects of two confounding factors were examined. One is consonant sequence; a single fricative or a sequence of two identical fricatives. The other is the stress position in the consecutive two monosyllable words; neutral phrase, the stress on the first word in the phrase, and the stress on the second word in the phrase. Table 2 and Figure 2 show the effect of the factors on the duration of the speech produced by the two subject groups. In Table 2, each number is duration in ms. Eng refers to English and Kor refers to Korean (hereafter Eng and Kor for English and Korean respectively in the tables and figures).

TABLE 2
t-Test Results and Mean Durations in ms of Fricative Intervals for Each Condition and Subject Group

		n	*M*	*SD*	*t*	*p*
Eng	V#C (N)	72	131	40	1.385	.170
	V_#C(W1F)	72	127	38		
	V#C (N)	72	131	40	-8.668	.000
	V#C_(W2F)	72	169	45		
	V_#C(W1F)	72	127	38	10.914	.000
	V#C_(W2F)	72	169	45		
	C#C (N)	72	247	88	-2.740	.008
	C_#C(W1F)	72	281	85		
	C#C (N)	72	247	88	-2.572	.012
	C#C_(W2F)	72	279	71		
	C_#C(W1F)	72	281	85	-0.189	.851
	C#C_(W2F)	72	279	71		
Kor	V#C (N)	72	179	58	0.809	.421
	V_#C(W1F)	72	171	73		
	V#C (N)	72	179	58	-1.274	.207
	V#C_(W2F)	72	190	61		
	V_#C(W1F)	72	171	73	1.926	.058
	V#C_(W2F)	72	190	61		
	C#C (N)	72	325	80	2.851	.006
	C_#C(W1F)	72	291	90		
	C#C (N)	72	325	80	3.328	.001
	C#C_(W2F)	72	282	79		
	C_#C(W1F)	72	291	90	-0.662	.510
	C#C_(W2F)	72	282	79		

As shown in Table 2, the lengthening effect of stress is smaller in the speech of Korean leaners of English than that of native English speakers. The shortening of duration in the fricative sequence is greater in the speech of Korean learners of English than those of native English speakers.

In regard to single fricative (#C), the durational pattern in the speech of Korean learners of English is similar to that in the speech of native English speakers in general. For English native speakers, the mean duration of one fricative in the neutral condition (V#C) is 131ms and the mean duration of one fricative with the stress on the second word (V#C_(W2F)) is 169ms. The duration difference is significant (t = -8.668, p < 0.05). However, the durational difference between fricatives in neutral condition (V#C (N)) and the condition of stress on the first word (V_#C (W1F)), where the mean duration is 127ms, is not significant (t = 1.385, p = 0.170). The duration difference between fricatives with stress on the first word (V_#C (W1F)) and with stress on the second word (V#C_ (W2F)) is significant (t = 10.914, p < 0.05).

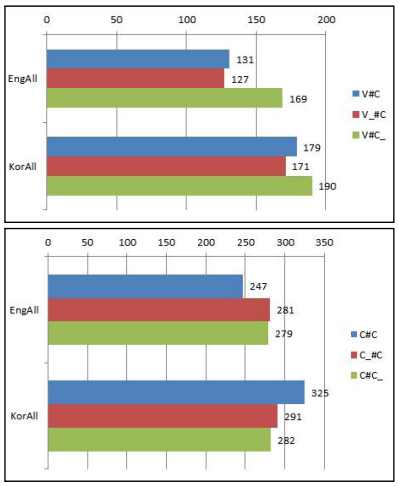

FIGURE 2 The Fricative Durational Pattern in Single Fricatives Versus Fricative Sequences With Each Stress Condition

For Korean learners of English, the pattern of the mean durations in each condition are similar to those of native English speakers while the durations in general are longer than those of native English speakers. The fricative duration in the condition of stress on the second word (V#C_ (W2F)) is the longest, 190ms. The fricative duration in the neutral condition is 179ms, and the duration in the condition of stress on the first word (V_#C (W1F)) is 171ms. However, the durational differences were not significant.

