

## Temporal Structures of Word-initial /s/ Plus Stop Sequences in English Words Produced by Korean Learners\*

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### ABSTRACT

The purpose of this study is to examine temporal structures of English words beginning with an /s/ plus stop sequence through production experiments with native speakers of Korean learning English and native speakers of English. According to the results of our production experiment, both a beginner and an advanced group of Korean English learners produced /s/ shorter than a following stop, while the opposite pattern was observed in English native speakers' production. An advanced group of Korean English learners were good at producing a stop after /s/ as unaspirated, but their production of a stop following /s/ was different from English native speakers' production in that the closure duration of the stop was much longer.

**Keywords:** temporal structures, an /s/ plus stop sequence, English words

### 1. Introduction

It is well-known that a second language (L2) learner is faced with a difficulty in pronouncing sounds or sound sequences of L2 which do not exist in his or her native language (L1). For example, French does not contain /ð/ and /θ/ in its phoneme inventory and French speakers replace them with /z/ and /s/, respectively (Stewart and Vaillette 2001). Thus, French speakers often pronounce English *this* [ðɪs] as [zɪs] and *thin* [θɪn] as

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[sm]. In addition, as shown in Seo et al. (2005), Korean speakers learning English, whose native language realizes word-medial stop plus nasal sequences as nasal plus nasal sequences, tend to pronounce a stop before a nasal as a nasal in English words. Thus, Korean English learners have a tendency to mispronounce the English word *bookmark* as [buŋmark]. It has been claimed that Korean English learners have a difficulty in pronouncing English words with word-initial consonant clusters since consonant clusters are not allowed word-initially in Korean. According to Kang and Lee (2001) and Cho (2003), among others, Korean English learners have a tendency to pronounce a stop after /s/ as aspirated, whereas native speakers of English pronounce it as unaspirated.

The purpose of this study is to examine temporal structures of English words beginning with an /s/ plus stop sequence through production experiments with a beginner and an advanced group of Korean English learners and native speakers of English. That is, we are to investigate the proportion of a stop consonant, that of [s], that of closure of a stop and that of VOT within a word. As we will see, the results of our experiment show that both a beginner and an advanced group of Korean English learners produce [s] shorter than a following stop, while the opposite pattern is observed in English native speakers' production.

This paper is organized as follows. The methods and results of the production experiment are given in section 2 and 3, respectively. Discussion based on experiment results is in section 4.

## 2. Methods

A production experiment was designed to investigate the duration ratio of a stop consonant, that of [s], that of closure of a stop and that of VOT in English words containing a word-initial /s/ plus stop sequence and produced by Korean English learners and native speakers of English.

### 2.1 Subjects

A production experiment was run with 20 native speakers of Seoul Korean and 4 native speakers of American English. Among 20 native speakers of Seoul Korean, 10 (7 males, 3 females) were a beginner group of English learners and 10 (4 males, 6 females) were an advanced group of English learners. The beginner group of English learners were the ones

who got a first or second level of English proficiency from an interview with an English instructor of the Institute of Foreign Language Studies at Korea University. The advanced group of Korean English learners were recruited from those who got a fifth or sixth level of English proficiency from the interview. Four American English speakers (1 male, 3 females) were graduate students at the Ohio State University.<sup>1)</sup> The Korean speakers were paid or participated in the experiment to earn extra credit points for their English class and the American English speakers were paid for their participation in the experiment.

## 2.2 Recording and Analysis

For the experimental tokens, six frequent English words with an /s/ plus stop sequence given in Table 1 were chosen.

Table 1. Experimental tokens

Sequences	English words
/sp/	space, spoon
/st/	stand, star
/sk/	skate, sky

Each word was put in a carrier sentence “\_\_\_\_\_ is a word” for a recording. Speakers were asked to read each sentence containing a target word at a natural speech rate five times. Sentences with a target word were shuffled each time recordings were made. Thus, each speaker recorded sentences five times in different orders, and sentences were presented in different orders to different speakers. Recordings were made in a sound-attenuated booth in the Spoken Language Information Laboratory at Korea University. For the recording, an SM58 SHURE microphone and a TASCAM DA-20 MKII tape recorder were used. Recordings with native speakers of American English were made in a sound-attenuated booth at the Ohio State University by using an SM10A SHURE microphone and a TEAC V-427C tape recorder. All the recordings were digitized at 22050 Hz with 16 bit samples.

1) We would like to thank Eun-Jong Kong for her assistance with the production experiment run at the Ohio State University.

