Processing English [s] into Korean Alveolar Fricative in Word-initial Position*

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Kang, Hyunsook & Kang, Seok-keun. 2005. Processing English [s] into Korean Alveolar Fricative in Word-initial Position. *The Linguistic Association of Korea Journal, 13*(4), 49-68. The sound system in English has only one alveolar strident fricative [s] whereas Korean sound system has two types of alveolar fricative, lax [s] and tense [S*]. When English words with initial [s] are borrowed into Korean, one of the two alveolar fricatives is selected in the systematic pattern. This paper investigates whether the loanwords with initial alveolar fricative reflect the perceptual differences Korean speakers hear in English words and if so, what phonetic properties of the sounds, consonantal properties of [s] or vocalic properties of the vowel that follows [s], affect the Korean speakers' perception. The experiments utilize cross-spliced stimuli which combined consonant properties of a stimulus of English [s] that is frequently perceived as one type of alveolar fricative by Korean speakers with vocalic properties of a stimulus of English [s] frequently perceived as the other type of alveolar fricative. The findings suggest that both the consonantal and vocalic information of English words with initial [s] affect the perception of Korean speakers and that vocalic information like F0 that follows the initial [s] affects the perception more strongly than the consonantal information of [s]. Similar findings have been also argued for Korean stops in AP-initial position (cf. Kim et al., 2002).

Key Words: alveolar strident fricative, lax [s], tense [S*], loanword, perception, phonetic properties

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1. Introduction

It has been known among Korean linguists that English [s] in word initial position corresponds with one of two different alveolar fricatives in Korean, lax [s] and tense [S*], when being adapted. As we see in (1), if English [s] appears before a vowel, it is adapted as tense [S*] in Korean: English 'sale' in (1a) is adapted as [S*eil] with tense [S*]. If English [s] appears before other consonant(s) in the onset cluster as in (2), it is adapted as lax [s] in Korean. Thus, English 'smile' is adapted as [simail] with lax [s].

(1) English #[s]+V	Korean tense [S*]
English	Korean Loanwords
a. sale	[S*eil]
b. site	[S*ait^{h}i]
c. sign	[S*ain]
d. signal	[S*ikinal]
(2) English #[s]+C	Korean lax [s]
English	Korean Loanwords
a. sleeping (bag)	[sillip^{h}iŋ]
b. smile	[simail]
c. snap	[sinep]
d. speaker	[sip^{h}ik^{h}i]
e. skate	[sik^{h}eit^{h}i]

Two possible explanations can be suggested for the pattern we observe in (1) and (2): The assumption in (3a) says that the pattern we see in (1) and (2) is arbitrary with no phonetic motivation whereas that in (3b) says that the systematic patterns in (1) and (2) occur because of the similarities of sounds between English and Korean: English [s] and Korean tense [S*] sound similar to each other if a vowel follows English [s] whereas English [s] is similar to Korean lax [s] if a consonant follows it.

(3) Two assumptions for the pattern in (1) and (2)

a. The correspondence pattern in (1) and (2) is accidental with no phonetic basis.
b. The correspondence pattern in (1) and (2) is phonetically motivated since foreign sounds are likely to be adapted into the similar sounds in the host language.

Several studies that have worked on the adaptation of foreign sounds to native sounds argued for (3b), namely that when foreign sounds are adapted, they are filtered through the phonological system of the host language and as a result, they are most likely to be perceived as some similar sounds that exist in the host language (cf. Silverman 1992, Yip 1993, H. Kang 1996, Y. Kang 2003, etc.). In this paper, we conducted the perception test to determine whether (3b) is responsible for the adaptation shown in (1) and (2). If the results in the perception tests fail to show that the correspondence between English sounds and Korean sounds in (1) and (2) is based on phonetic motivation, then the alternative (3a) will be adopted. Specifically, this paper investigates the phonetic properties that may play a prominent role in determining the particular correspondence we observe in (1) and (2).

In order to investigate why English [s]'s are adapted into different fricatives in different contexts, we need to know some phonological and phonetic details of a host language, Korean, since the foreign sounds are perceived by the speakers with Korean phonological system. First, consider Korean syllable structure. As is written in (4), Korean allows a maximal CGVC syllable structure. Since only one consonant other than a glide is allowed as onset in Korean, some phonological processes apply to English words with a consonant cluster to make them fit to Korean syllable structure. For instance, when words with the onset clusters are borrowed, a default vowel is inserted after each consonant of the onset cluster except the last one that is followed by a vowel as in [t^hri] in (5a). That is why all the adapted words in (2) show a default vowel after [s].