Concerning fricative sequence (C#C), the mean duration in neutral condition (C#C (N)) is 247ms in the speech of native English speakers. The duration in the condition of stress on the first word (C_#C (W1F)) and the second word (C#C_ (W2F)) is 281ms and 279ms respectively. There is little difference between the mean duration of the condition of stress on the first word (C_#C (W1F)) and the second word (C#C_ (W2F)).

The duration difference between neutral condition (C#C (N)) and the condition of stress on the first word (C_#C (W1F)) is significant (t = -2.740, p < 0.05), and the duration difference between neutral condition (C#C (N)) and the condition of stress on the second word (C#C_ (W2F)) is significant (t = -2.572, p < 0.05) as well. However, the durational difference between fricatives in the condition of stress on the first word (C_#C (W1F)) and the second word (C#C_ (W2F)) is not significant (t = -0.189, p = 0.851).

Fricative sequences (C#C) produced by Korean learners of English show the durational patterns different from that of native English speakers. Unlike the speech of native English speakers, which has the lengthening effect of stress on the fricative duration, the speech of Korean learners of English seems to have the shortening effect

of stress on the fricative duration. In the case of Korean learners of English, the mean duration of fricative in neutral condition is 325ms and it is longer than those in the condition of the stress on the first word or second word, which are 291ms and 282ms respectively. The durational patterns are depicted on the Figure 2. The duration difference between neutral condition (C#C (N)) and the condition of stress on the first word (C_#C (W1F)) is significant ($t = 2.851$, $p = 0.006$), and the duration difference between neutral condition (C#C (N)) and the condition of stress on the second word (C#C_ (W2F)) is significant ($t = 3.328$, $p = 0.001$) as well. However, the durational difference between fricatives in the condition of stress on the first word (C_#C (W1F)) and the second word (C#C_ (W2F)) is not significant ($t = -0.662$, $p = 0.510$).

The result suggests that the stress on a monosyllable word induce the lengthening of both word initial and final fricative and the lengthening effect is almost equivalent. This result is interesting, as previous studies reported that consonants are longest in word-initial position, about 10-30ms shorter in word-final position, and shorter still in medial positions (Klatt, 1974; Oller, 1973; Umeda, 1975). In view of this, the stress effect is expected to be different for word-initial and word-final fricative positions, which seems not to be supported by the present study.

Korean learners of English considerably overlap the two identical fricatives when they come consecutively across a word boundary. The results also show that Korean learners of English are in their hardship when they have to lengthen the fricatives when they are in a stressed syllable.

2. Effect of Voicing Contrast

One of the aims of this study is to determine whether Korean learners of English produce the temporal contrast between English voiceless and voiced fricatives. Thus, the durational pattern of fricative sequences as well as single fricatives was examined. Table 3 and Figure 3 show the durational difference in ms between voiceless and voiced fricative in one fricative (V#C) and fricative sequence (C#C) for the two subject groups.

TABLE 3

t-Test Results and Mean Durations in ms and Durational Differences Between Voiceless and Voiced Fricatives in One Fricative and Fricative Sequence for the Two Subject Groups

			n	*M*	*SD*	*t*	*p*
Eng	V#C	Voiceless	108	171	34	16.162	.000
		Voiced	108	114	36		
	C#C	Voiceless	108	297	70	6.189	.000
		Voiced	108	241	82		
Kor	V#C	Voiceless	108	206	51	6.580	.000
		Voiced	108	155	66		
	C#C	Voiceless	108	319	66	4.425	.000
		Voiced	108	280	92		

As can be seen in Table 3, voiceless fricatives are longer than voiced fricatives in both single fricative and fricative sequence, which holds for the two subject groups. However, the magnitude of the duration differences between voiceless and voiced fricatives vary between the two subject groups.

