

# **Tense/lax distinctions of English [s] in intervocalic position by Korean speakers: consonant/vowel ratio as a possible universal cue for consonant distinctions**

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**Kang, Hyunsook and Kyuchul Yoon. 2005. Tense/lax distinctions of English [s] in intervocalic position by Korean speakers: consonant/vowel ratio as a possible universal cue for consonant distinctions.** Studies in phonetics, phonology and morphology 0.0. 00-000. Several experiments have investigated voicing judgments in Germanic Languages when the duration of the first/stressed vowel and the following fricative or stop closure are varied while other cues for voicing remain constant and ambiguous (cf. Denes 1955, Port & Dalby 1982, etc.), showing that consonant/vowel ratio serves an important role for voicing distinctions. This paper investigates whether a temporal relation like consonant/vowel ratio can also be a possible cue for the distinctions of other features of consonants in a language that employs a totally different phonological system from Germanic languages. Several experiments examine how English words with intervocalic [s] are perceived by the speakers of Korean in which there are two alveolar sibilant fricatives, tense [S\*] and non-tense [s]. Experiment 1 investigates how a nonce word [bɪsən] spoken by an English speaker is identified by Korean native speakers when the duration of the fricative and its preceding vowel varies in small steps. Experiment 2 investigates the effect of the vowel that follows the fricative on tensing judgment. The findings from these experiments show that a simple temporal cue like consonant/stressed vowel ratio also influences Koreans' tensing judgment, suggesting the possible nature of its universality in perception. (Hanyang University and The Ohio State University)

Keywords: tense/lax distinction, consonant/vowel ratio, voicing, temporal cue, perception

## **1. Introduction**

Several studies have examined the adaptation of English words into Korean (H. Kang 1996, Y. Kang 2003, etc.) and into many other languages (Silverman 1992, Yip 1993, etc.), showing that sounds in a foreign language are perceived as similar sounds in the host language while being filtered through the phonological system of the host language. Interestingly, some sounds in one language have not just one but a few corresponding sounds in the host language when being adapted. The correspondence, however, is not random but rather systematic. This paper examines one such case of adaptation of English sounds into Korean and investigates why such systematic patterning occurs.

We first present the inventory of Korean obstruents in (1).

(1)		
Lax	Tense	Aspirated
p	P*	p <sup>h</sup>
t	T*	t <sup>h</sup>
k	K*	k <sup>h</sup>
s	S*	
h		

As we can see in (1), Korean has two alveolar fricatives, namely tense [S\*] and lax [s]. Thus, when English words with [s] are adapted into Korean, Korean has two sounds to substitute English [s]. The correspondence between English [s] and one of Korean alveolar fricatives is very systematic as is shown in (2) and (3).

(2)	English Words	Loanwords
a.	sign	[S*ain]
b.	song	[S*oŋ]
c.	smile	[simail]
d.	style	[sit <sup>h</sup> ail]

(3)	English words	Loanwords
a.	lesson	[leS*in]
b.	Macy	[meiS*i]
c.	Tesel	[t <sup>h</sup> eS*iɪl]

In (2), an English [s] in word(utterance)-initial position is shown to be adapted as either Korean tense [S\*] or lax [s] depending on the segment that follows it: If a vowel follows, English [s] is adapted into Korean tense [S\*] whereas if a consonant follows, it is adapted as Korean lax [s]. In (3) are given English words with intervocalic [s], which are all systematically adapted into Korean tense [S\*].