(4) Korean Maximal Syllable Structure: CGVC

(5) Borrowed words with an onset cluster
   a. tree [t^hiri]
   b. dream [tirim]
   c. smile [simail]

Secondly, we need to know some phonetic properties of different manners of Korean consonants. The consonant inventory in Korean is given in (6).

(6) Korean consonant inventory

Stop	p, P^*, p^h	t, T^*, t^h		k, K^*, k^h
Affricate			c, C^*, c^h	
Fricative		s, S^*		h
Nasal	m	n		ŋ
Liquid		l		

As we see in (6), there are three types of stops but only two types of fricatives in Korean. Three types of stops are usually classified as aspirated, tense and lax. One of the phonetic cues that distinguish three types of stops from one another is the VOT (voice onset time). Aspirated stops have the longest VOT, and tense stops the shortest, while lax stops have the intermediate VOT (cf. Lisker & Abramson, 1964; C-W Kim, 1965, 1970; Han & Weitzman, 1970; Han, 1996; etc.). Not only the phonetic properties of the consonant, but properties like F0 and H1-H2 in the vowels that follow the stops are also important phonetic cues in identifying the consonant types (Han & Weitzman, 1970; Jun, 1993; Ahn, 1999; etc.): For example, F0 of the vowel that follows tense or aspirated stop is higher than that of the vowel following lax stop in Korean. Interestingly, the F0 variations on the vowels that follows different types of stops are not typical segmental effects caused by the different types of stops, but rather pervasive (cf. Jun, 1993; Ahn, 1999, etc.) such that Jun (1993) argued that this F0

variations in the initial position of an accentual phrase (AP) should be encoded as a phonological feature.

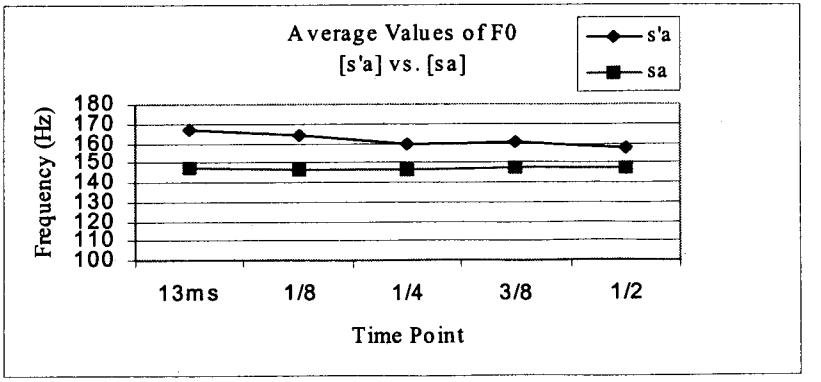
In fact, Kim et al. (2002) show that vocalic properties such as F0 and H1-H2 from the voice onset of the vowel dominate the consonant properties such as VOT in identifying the consonant types of Korean in accentual phrase(AP)-initial position. They conducted the perception test with the cross-spliced stimuli which combined the portion of the consonant properties of a stimulus with one phonation type with vocalic properties of a stimulus of other phonation type. The results show that vocalic properties of a stimulus such as F0 and H1-H2 are more prominent than the consonant properties like VOT in identifying the manner of consonant. For example, a stimulus with consonantal portions of the VOT of an aspirated stop combined with vocalic portions like low F0 following a lax stop was identified as a lax stop by most subjects.

Ahn (1999) argues that the pervasive F0 different occurs in the vowels that follow different types of fricatives as well. That is, F0 of the vowels after tense fricative [S*] is higher than that of non-tense fricative [s] even at the mid point of the following vowel as in (7). This is important observation since Korean [s] at the initial position of a word is considered an aspirated consonant due to its aspiration (cf. Kagaya, 1974; Yoon, 1999, etc.) and aspirated stops were shown to carry high F0 just like tense stops. Interestingly, however, Ahn (1999) shows that the F0 of a vowel after Korean non-tense [s] which is aspiraetd is considerably lower than that of a vowels after tense [S*].