For native English speakers, the durational difference between voiceless fricative and voiced fricative is greater than that for Korean learners of English. For single fricative, the average duration of voiced fricative is 67 % of voiced fricative duration, and the duration of voiced fricative sequence is 81% of the duration of voiceless fricative sequence. For the difference between the duration of single fricative and fricative sequence, the average duration of voiceless fricative sequence is 174% of the average duration of voiceless single fricative. The average duration of voiced fricative sequence is 211% of the average duration of voiced single fricative. The durational data suggests that there is considerable overlapping in voiceless fricative sequence while it is not the case for voiced fricative sequence.

For Korean learners of English, the duration difference between voiceless and voiced fricative is smaller than that of native English speakers. For single fricative, the duration of voiced one is 75% of the duration of voiceless one. The duration of voiced fricative sequence is 88% of the duration of voiceless fricative sequence. The durational differences between voiceless and voiced fricatives in the speech of Korean learners of English are smaller in magnitude than those in the speech of native English speakers.

The data of Korean learners of English indicates that there are greater overlapping in fricative sequence in comparison with native English speakers' data, and the overlapping and the shortening effect is more salient in voiceless fricative than in voiced fricative.

Regarding the fricative sequence, the average duration of voiceless fricative sequence is 155% of that of single fricative, which shows that there is considerable overlapping in voiceless fricative sequence. The overlapping effect in fricative sequence is smaller for voiced fricative. The duration of voiced fricative sequence is 181% of that of single voiced fricative. The durational data show that there is substantial overlapping for both voiceless fricative sequence and voiced fricative sequence in the speech produced by Korean learners of English.

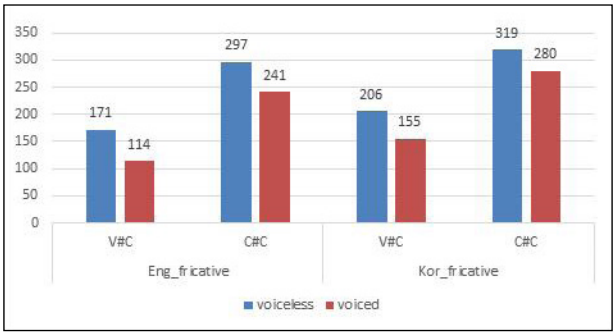

FIGURE 3 Durational Pattern of Voiceless and Voiced Fricatives in the Two Subject Groups

TABLE 4
Fricative Durational Pattern for Each Place of Articulation

			n	*M*	*SD*	*t*	*p*
Eng	V#C voiceless	Labio-dental /#f/	36	174	33	2.702	.011
		Dental /# θ/	36	161	33		
		Dental /# θ/	36	161	33	-2.714	.010
		Alveolar /#s/	36	177	34		
		Labio-dental /#f/	36	174	33	-0.769	.447
		Alveolar /#s/	36	177	34		
	V#C voiced	Labio-dental /#v/	36	120	36	5.886	.000
		Dental /# ð/	36	95	36		
		Dental /# ð/	36	95	36	-4.789	.000
		Alveolar /#z/	36	126	29		
		Labio-dental /#v/	36	120	36	-1.004	.322
		Alveolar /#z/	36	126	29		
	C#C voiceless	Labio-dental /f#f/	36	290	61	-2.196	.035
		Dental /θ#θ/	36	316	67		
		Dental /θ#θ/	36	316	67	1.972	.057
		Alveolar /s#s/	36	283	91		
		Labio-dental /f#f/	36	290	61	0.479	.635
		Alveolar /s#s/	36	283	91		
	C#C voiced	Labio-dental /v#v/	36	214	66	-1.155	.256
		Dental /ð#ð/	36	231	74		
		Dental /ð#ð/	36	231	74	-2.682	.011
		Alveolar /z#z/	36	279	91		
		Labio-dental /v#v/	36	214	66	-3.387	.002
		Alveolar /z#z/	36	279	91		
Kor	V#C voiceless	Labio-dental /#f/	36	202	37	-0.753	.456
		Dental /# θ/	36	212	78		
		Dental /# θ/	36	212	78	0.840	.406
		Alveolar /#s/	36	201	22		
		Labio-dental /#f/	36	202	37	0.189	.851
		Alveolar /#s/	36	201	22		
	V#C voiced	Labio-dental /#v/	36	146	28	1.225	.229
		Dental /# ð/	36	130	73		
		Dental /# ð/	36	130	73	-3.341	.002
		Alveolar /#z/	36	189	72		
		Labio-dental /#v/	36	146	28	-3.517	.001
		Alveolar /#z/	36	189	72		
	C#C voiceless	Labio-dental /f#f/	36	328	59	-0.589	.560
		Dental /θ#θ/	36	335	74		
		Dental /θ#θ/	36	335	74	2.681	.011
		Alveolar /s#s/	36	295	74		
		Labio-dental /f#f/	36	328	59	2.419	.021
		Alveolar /s#s/	36	295	74		
	C#C voiced	Labio-dental /v#v/	36	236	30	-3.149	.003
		Dental /ð#ð/	36	296	115		
		Dental /ð#ð/	36	296	115	-0.532	.598
		Alveolar /z#z/	36	306	95		
		Labio-dental /v#v/	36	236	30	-4.471	.000
		Alveolar /z#z/	36	306	95		