Kang, H. and S-K Kang (2002) argue that phonetic cues such as the durations of the fricative and the following vowel in word-initial position do not play a significant role when English word-initial [s] are adapted into Korean, contrary to Kim and Curtis (2002). Rather, they argued that F<sub>0</sub> of the following segment is more important. Specifically, they used cross-spliced items in which [s] in 'slit,' for example, was substituted with [s] from 'same,' and vice versa. According to them, regardless of the origin of the English [s] for the cross-spliced stimuli, most subjects identified it as Korean tense [S\*] or lax [s] depending on the properties of the segment that follows [s]. Furthermore, they showed that one vowel pulse or sonorant pulse was enough to influence the perception of the subjects. Based on this, they concluded that in the word(utterance)-initial position, duration of the fricative and duration of the following vowel do not play an

important role. Rather,  $F_0$ s of the segment that follow [s] determines how English [s] will be adapted into Korean. Since vowels have higher  $F_0$  than the sonorant, phrase-initial English [s] will be perceived as tense [S\*] if followed by a vowel whereas the same [s] will be perceived as Korean lax [s] if followed by a low  $F_0$  sonorant. They also argued that this is what is expected if Korean speakers use their own phonological system in perceiving a foreign sound: Ahn (1999) examined the duration of turbulence of Korean alveolar fricatives, tense [S\*] and lax [s], and  $F_0$  of the vowels that follow these fricatives in the word(utterance)-initial position and showed that the difference in the duration of turbulence production between lax [s] and tense [S\*] in word(utterance)-initial position in Korean is statistically non-significant whereas the  $F_0$  of the vowel after Korean lax [s] is considerably lower than that after tense fricative [S\*].

Unlike the word-initial English [s]s, intervocalic English [s]s are all adapted into tense [S\*] in Korean as in (3). One may simply assume that all English medial [s]s in (3) are adapted into tense [S\*] since they are followed by a vocalic segment as is the case of English [s] in the word-initial position. However, unlike the one in the word-initial position, medial English [s] is also preceded by another vocalic segment, which might as well affect its being perceived as tense [S\*]. In fact, it is well known that different phonetic qualities play different roles in different phonological environments as is the case with English voiced/voiceless segments. For example, many experimental studies on English reported that unlike consonants in the utterance-initial position, the voicing perception of a syllable-final stop/fricative is significantly affected by duration of consonant (fricative duration or the closure duration of a stop) and the duration of the preceding stressed vowel. For example, Denes (1955) reported that for the synthetically constructed 'his' and 'hiss,' perception of the voicing of final [s] depended on the relative duration of the fricative [s] and the preceding vowel. Port and Dalby (1982) also show that relative duration of the vowel and its following stop closure is an important perceptual cue for voicing distinction in English. They also note that "the extent to which such simple temporal relations play a role in languages outside the Germanic group is not known."

However, as one can easily see, there is no reason that the duration of consonant and its preceding vowel should not affect the perception of other features of consonant. In fact, H. Kang and S-Y Kang (2005) showed that in Korean in which voicing is not a distinctive feature for stops, the length of the vowel and the closure duration of a following stop may also play a role in tensing distinctions. Specifically, when the closure durations of tense stops in word-medial, intervocalic positions are shortened, these stops are perceived as lax; conversely, when the closure durations of lax stops in word-medial, intervocalic positions are lengthened, these stops are mostly perceived as tense (Cf. J-I Han 1996). The long closure duration

associated with a tense stop in word-medial position has also been shown to serve as an important cue in a post-lexical phonological process known as *post-stop tensification*. Under this process, lax stops are transformed into tense stops when they occur after another stop through morpheme concatenation. Kang and Kang (2005) showed in a perception experiment that the long closure duration associated with the unreleased first stop is responsible for making the following lax stop sound tense.

Since the durations of the stop closure seem to affect tensing distinction of stops in Korean, it is interesting to examine whether the same variable also plays a role in tensing judgments of Korean fricatives. Since Port and Dalby (1982) argued that the preceding vowel, not the following vowel, might serve a more important role on the voicing distinction in English since it is stressed and Korean is not a stressed language but English is, we thought that stimuli from English might be a good case to test whether stressed vowel also affects the tensing judgments of speakers whose native language does not have stress distinction. Therefore, this paper investigates whether C/V ratio influences the adaptation of English [s] in intervocalic position into Korean.