(7)

Figure 1. F0 of the vowels after Korean alveolar fricatives (Ahn, 1999):[1)]

1) In this figure, [s'] represents tense [S*].



Furthermore, Ahn (1999) notes that the difference in the duration of turbulence production between non-tense [s] and tense [S*] in Korean is statistically non-significant as is shown in (8) (cf. Yoon, 1998).

(8) Table 1. Characteristics of Korean tense [S*] and lax [s]
(Ahn, 1999)

Tense Fricative	199.0 (ms)	10.35 (ms)	.821
Non-tense Fricative	194.1 (ms)	10.30 (ms)	

Phonological and phonetic properties in Korean which we have considered so far may become important in perception of an English word with [s]. For instance, significant F0 difference of the vowels that follow English [s] may influence Korean speakers to hear different types of fricatives for English [s] since as we have noted above, significant F0 difference occurs for different types of fricatives in Korean. Furthermore, Korean syllable structure which makes the initial [s] in an onset cluster of an English word perceived as a syllable with an imaginary vowel as is shown in (2) and (5) (cf. H. Kang, 1999) may influence the [s] to be perceived as lax [s] in Korean: an imaginary vowel, being voiceless, cannot be perceived as a segment with high F0. Consonantal properties of English [s] which may vary due to the

co-articulation effect by the following segment might also have influenced the adapted form of English [s]. Therefore, for the following perception tests, we will take into account consonant information as well as vowel information to see 1) whether these properties play a role in the systematic adaptation of English [s] sound into Korean that is observed in (1) and (2) and 2) if so, which properties play a more prominent role.

This experiment will supplement another experiment done by Kim and Curtis (2002). They showed that English word-initial [s] that are adapted as tense [S*] in Korean has longer turbulence than that which is adapted as lax [s] in Korean. We would like to show that another factor may affect the adaptation of English word-initial [s] into Korean.

2. Perception Test

To investigate whether the pattern we observed in (1) and (2) is phonetically motivated, we conducted the following perception tests.

2.1. Recording

English words with [s] in different contexts are recorded as in Table 1. The contexts include [s]+stressed vowel in (A), [s]+unstressed vowel in (B) and [s]+consonant (p, t, k, m, n, l) in (C). We also recorded English words which are same as those in (A-C) but without the initial [s] sound. These tokens were given in (D), (E) and (F). The talker is a native English speaker and a trained phonetician and at the time of recording, was a linguistics student at University of Illinois at Urbana-Champaign. He was given specific phonetic details such that for words in (D-F) their phonetic properties should be the same as those in (A-C) except the initial [s]. For example, he was instructed to produce 'pit' in (E) without aspiration. The recording was done in the sound-proof booth in Phonetics Lab at University of Illinois and CoolEdit Pro was used for recording and Praat was used for the segmentation.

Table 1

A. [s]+stressed vow	site, same, sit, sought, suit
B. [s]+unstressed vowel	support, serene, salute
C. [s]+consonant (p,t,k,m,n,l)	spit, stick, skick, smear, sneak, slit
D. Same words as in (A) except the initial [s]	-ite as in 'site' -ame as in 'same' -it as in 'sit' -ought as in 'sought' -uit as in 'suit'
E. Same words as in (B) except the initial [s]	-upport as in 'support' -erene as in 'serene' -alute as in 'salute'
F. Same words as in (C) except the initial [s]	-mear as in 'smear' -neak as in 'sneak' -lit as in 'slit' pit tick kik

2.2. Subjects

Five Korean subjects at University of Illinois at Urbana-Champaign participated in the pilot study in selecting the M(ost)T(ense-like)[s] and the L(east)T(ense-like)[s] after hearing the [s]'s sliced from words in (A-C). For the main experiment, eleven Korean subjects at the same school who did not participated in the previous pilot test participated. All the subjects had been in USA less than 3 years at the time of perception test and they were paid for their participation. None of them reported any speech or hearing problem.

2.3. Procedures

We first segmented the initial [s]'s from the words in (A), (B) and

(C). These 14 [s]s were then repeated 5 times in random order, resulting in total 70 tokens. Five Seoul-dialect speaking subjects who are students at University of Illinois at Urbana Champaign participated in the experiment. They were asked to press 1 or 2 in the keyboard depending on what they hear.