The total word duration, the total stop consonant duration, the duration of [s], that of stop closure and that of VOT of each recorded word were measured using Wavesurfer 1.7.5 of Center for Speech Technology to examine the proportion of each of them within a word. Excluding 1 out of 720 tokens (6 words  $\times$  5 repetitions  $\times$  24 speakers), 719 tokens were used for the analysis. One token excluded from the analysis was the one which was mispronounced.

### 3. Results

We analyzed the obtained data in a one-way analysis of variance (ANOVA) to compare the three subject groups on the duration ratio of a stop, that of [s], that of stop closure and that of VOT within a word. The effect of the proportion of stop duration within a word (i.e. stop duration/total word duration) was significant [ $F(2, 716) = 228.50, p < .05$ ]. In addition, there was also a significant effect of the proportion of [s] duration within a word (i.e. [s] duration/total word duration) [ $F(2, 716) = 151.06, p < .05$ ]. Post-hoc analysis using the Scheffe test indicated significant differences among the three subject groups with respect to the proportion of [s] duration and that of stop duration ( $p < .05$ ).

As can be seen in Figure 1, the three subject groups showed different patterns with respect to the duration ratio of [s] and that of a stop consonant in the analyzed English words beginning with an /s/ plus stop sequence.

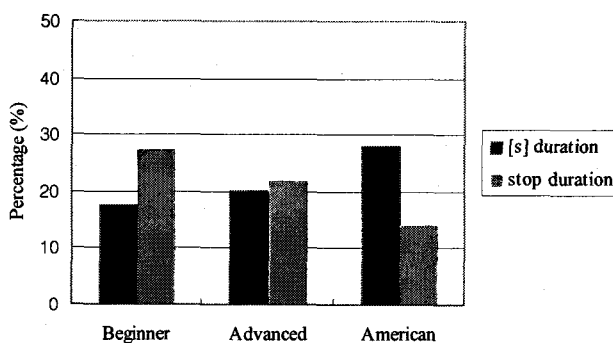


Figure 1. The average duration ratio of [s] and that of a stop in English words with a word-initial /s/ plus stop sequence

English native speakers pronounced [s] longer than a following stop by producing 28.0% of a whole word as [s] and 14.2% of a whole word as a stop, on average.<sup>2)</sup> On the other hand, the opposite pattern was observed in the beginner group of Korean English learners' production. They pronounced a stop longer than a preceding [s]. In their production, on average, the percentage of [s] duration within a word was 17.5% and that of stop duration was 27.5%.<sup>3)</sup> In the case of the advanced group of Korean English learners, the percentage of [s] duration within a word was 20.2% and that of stop duration was 22.0%. That is, the proportion of [s] duration and that of stop duration were almost the same in this group.

The effect of the proportion of closure duration within a word (i.e. closure duration/total word duration) was significant in a one-way variance of analysis [ $F(2, 716) = 112.10, p < .05$ ], and the effect of the proportion of VOT duration within a word (i.e. VOT duration/total word duration) was also significant [ $F(2, 716) = 143.18, p < .05$ ].

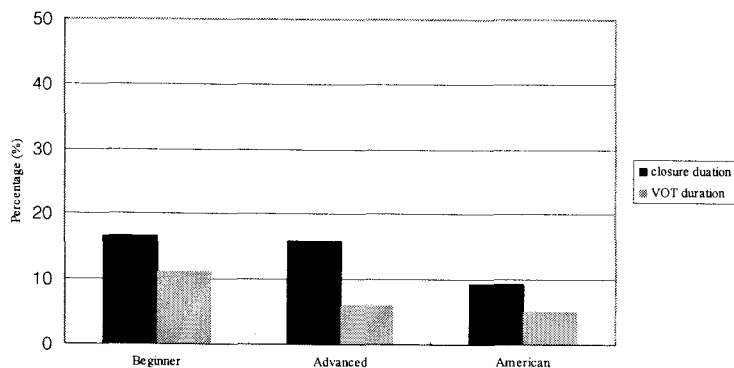


Figure 2. The average duration ratio of closure and that of VOT in English words with a word-initial /s/ plus stop sequence

As we can see from Figure 2, the beginner group of Korean English learners produced VOT longer (11.1 % of a word; 60.9 ms) than both the advanced group of Korean English learners and American English speakers did (6.1%; 31.0 ms, and 5.1%; 25.3 ms, respectively). With respect to the proportion of VOT duration within a word, post-hoc

2) On average, English native speakers produced each word in 537.1 ms, [s] in 143.7ms and a stop in 72.7 ms.