Two experiments in this paper investigate the role of vowel/consonant ratio as a perceptual cue for tensing distinction of English [s] in Korean. In experiment 1, the overall duration of the stressed vowel and its following fricative of a nonce word [bɪsən] produced by English native speaker was altered in small steps. In experiment 2, we used stimuli with both short and long V<sub>1</sub>s and V<sub>2</sub>s with altered duration of medial fricatives in small steps. Throughout this paper, the duration we refer to as “vowel duration” was measured from the spectrogram with the help of the wave form (after initial consonant release to the beginning for the following consonant) and may be referred to as CV (e.g., *bi*). The duration we refer to as “consonant duration” was also measured from the spectrogram with the help of the wave form.

## **2. Experiments**

To investigate whether the durations of vowel and its following fricative affect Korean speakers’ tensing distinction, we conducted the following set of experiments, which are similar to those conducted by Port and Dalby (1982).

### **2.1 Experiment 1**

#### **2.1.1 Subjects**

Fifteen native Seoul dialect speaking students at Ohio State University participated in the experiment. All subjects stayed less than 3 years in the U.S.A. and no one reported any speech or perception problem. They were instructed that they would hear a word spoken by English speaker, and they

have to determine whether English [s] in a word sounds like Korean tense [S\*] or Korean lax [s]. In order to avoid the influence of loanwords in which they hear only tense [S\*] in intervocalic position, the subjects were tested whether they could distinguish tense [S\*] and lax [s] in intervocalic position using [p<sup>h</sup>iS\* ] and [p<sup>h</sup>is ] spoken by the first author. They were also instructed to speak these words several times before taking a perception test. Only those who can hear the difference of tense [S\*] and lax [s] and produce them properly in intervocalic position took the test. Two people could not distinguish tense [S\*] and lax [s] in this position and thus were excluded in the experiment. The subjects were paid for their participation.

#### 2.1.2 Procedure

Subjects listened to a block of 5 trials for practice and then a stimulus block of 2400 tokens for the actual experiment. They were instructed to listen to the stimuli, decide whether they heard Korean lax [s] or tense [S\*] and select 1 or 2 on the keyboard. The stimuli were presented over Sony MDR-V300 headphones from the computers at a comfortable listening level in the phonetics laboratory at Ohio State University.

#### 2.1.3 Stimuli

A nonce word [bɪsən] with the stress on the first syllable was produced by English native speaker. It was recorded at the phonetics laboratory of University of Illinois at Urbana Champaign. The vowel duration of original stimulus was 60msec and its fricative duration 142msec. For the stimuli of the experiment, the overall duration of the vowel and its following fricative was altered in small steps using Praat (PSOLA) algorithm and a set of [bɪsən] was constructed with five different durations of vowel [ɪ] over the range of 20msec to 100msec. Eight different steps of medial fricative [s] were constructed in 15msec steps over the range of 37msec to 142msec. Thus, 40 stimuli were constructed from the combination of five “vowel durations” with eight “fricative durations.” The stimulus block containing 2400 tokens (15 subjects \* 40 stimuli \* 4 repetitions = 2400 tokens) was prepared. Each token was separated from another with 3 sec interval.

#### 2.1.4 Results

Figure 1 presents the percent identification of the stimulus as [bɪS\*ən] as a function of the duration of medial fricative consonant for each of the five [bɪ] syllable durations.