Among these segmented [s]'s, we selected the most T(ense)-L(ike)[s] and the L(east)T(ense)-Like[s] and then concatenated these two alveolar fricative sounds, MT[s] and LT[s], to the vowel-initial words in (D) and (E) and to the consonant-initial words in (F) and made new stimuli that begin with one of alveolar fricatives, MT[s] or LT[s]. These newly constructed stimuli as well as the original stimuli given in (A-C) were then gated or segmented further to a new set of stimuli. This new set of stimuli contains only portions of the stimuli we constructed in the previous step, such as [s]+one vowel pulse, [s]+two vowel pulses, etc. If the following segment is sonorant, two sonorant pulses were added incrementally, instead of one, as is shown in (10). Only gated stimuli that contained portions of the full word were used for the experiment not to bias the subjects with the loanwords. Total 28 words were segmented into several gates and each of these gated stimuli was repeated 5 times in random order. 11 subjects participated in the experiment.

(9) Stimuli for Experiment 1
O[s]: original [s]
LT[s]: Least Tense-like [s]
MT[s]: Most Tense-like [s]
a. original word: O[s]+S(tressed) V(owel)
b. combined word: LT[s]+S(tressed) V(owel)
c. original word: O[s]+U(nstressed) V(owel)
d. combined word: LT[s]+U(nstressed) V(owel)
e. original word: O[s]+[p,t,k]V
f. combined word: MT[s]+[p,t,k]V
g. original word: O[s]+[m,n,l]V
h. combined word: MT[s]+[m,n,l]V

(10) vp: vowel pulse sp: sonorant pulse

Gate	1	2	3	4
s+V	s+vp1	s+vp2	s+vp3	
s+son	s+sp2	s+sp4	s+sp6	s+(full)son
s+stop	s+burst	s+bt+vp1	s+bt+vp2	

2.4. Results

The results show that [s] in 'same' was the best sound for being perceived as Korean tense [S*]: 15 responses out of 25 said to have perceived Korean tense [S*] for this sound. In contrast, [s] in 'slit' was mostly perceived as lax [s]: 5 out of 25 responded to have perceived it as Korean tense [S*].

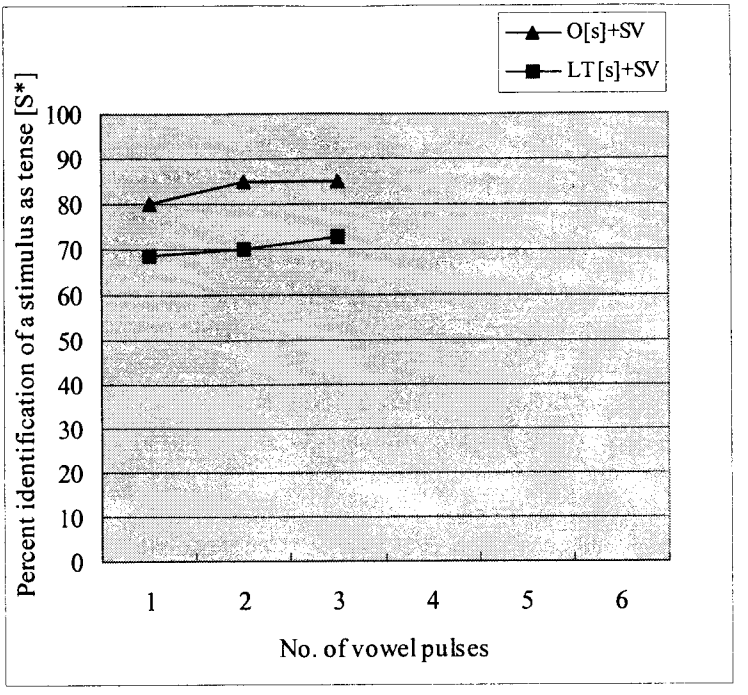
Figure 2 shows the results of the percent identification of a stimulus as tense [S*] as the function of vowel duration. As we have noted earlier, only 20 percent of the responses identified LT[s] as tense [S*] when it was perceived by itself and 60 percent have identified MT[s] in 'same' as tense [S*]. However, when one vowel pulse of the stressed vowel is added to it, the identification percentage of LT[s] as tense [S*] rises up to 69 percent, crossing the perceptual category boundary: This shows that the vocalic properties such as F0 play a major role in identifying consonant types rather than the consonant properties: A stressed vowel has high F0 and this made the LF[s] to be perceived as tense [S*]. The percent identification of English O[s] as tense [S*] as the function of vowel duration also increases when a vowel pulse is added to it but the rise is not as sharp as that of English LT[s]+stressed vowel. As more vowel pulses are added, the percent identification of O[s] or LT[s] as tense [S*] shows a continuous rise but the difference is not as big as the one observed when the first vowel pulse is added to consonant [s].