3. Effect of Place of Articulation

In this study, place of articulation is also found to affect the durational pattern of fricatives. Table 4 and Figure 4 summarize the fricative duration changes for each place of articulation. In Table 4, each number is duration in ms.

In the speech of native English speakers, the dental fricatives are shorter than labio-dental and alveolar fricatives when it comes to single fricatives. Average duration of dental voiceless fricative is 161ms and that of dental voiced fricative is 95ms. Average duration of voiceless labio-dental fricatives and alveolar fricatives are 174ms and 177ms respectively, and that of voiced labio-dental fricatives and alveolar fricatives are 120ms and 126ms respectively. The durational pattern in single labio-dental is similar to that in single alveolar.

Labio-dental voiceless and voiced fricative sequence show some overlapping. Dental fricative sequences seem to undergo almost no overlapping when they appear consecutively (196% for voiceless and 244% for voiced). It is notable that dental voiced fricative sequence, [ð#ð] and alveolar voiced fricative sequence, [z#z] do not show overlapping effect (244% and 220% respectively). Overall, labiodental fricatives (/f/, /v/) and alveolar voiceless fricatives (/s/) have considerable overlapping and duration shortening when they appear in sequence.

In the speech of Korean learners of English, the greatest durational difference between voiceless and voiced fricatives occurs in dental ones. The duration of voiced fricative is 61% of the duration of voiceless fricative. The next greater durational difference, in labio-dental ones, and the smallest durational difference, in alveolar ones. For labio-dentals, the duration of voiced fricative is 72% of the duration of voiceless fricative. For alveolars, the duration of voiced fricative is 94% of the duration of voiceless fricative. There is little durational difference between voiceless alveolar fricative and voiced alveolar fricative.

For fricative sequences in the speech of Korean learners of English, there are considerable overlapping in all the three places of articulation, and the magnitude of overlapping does not vary much. The durations of fricative sequences are from 147% to 162% of the durations of single fricatives. One exception is voiced dental fricative sequence, [ð#ð], in which the duration of fricative sequence is 227% of the duration of single fricative.

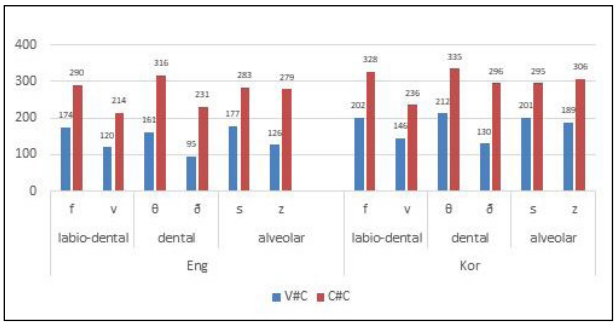

FIGURE 4 Fricative Durational Differences in Relation With Each Place of Articulation

4. Effect of Each Factor for Native Subjects

Table 5 and Table 6 show the durational pattern in the speech of native English speakers. Durational differences between voiceless and voiced fricative vary in regard with stress placement, fricative sequence, and place of articulation.