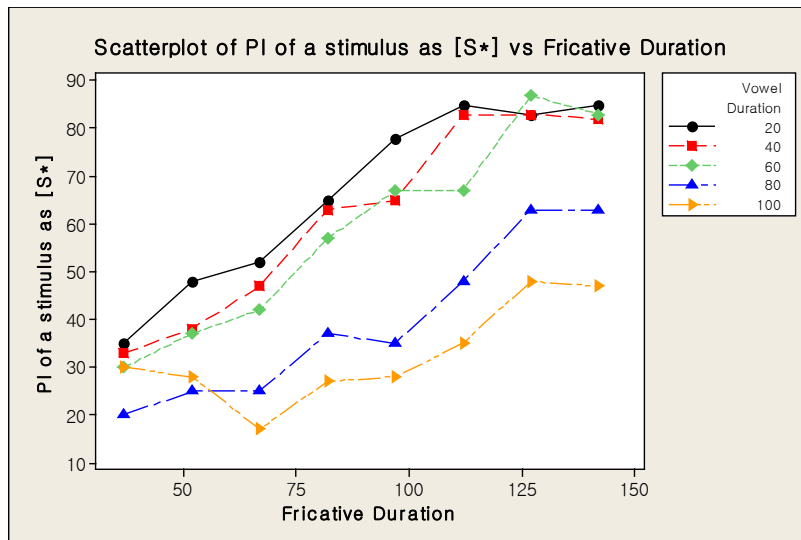


Figure 1 Percent identification of the stimuli as [bɪS\*ən] as a function of the duration of medial fricative consonant

In Figure 1, it is shown that as the vowel duration of  $V_1$ , *bi*, becomes shorter, the perceptual boundaries of tense/lax distinction (as 50% crossovers) tend to lie farther on the left of the X-axis. That is, as the vowel duration of  $V_1$  gets shorter, the same duration of [s] sound is more likely to be perceived as tense [S\*]. Also, as the duration of fricative [s] gets longer for each of the five “vowel durations,” the more it is likely to be perceived as tense [S\*].

The results demonstrate that durations of the vowel and its following fricative affect tensing distinction in Korean. In order to see whether the contribution of the duration of the vowel and its following fricative to tensing distinction can be understood as that of a simple temporal cue like C/V ratio, we divided the medial fricative duration by the duration of the first syllable  $V_1$ , (namely that of the *bi* syllable) and replotted the results in Figure 2. Figure 2 shows the percent identification of the stimulus as [bɪS\*ən] as a function of C/V ratio.

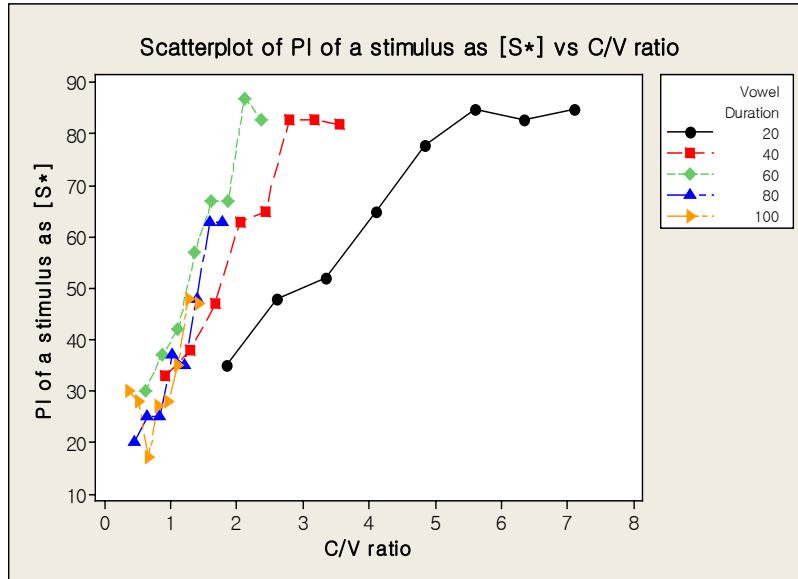


Figure 2: Percent identification of the stimulus as [bɪS\*əŋ] as a function of C/V ratio

With the exception of the shortest vowel of 20msec, an apparent outlier, constant ratio seems to exist between the duration of the vowel and the duration of its following fricative for the perceptual boundary. That is, all boundary values seem to cluster around a certain C/V ratio in Figure 2.