(11) a. original word: O[s]+Stressed Vowel

b. combined word: LT[s] (from 'slit')+Stressed Vowel

	No. of vowel pulses		
Types	1	2	3
O[s]+SV	80	85	85
LT[s]+SV	69	70	73

Figure 2. Percent Identification of a stimulus as tense [S*] as the function of vowel duration



Additionally, some difference in perception results still exists depending on the identity of [s]: The stimuli with the original [s] elicited more responses of tense [S*] than the stimuli with LT[s],

suggesting that consonantal properties may still play a role in identifying the consonant types.

Figure 3 shows the percent identification of O[s]+[p,t,k] and MT[s]+[p,t,k] as tense [S*] as the function of vowel duration. The closure durations between the initial MT[s] and the burst release of a stop for the newly constructed stimuli, MT[s]+ [p,t,k], are same as those of the original words with the same segments, respectively.

As we see in (12), regardless of the origin of the initial [s], the percent identification of a stimulus as tense [S*] has decreased sharply as some portion of the following obstruent is added: as we have noted, the percent identification of MT[s] as tense [S*] was 60 percent when it was heard by itself. However, it sharply went down to around 15 percent as soon as the burst release is added to it. As the vocalic pulses are added, the percent identification of the stimulus as tense [S*] is not improved. The effect of the following segment in the identification of alveolar fricative is again shown to be important.

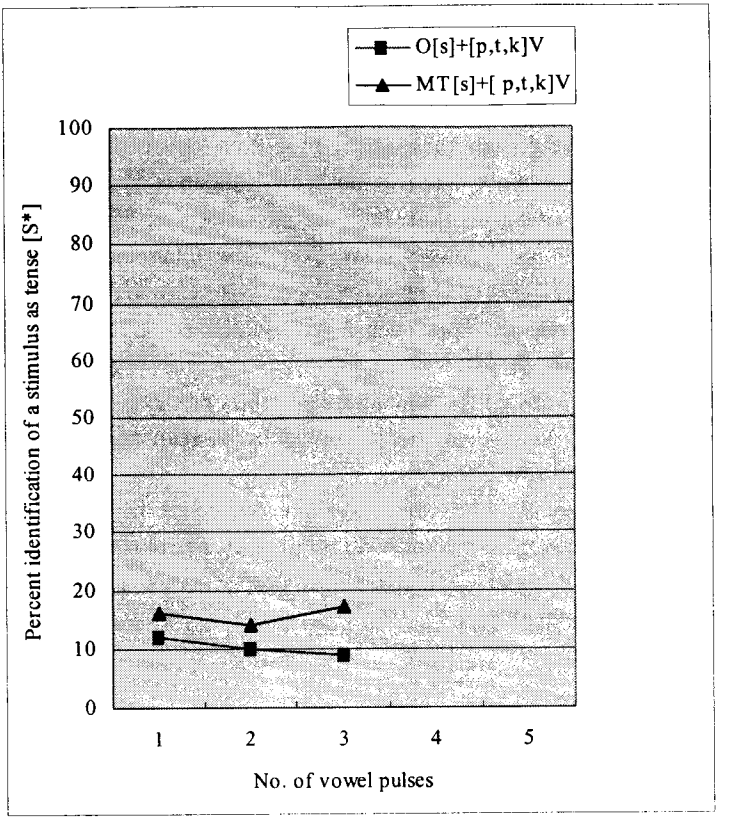
We would like to suggest that this might have to do with Korean syllable structure and F0 difference on vowels after different types of fricatives. As we have discussed earlier, the initial [s] in an onset cluster of an English word is perceived as a syllable with an imaginary vowel as is shown in (2) and (5) (cf. H. Kang 1999, etc.) as soon as the burst of the following stop is perceived. Since the perceived imaginary vowel, being voiceless, is not to be perceived as a segment with high F0, the fricative in front of this imaginary vowel may be perceived as lax [s] in Korean.