3) On average, the beginner group of Korean English learners pronounced each word in 532.0 ms, [s] in 92.2ms and a stop consonant in 145.0 ms.

analysis using the Scheffe test indicated a significant difference between the beginner and the advanced group of Korean English learners, and between the beginner group of Korean English learners and American English speakers ( $p < .05$ ), while no significant difference was found between the advanced group of Korean English learners and American English speakers ( $p > .05$ ).

With respect to the proportion of closure duration within a word, both the beginner and the advanced group of Korean English learners had a higher ratio (16.7%; 86.3 ms and 15.9%; 73.2 ms, respectively) than American English speakers did (9.3%; 48.6 ms). According to Post-hoc analysis using the Scheffe test, with respect to the proportion of closure duration within a word, there was a significant group difference between the beginner group of Korean English learners and American English speakers, and between the advanced group of Korean English learners and American English speakers ( $p < .05$ ), but the difference between the beginner and the advanced group of Korean English learners was insignificant ( $p > .05$ ).

A one-way ANOVA to compare the three subject groups on the duration ratios of a stop within each of the /sp/, /st/ and /sk/-initial word groups showed that the effect of the proportion of stop duration was significant in all the three word groups [/sp/-initial word group:  $F(2, 236) = 77.97$ ,  $p < .05$ , /st/-initial word group:  $F(2, 236) = 135.32$ ,  $p < .05$ , /sk/-initial word group:  $F(2, 237) = 55.67$ ,  $p < .05$ ]. In addition, the effect of the proportion of [s] duration was also significant within each of the three word groups [/sp/-initial word groups:  $F(2, 236) = 37.01$ ,  $p < .05$ , /st/-initial word group:  $F(2, 236) = 40.52$ ,  $p < .05$ , /sk/-initial word group:  $F(2, 237) = 94.04$ ,  $p < .05$ ]. Post-hoc analysis using the Scheffe test indicated significant differences among the three subject groups with respect to the proportion of [s] duration and that of stop duration within each of the /sp/, /st/ and /sk/-initial word groups ( $p < .05$ ). The average duration ratio of [s] and that of a stop consonant within each of the /sp/, /st/ and /sk/-initial word groups are illustrated in Figure 3.

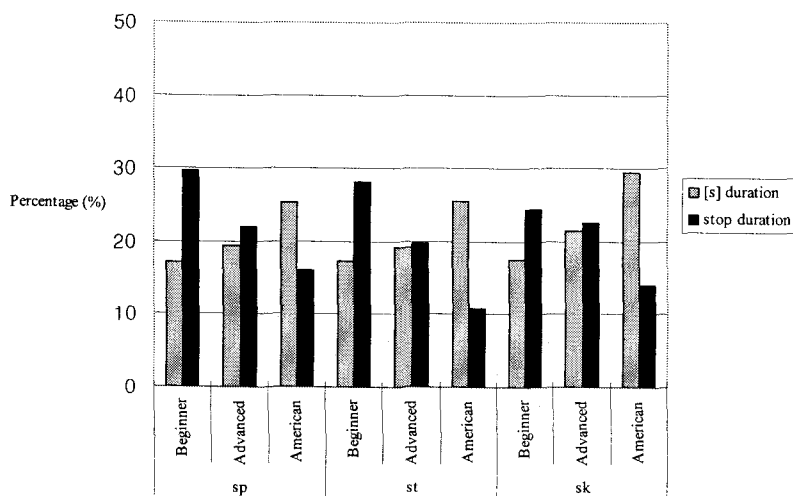


Figure 3. The average duration ratio of [s] and that of a stop in the /sp/, /st/ and /sk/-initial word groups

When the average duration ratio of [s] and that of a stop in a word were calculated within each of the /sp/, /st/ and /sk/-initial word groups, we got the same results as we did when they were calculated across all the recorded words. That is, regardless of the place of articulation of a stop following /s/, the beginner group of Korean English learners pronounced [s] shorter than a following stop, while the reverse pattern was found in the production of American English speakers. In addition, the duration ratio of /s/ and that of a following stop in a word were almost the same in the production of the advanced group of Korean English learners.

A one-way ANOVA was performed to compare the three subject groups on the duration ratio of VOT and that of stop closure within each of the /sp/, /st/ and /sk/-initial word groups, and we got the same results as we did when the duration ratio of VOT and that of stop closure were calculated across all the recorded words, ignoring the place articulation of a stop. That is, the three subject groups were significantly different one another on the duration ratio of VOT [/sp/-initial word group:  $F(2, 236) = 64.35, p < .05$ , /st/-initial word group:  $F(2, 236) = 64.79, p < .05$ , /sk/-initial word group:  $F(2, 237) = 94.04, p < .05$ ] and that of stop closure [/sp/-initial word group:  $F(2, 236) = 35.66, p < .05$ , /st/-initial word group:  $F(2, 236) = 60.42, p < .05$ , /sk/-initial word group:  $F(2, 237) = 45.27, p < .05$ ].