To compare the amount of variance accounted for by the absolute values of vowel and consonant duration with that by the simple temporal ratio of the two intervals, we applied a multiple regression. The results of regression analysis of the number of [bɪS\*əŋ] responses were given in Table 1. When consonant duration and vowel duration are entered as separate variables, the consonant duration accounts for about 52% of the variance whereas the combination of two variables account for about 87%. On the other hand, the C/V ratio shows that about 60% of the variance is accounted for. At first glance, it seems then that the absolute duration of the consonant and its preceding vowel accounts for more amount of variance in tensing judgments than the C/V ratio.

	R <sup>2</sup>	R <sup>2</sup>
Cons	52.32	C/V ratio 59.95
Vowel	87.31	

However, if we apply the multiple regression on the number of [bɪS\*əŋ] responses while excluding responses for the stimuli with 20msec vowel duration, which looked like outliers as we previously mentioned, the following results of regression analysis are obtained shown in Table 2.

Table 2. Stepwise Regression

	R <sup>2</sup>	R <sup>2</sup>
Cons	52.43	C/V ratio 87.4
Vowel	86.18	

As we see in Table 2, the amount of variance accounted for by C/V ratio is as good as or even better than that accounted for by the combination of C duration and V duration.

#### 2.1.5 Discussion

This result clearly replicates and extends the observation made by Denes (1955) and Port and Dalby (1982), namely that simple ratio of two intervals, when other cues remain ambiguous and constant, is an important phonetic cue in determining not only English voicing distinctions but other distinction such as tensing in a language where voicing is not a distinctive feature.

This result also answers the question we raised at the beginning of the paper. That is, English words with the intervocalic [s] are adapted into Korean as loanwords with tense [S\*] possibly due to the C/V ratio in English words. The stimulus we used for the experiment has the vowel duration of 60msec and the consonant duration of 142msec and thus, its C/V ratio is larger than the one for the 50% crossover of the perception boundary in Figure 2. This seems to suggest that loanword adaptation for English [s] in Korean reflects the perception of Korean speakers.

The results also show that acoustic properties of a sound in the host language are not always required in perceiving that sound: Korean language does not have stress but stressed vowel in English is utilized in determining tense distinctions by Korean speakers.

## 2.2 Experiment 2

In this experiment, we will explore the effect of the duration of the second syllable on the perception of intervocalic English fricative [s] by Korean speakers and see whether the claim by Port and Dalby (1982), namely that the preceding stressed vowel has a far stronger effect on English voicing judgments than does the following vowel, can be also supported in loanword adaptation by Korean speakers. This is particularly worthwhile to look into since Korean is not a stressed language.

### 2.2.1 Subjects:

Eleven Seoul dialect speaking OSU students who did not participate in the Experiment 1 participated in Experiment 2. All of them have stayed less than 3 years in U.S.A. and reported no history of speech or perception problem. The instructions and simple listening and production tests given to subjects in Experiment 1 were also applied to subjects in Experiment 2. They were paid for their participation.

### 2.2.2 Procedure

Subjects listened to a block of 5 trials for practice and then a stimulus block of 1408 tokens for the actual experiment. They were instructed to listen to the stimuli, decide whether they heard Korean lax [s] or tense [S\*] and select 1 or 2 on the keyboard. The stimuli were presented over Sony MDR-V300 headphones from the computers at a comfortable listening level in the phonetics laboratory at Ohio State University as in Experiment 1.

### 2.2.3 Stimuli

The same original stimulus used in Experiment 1 was used for Experiment 2. In Experiment 2, two *bi* syllables, or  $V_1$ s, were chosen from Experiment 1 with the second shortest (40msec) and the second longest (80msec) durations. Two durations of the second syllable (-on-) were also produced by using Praat, the long one with 455msec and the short one with 155msec from the original second syllable of 355msec. The four combinations of short and long  $V_1$  with the short and long  $V_2$  were constructed with eight different fricative durations over the range of 37 to 142msec.