TABLE 5
Means (*SDs*) and *t*-Test Results for Durational Differences Between Voiced and Voiceless Single Fricatives in Relation With Stress Condition for English Native Speakers

			n	*M*	*SD*	*t*	*p*
Eng	V#C(N)	/f/	12	162	37	4.385	.001
		/v/	12	108	25		
		/θ/	12	152	35	7.232	.000
		/ð/	12	86	22		
		/s/	12	159	29	4.320	.001
		/z/	12	122	28		
	V_#C(W1F)	/f/	12	156	16	8.238	.000
		/v/	12	107	22		
		/θ/	12	146	25	9.889	.000
		/ð/	12	71	17		
		/s/	12	165	17	5.819	.000
		/z/	12	115	23		
	V#C_(W2F)	/f/	12	204	19	4.171	.002
		/v/	12	107	22		
		/θ/	12	186	25	5.235	.000
		/ð/	12	128	38		
		/s/	12	207	33	4.551	.001
		/z/	12	142	32		

For native English speakers, the durational difference between voiceless and voiced fricative in single fricatives is significant in all the stress conditions. As seen in Table 5, the voiced fricatives are shorter than their voiceless counterparts. For fricative sequence, /f-v/ and /θ-ð/ show the significant durational difference between voiceless fricatives and voiced fricatives in the condition of stress on the first word and the condition of stress on the second word. However, there is no significant durational difference in the neutral condition. The /s-z/ pair does not show significant durational difference between the voiceless and voiced in all three stress conditions.

TABLE 6
Means (*SDs*) and *t*-Test Results for Durational Differences Between Voiced and Voiceless Fricative Sequences in Relation With Stress Condition for English Native Speakers

			n	*M*	*SD*	*t*	*p*
Eng	C#C(N)	/f/	12	206	72	1.983	.073
		/v/	12	210	84		
		/θ/	12	293	92	1.809	.098
		/ð/	12	229	109		
		/s/	12	256	90	0.969	.353
		/z/	12	231	67		
	C_#C(W1F)	/f/	12	307	56	4.695	.001
		/v/	12	214	60		
		/θ/	12	322	58	4.858	.001
		/ð/	12	221	61		
		/s/	12	313	86	0.104	.919
		/z/	12	308	110		
	C#C_(W2F)	/f/	12	303	45	3.531	.005
		/v/	12	219	57		
		/θ/	12	333	39	5.975	.000
		/ð/	12	243	43		
		/s/	12	281	94	0.508	.622
		/z/	12	297	77		

5. Effect of Each Factor for Korean Subjects

In the speech of Korean learners of English, pairs of single fricatives, /f-v/ and /θ-ð/ have significant durational difference between the voiceless and voiced ones. As it is shown in Table 7, one exception is the case of /θ-ð/ with stress on the second word. They have durational difference in average, but the difference is not significant. On the other hand, the fricative pair /s-z/ has little difference in duration and it is not significant.

TABLE 7
Means (*SDs*) and *t*-Test Results for Durational Differences Between Voiced and Voiceless Single Fricatives in Relation With Stress Condition for Korean Learners

			n	*M*	*SD*	*t*	*p*
Kor	V#C(N)	/f/	12	199	28	4.049	.002
		/v/	12	155	33		
		/θ/	12	207	40	6.059	.001
		/ð/	12	107	30		
		/s/	12	202	24	0.147	.886
		/z/	12	205	89		
	V_#C(W1F)	/f/	12	190	32	7.083	.000
		/v/	12	127	30		
		/θ/	12	221	122	3.072	.011
		/ð/	12	108	22		
		/s/	12	201	18	0.854	.411
		/z/	12	201	18		
	V#C_(W2F)	/f/	12	219	47	5.745	.000
		/v/	12	154	24		
		/θ/	12	209	52	1.169	.267
		/ð/	12	176	110		
		/s/	12	201	25	2.184	.052
		/z/	12	180	45		