The average duration ratio of VOT and that of stop closure within each of the /sp/, /st/ and /sk/-initial word groups are shown in Figure 4.

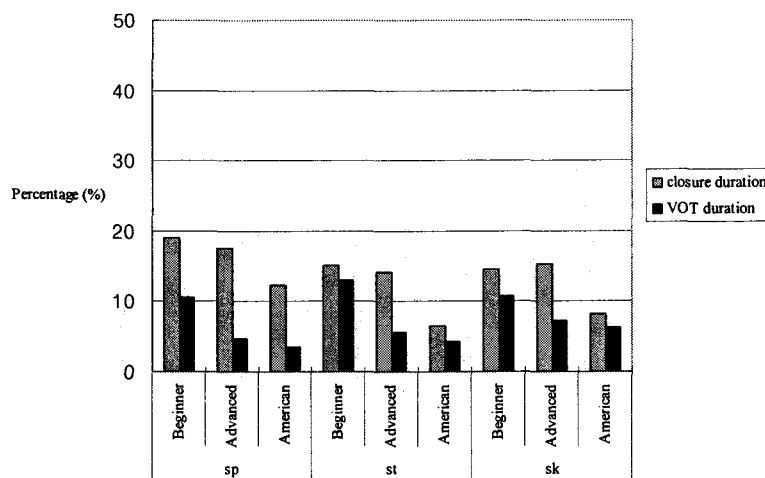


Figure 4. The average duration ratio of VOT and that of closure in the /sp/, /st/ and /sk/-initial word groups

The results of Post-hoc analysis using the Scheffe test were the same as the ones comparing the three subject groups on the duration ratio of VOT and that of stop closure across all the recorded words ignoring the place of articulation of a stop following /s/, except that the beginner and the advanced group of Korean English listeners were significantly different regarding the duration ratio of closure within the /sp/-initial word group. That is, the beginner group of Korean English learners had a tendency to produce VOT longer in duration than the advanced group of Korean English learners and American English speakers did. In addition, both groups of Korean English learners were inclined to pronounce stop closure longer in duration than American English speakers. In the /sp/-initial word group, the advanced group of Korean English learners produced closure of a stop shorter than the beginner group did, but they still pronounced it much longer than American English speakers did.

The average duration ratio of [s], that of a stop consonant, that of stop closure and that of VOT in each English word analyzed are given in Table 2.



Table 2. The average duration ratios of [s], a stop, closure and VOT in each English word analyzed (%)

	Group	[s]	stop	closure	VOT
space	Beginner	15.6	25.5	<i>17.0</i>	8.5
	Advanced	18.3	19.5	<i>16.2</i>	<i>3.4</i>
	American	24.0	15.0	12.2	<i>2.8</i>
spoon	Beginner	<i>18.6</i>	33.5	20.9	12.5
	Advanced	<i>20.6</i>	25.1	19.2	<i>5.9</i>
	American	26.7	16.9	12.7	<i>4.3</i>
stand	Beginner	<i>17.2</i>	26.7	<i>13.1</i>	13.9
	Advanced	18.4	18.9	<i>13.4</i>	<i>5.5</i>
	American	23.2	10.6	6.6	<i>4.0</i>
star	Beginner	<i>17.4</i>	29.3	17.1	12.2
	Advanced	<i>20.2</i>	20.7	14.9	<i>5.8</i>
	American	28.3	11.1	6.5	<i>4.6</i>
skate	Beginner	17.1	<i>22.2</i>	<i>13.9</i>	10.1
	Advanced	22.7	23.8	<i>16.1</i>	<i>7.7</i>
	American	31.9	14.4	8.5	<i>7.2</i>
sky	Beginner	<i>18.0</i>	26.9	<i>15.2</i>	11.7
	Advanced	<i>20.1</i>	21.5	<i>14.5</i>	<i>6.9</i>
	American	27.1	13.5	8.0	<i>5.5</i>

According to a one-way ANOVA, the effects of the average duration ratio of [s], that of a stop, that of closure and that of VOT within each English word analyzed were significant. (For the results of a one-way ANOVA, see Appendix 1.) In the table above, when two groups showed no significant difference regarding a variance factor according to post-hoc analysis using the Scheffe test at the p-value of .05, then the percentage values of the two groups regarding the factor are represented in italic. Thus, for example, in the case of the word *space*, the beginner and the advanced group of Korean English learners showed no significant difference according to post-hoc analyses, and thus the percentage numbers 17.0 and 16.2 are in italic.