### 2.2.4 Results:

The percent identification of the stimulus as [biS\*ən] as a function of the duration of medial fricative consonant for each of the four [bi-on] syllable durations is given in Figure 4. Note that the perceptual boundary between tense [S\*] and lax [s] is affected by the duration of the fricative, the duration of the preceding *bi* syllable (or  $V_1$ ) and the duration of the following *on* syllable ( $V_2$ ) but the amount of variance accounted for by each of these variables is different.

In order to evaluate the role of C/V ratio for these data, the results were replotted as a function of C/V ratio as in Figure 4. In this display there is far less variation, since all boundary values cluster around a certain C/V ratio.

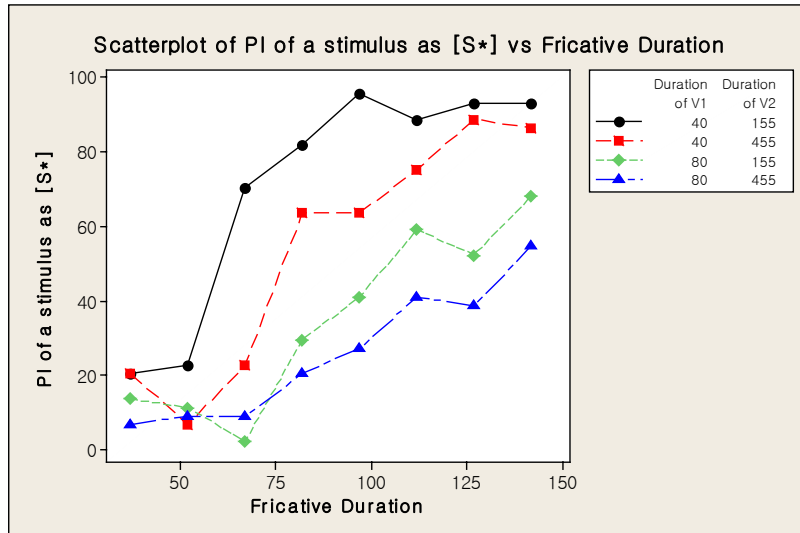


Figure 3 The percent identification of the stimulus as [bɪS\*əŋ] as a function of the duration of medial fricative consonant for each of the four [bɤŋon] syllable durations

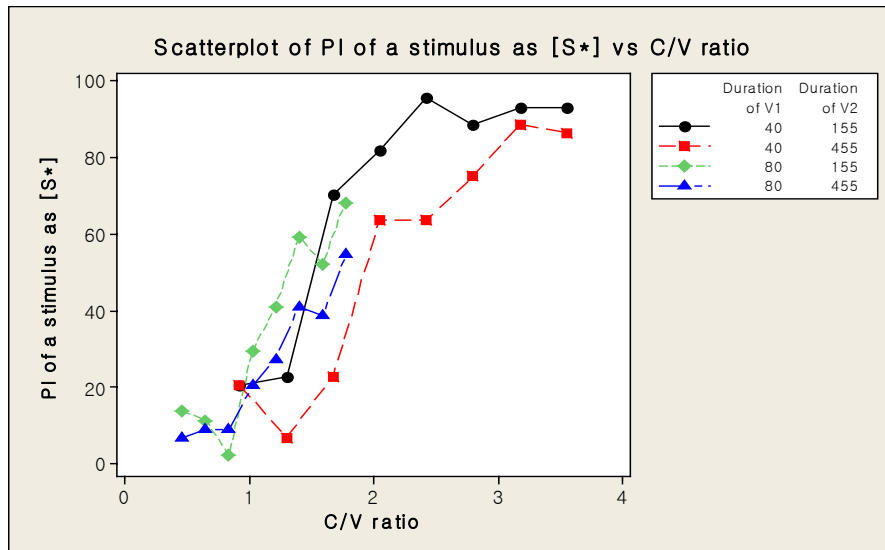


Figure 4 The percent identification of the stimulus as [bɪS\*əŋ] as a function of C/V ratio