In regard with fricative sequence (C#C), labio-dental fricatives, /f-v/ had significant durational differences for all the three stress conditions. In contrast, alveolar fricatives, /s-z/ do not have significant durational differences between voiced versus voiceless fricatives. The mean duration of voiced fricative sequences was longer than the voiceless ones, while the difference was not significant. The dental fricatives, /θ-ð/ do not show significant durational difference in the condition of stress on the first word. As it is shown in Table 8, the durational difference in neutral condition is 58ms ($t = 2.102$, $p = 0.059$). In the condition of stress on the second word, the durational difference is 47ms and it is significant ($t = 2.211$, $p = 0.049$).

In summary, the speech of Korean learners of English shows that their durational pattern is similar to that of native English speakers for fricative pair /f/ and /v/, and the data of /θ/ and /ð/ show mixed results in the significance of durational difference. For /s/ and /z/, the average durational differences that they have are not significant. Figure 5 shows the rate of durational change of voiceless and voiced fricatives in six conditions for each subject group.

For native English speakers, the duration of voiceless single fricative with stress on the second word is 126% of the voiceless fricative in neutral condition. The fricatives in word initial position undergo lengthening when they

are stressed. The voiced fricatives also have the durational change similar to that of the voiceless fricatives. The voiced fricatives lengthen by 31% when they are in the stressed word initial position. For fricative sequence, the average duration of voiceless fricatives is 171% of that of the single voiceless fricatives when stress is not placed on them, which indicates that there is some overlapping effect when the two identical fricatives come consecutively at the word boundary. In contrast, the average duration of voiced fricative sequences, when stressed, is 212% of the duration of single voiced fricatives, which suggests that the two consecutive fricatives do not undergo the overlapping.

TABLE 8
Means (*SDs*) and *t*-Test Results for Durational Differences Between Voiced and Voiceless Fricative Sequences in Relation With Stress Condition for Korean Learners

			n	*M*	*SD*	*t*	*p*
Kor	C#C(N)	/f/	12	306	54	6.828	.000
		/v/	12	244	34		
		/θ/	12	389	90	2.102	.059
		/ð/	12	331	83		
		/s/	12	325	66	1.225	.246
		/z/	12	230	63		
	C_#C(W1F)	/f/	12	316	55	4.838	.001
		/v/	12	227	27		
		/θ/	12	318	47	0.215	.833
		/ð/	12	306	171		
		/s/	12	280	59	0.678	.512
		/z/	12	298	84		
	C#C_(W2F)	/f/	12	307	58	4.604	.001
		/v/	12	237	30		
		/θ/	12	298	44	2.211	.049
		/ð/	12	251	48		
		/s/	12	280	91	1.324	.212
		/z/	12	321	132		

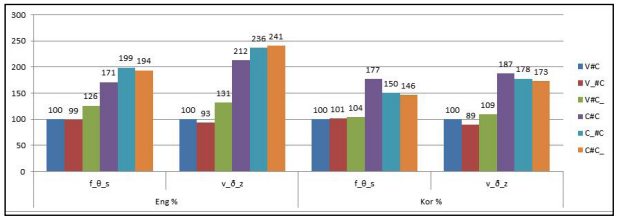

FIGURE 5 Durational Change of Voiceless and Voiced Fricatives in Six Conditions for Each Subject Group

On the other hand, the fricatives of Korean learners of English show lower rate of the duration increase than those of native English speakers concerning stress placement, and shortening for fricative sequence is greater in the speech of Korean learners of English. For the 100 % duration rate of neutral single fricative condition, the duration rates of the fricatives with stress are 104% and 109% for voiceless and voiced fricatives respectively. That is, there is little change in duration of the fricatives when they are stressed. For fricative sequence, the average duration of voiceless fricatives is 177% of that of the single voiceless fricatives when stress is not placed on them, which indicates some overlapping effect when the two identical fricatives come consecutively at the word boundary. The overlapping effect also exists in the voiced fricatives. The duration of voiced fricative sequences, when stressed, is 187% of that of single voiced fricatives.