As we can see from Table 2, the advanced group of Korean English learners and American English speakers showed no significant difference each other regarding the average duration ratio of VOT. However, the advanced group of Korean English learners produced the closure part of a stop consonant longer than American English speakers did, and thus the duration ratio of a stop consonant got longer in the production of the group. In particular, in each of the words *space*, *stand*, *skate* and *sky*, they produced the closure part of a stop as long as the beginner group did. In addition, the advanced group of Korean English learners had a tendency to pronounce the part [s] significantly shorter than American English speakers did. Especially, they produced the part [s] as short as the beginner group did in each of the words *spoon*, *stand*, *star* and *sky*.

#### 4. Discussion and Conclusion

This paper investigated temporal structures of English words with a word-initial /s/ plus stop sequence through production experiments with the beginner and the advanced group of Korean English learners in comparison of native speakers of English, paying attention to the duration ratios of /s/, a stop, closure and VOT within a word.

Our production experiments showed that Korean English learners produced /s/ shorter than a following stop regardless of their English proficiency level, while American English speakers produced /s/ longer than a following stop. It is well-known that Korean English learners tend to insert the epenthetic vowel [i] between /s/ and a following stop to pronounce a word-initial /s/ plus stop sequence which is not allowed in Korean. According Shin (2001), [i] following [s] tends to be realized as the devoiced [i̥]. An acoustic analysis of the data from our production experiments showed that Korean English learners realized the epenthetic vowel [i] as the devoiced [i̥] for all the tokens we heard the epentheticized vowel [i] between [s] and a following stop. Since the boundary between [s] and the devoiced vowel [i̥] is hard to tell from a spectrogram, we included the devoiced vowel [i̥] when we measured the [s] duration part. It is interesting that, even with this methodology, both the beginner and the advanced group of Korean English learners showed a much smaller duration ratio of [s] than American English speakers did.

The advanced group of Korean English learners pronounced a stop after /s/ as unaspirated by realizing VOT of a stop consonant in almost the same duration ratio as

American English speakers. On the other hand, a stop after /s/ was realized as aspirated in the production of the beginner group of Korean English learners. That is, the beginner group of Korean English learners produced the VOT part longer than American English speakers did, while the advanced group produced the VOT part in almost the same duration ratio as American English speakers. However, regardless of the English proficiency level, Korean English learners produced the closure part of a stop consonant longer than American English speakers did.

It is relatively well-known through former researches that, unlike native speakers of English, Korean English learners have a tendency to pronounce a stop after /s/ as aspirated (Kang & Lee, 2001; Cho, 2003; among others), and thus the instruction of the pronunciation of an English word with a word-initial /s/ plus stop sequence was mainly focused on the correction of such mispronunciation. The results of our production experiments imply that the relative duration ratios of /s/ and a stop consonant within a word also need to be paid attention to in instructing Korean English learners how to pronounce an English word with a word-initial /s/ plus stop sequence.

Appendix 1. One-way ANOVA results for the average duration ratios of [s], a stop consonant, closure of a stop consonant and VOT within each English word analyzed

	[s]	stop	closure	VOT
space	F (2, 117)=29.1 P = .000	F (2, 117)=41.6 P = .000	F (2, 117)=16.8 P = .000	F (2, 117)=35.1 P = .000
spoon	F(2, 117)=15.9 P = .000	F(2, 117)=76.4 P = .000	F(2, 117)=25.2 P = .000	F(2, 117)=48.9 P = .000
stand	F(2, 117)=18.9 P = .000	F(2, 117)=63.7 P = .000	F(2, 117)=20.9 P = .000	F(2, 117)=32.3 P = .000
star	F(2, 116)=23.3 P = .000	F(2, 116)=80.3 P = .000	F(2, 116)=50.6 P = .000	F(2, 116)=32.0 P = .000
skate	F(2, 117)=63.6 P = .000	F(2, 117)=20.1 P = .000	F(2, 117)=15.7 P = .000	F(2, 117)=5.6 P = .005
sky	F(2, 117)=38.6 P = .000	F(2, 117)=59.2 P = .000	F(2, 117)=54.5 P = .000	F(2, 117)=27.3 P = .000

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