A multiple regression analysis of the number of tense [S\*] responses was conducted in order to evaluate the importance of the absolute values of the consonant and vowel durations. First, consonant duration, first vowel duration, and second vowel duration were entered separately, using a stepwise regression procedure and its results are given in Table 3. It can be seen that consonant duration alone accounts for about 54.3% of the variance and the addition of V<sub>1</sub> duration accounts for 81.3%. The duration of V<sub>2</sub>, however, does not add a whole lot. In the second model, C/V<sub>1</sub> ratio was computed for each stimulus, and this variable was extracted along with the second syllable. As can be seen in Table 3, C/V<sub>1</sub> ratio again accounts for almost as much variance as first vowel duration and consonant duration combined (81.3% vs. 81.5%) and yet contains no information about the absolute durations of the vowel and consonant.

Table 3: Stepwise Regression:

R2		R2	
Consonant D.	54.29	C/V <sub>1</sub> -ratio	81.51
Vowel 1	81.31		
Vowel 2	85.85		86.06

#### 2.2.4 Discussion

The results clearly show that the duration of the preceding vowel V<sub>1</sub> affects the perception of the following fricative [s] more strongly than that of the following vowel V<sub>2</sub>. This observation raises the following interesting questions. Why does then the duration of the vowel that precedes the consonant in question serve such an important role in voicing distinction in English and tensing distinction in English loanwords? Port and Dalby (1982) argue that the duration of the stressed vowel plays a significant role in English voicing distinction and that the stressed vowel happens to immediately precede the consonant in question: thus, the V<sub>1</sub> in C/V<sub>1</sub> ratio refers to the stressed vowel. In the above experiments on English loanword adaptation in Korean, we have also shown that Korean listeners whose native language does not employ stress utilize the same information, C/V<sub>1</sub>-ratio, in tensing distinction just like English speakers do in voicing distinction.

Why then does the preceding, stressed vowel serve a more significant role on tensing judgments of English medial consonant [s] into Korean even when stress does not play a distinctive role in Korean? Several explanations can be entertained. First, Korean speakers may in fact react to the stress of English since it is perceptually prominent feature. In this case, since intervocalic [s] may be resyllabified as a coda of the stressed vowel or as an ambisyllabic segment, it is possible that its duration is primarily compared to that of the stressed vowel. Secondly, Korean speakers may

associate English stress with other similar, perceptually prominent features in Korean as well, such as high tone (high F0). If so, the vowel that affects tensing judgments on Korean phonemes will be determined by the tone feature it carries rather than its position. If this is the case, Korean speakers may react to the second syllable, not to the first syllable, when the high tone occurs on the second syllable with the preceding [s]. Thirdly, it may be simply because of the order of the vowels. That is, the preceding vowel affects more on Korean tensing judgments just because it is in the preceding environment, not that it is stressed.

### 3. Conclusion

In this paper, we have shown that English [s] in intervocalic position is adapted into Korean tense [S\*] because that is the sound Korean speakers perceive in that position. Specifically, we have shown that the durations of the fricative and its preceding vowel affect the perception of the intervocalic [s] in English words of Korean speakers.

Since it is shown that C/V<sub>1</sub> ratio affects the perception of English [s] of the Korean speakers, it would be interesting to see whether the same variables, namely the durations of the fricative and its preceding vowel, also affect the perception of Korean fricatives as well. Since there are two Korean alveolar fricatives, namely tense [S\*] and lax [s], one has to work on both sounds to see whether C/V<sub>1</sub> ratio influences the perception change from tense [S\*] to lax [s] as well as from lax [s] to tense [S\*].

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