It is interesting to note that the fricative sequences with stress are shorter, not longer, than those without stress, which is the durational pattern opposite to that in the speech of native English speakers. The results indicate that Korean learners of English have difficulty in realizing the lengthening due to stress placement. Moreover, the fricatives are consistently overlapped when they come in sequence.

Overall, the speech of native English speakers has the strong lengthening effect of stress and the moderate overlapping effect of fricative sequence. In contrast, the speech of Korean learners of English shows that the stress placement does not elicit sufficient lengthening effect, and their fricatives in sequence have considerable shortening effect.

V. CONCLUSION

In the present study, we examined the interaction of factors that affect durational patterns of fricatives, such as inherent duration of voiced versus voiceless fricatives, fricative sequence at word boundary, and stress.

The study result shows that the mean duration of voiceless fricative is longer than that of voiced fricatives in general for both subject groups and the fricative durations in the speech of Korean learners of English are greater in magnitude than those in the speech of native English speakers.

In regard with the effect of fricative sequence and stress placement, the speech of English native speakers presents overlapping and shortening effect of fricative sequence and lengthening effect of stress. For Korean learners of English, the shortening of duration in the fricative sequence is greater in the magnitude than that of the native English speakers. The result suggests that Korean learners of English overlap the fricative sequence much more than the native English speakers. On the other hand, the effect of stress is smaller. Korean learners of English show the tendency of not sufficiently lengthening the fricatives when they are stressed.

The durational data show that there is substantial overlapping for both voiceless and voiced fricative sequence in the speech produced by Korean learners of English, and the overlapping and shortening effect is more salient in voiceless fricative than in voiced fricative.

In this study, place of articulation was found to affect the durational pattern of fricatives. For native English speakers, labiodental fricatives (/f, v/) and alveolar voiceless fricative (/s/) have moderate overlapping and shortening when they occur in sequence. In the speech of Korean learners of English, fricative sequences undergo consistent and considerable overlapping across the three places of articulation. The magnitude of overlapping is similar

among the three places of articulation with the exception of voiced dental fricative sequence.

Overall, the variability of durational pattern is smaller in magnitude and the mean durations in general are longer for Korean learners of English. The characteristic durational patterns of Korean learners of English are that the overlapping and shortening effect for the fricative sequence is greater and the lengthening effect of stress is smaller compared with those in native English speakers.

The present results suggest that the phonological contrasts which exist in English but not the native Korean language may cause Korean learners of English to have difficulty in their English pronunciation. Korean learners of English should learn to pronounce English fricatives focusing on the durational difference between voiceless and voiced fricatives. They also need to have knowledge on the durational change due to the stress placement and the overlapping effect when two identical fricatives come consecutively. The present study implicates that efficient methods of instruction should be devised to help Korean learners of English train themselves to lengthen the fricatives in stressed syllable and to realize fricative sequence in proper duration so that the duration will not shorten excessively. It must be a challenge for Korean learners of English to defy the interference of the phonological durational pattern of Korean and acquire the durational pattern of English affected by voicing contrast, consonant sequence, and stress placement.

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APPENDIX

Experiment Material

	V#C	C#C
f	bee farm Lee fund say foot	beef farm leaf fund safe foot
v	say vests Kay vents lie vets	save vests cave vents live vets
θ	Ree Thorn two threads boo things	wreath thorn tooth threads booth things
ð	bay that see there sue them	bathe that seethe there soothe them
s	pea sound lay sets bay sits	peace sounds lace sets base sits
z	May zoo E zone sigh zip	maze zoo ease zone size zip