Some difference occurs again in percent identification of O[s]+[p,t,k]V and MT[s]+[p,t,k]V as tense [S*] as the function of vowel duration. Again, the stimuli with MT[s] elicited slightly more responses of tense [S*] than the stimuli with the original [s], suggesting that consonantal properties also play a role in identifying the consonant types.

(12) a. original word: O[s]+[p,t,k]
b. combined word: MT[s]+[p,t,k]

	No. of vowel pulses		
Types	1(burst)	2	3
O[s]+[p,t,k]V	12	10	9
MT[s]+[p,t,k]V	16	14	17

Figure 3. Percent Identification of a stimulus as tense [S*] as the function of vowel duration



Similar results are obtained when MT[s] is added to a sonorant. Consider (13). As we see in Figure 4, the percent identification of a stimulus as tense [S*] drops significantly as the pulses of the following sonorant are added. Note again that the percent identification of MT[s] as tense [S*] was 60 % when no other segment followed it. Phonetic properties of a segment that follows English [s] again affect the consonant identification more than the consonantal properties of English [s] as was the case in Figure 2 and Figure 3. We again suggest this is due to low F0 of the segment that follow English [s]: As we have discussed for an English word with [s]+[p,t,k] onset cluster, this initial [s] will be perceived as a syllable with an imaginary vowel and this imaginary vowel cannot be perceived as a vowel with high F0 by Korean speakers.

Interestingly, the identification percentage of [s] in a sonorant cluster as tense [S*] is higher than that of [s] in a stop cluster as tense [S*]. We suggest that this might have to do with [s]'s in a sonorant cluster being followed by sonorant that has certain value in F0: F0 of the sonorant might have been perceived as F0 of the imaginary vowel and thus, the [s] that precedes a sonorant is more likely to be perceived as tense [S*] than the one that precedes a stop which is perceived with an imaginary vowel with no F0.

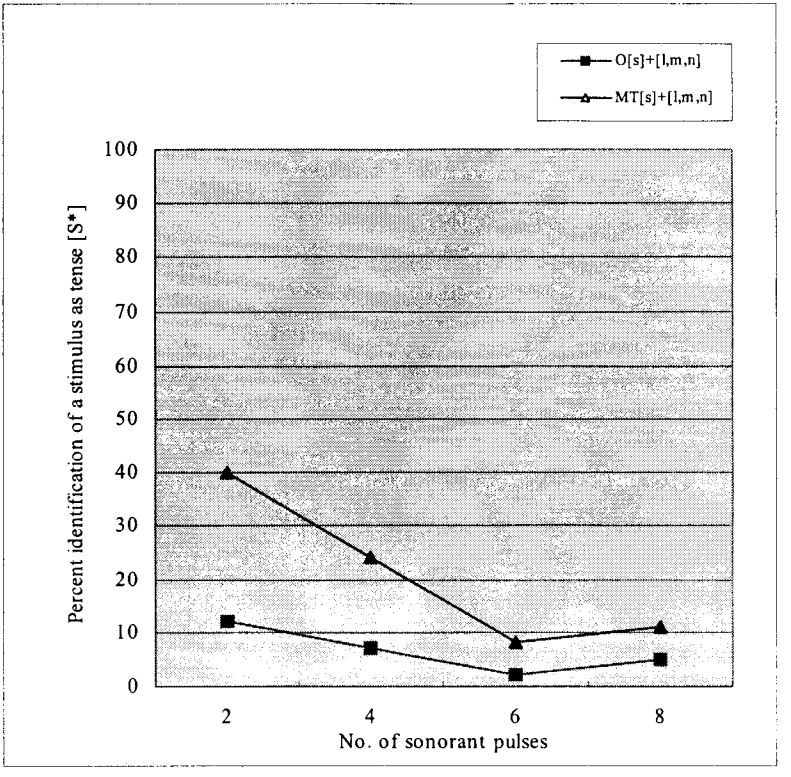
Sonorants have low F0, which made the previous [s] and an imaginary vowel between them be perceived by Korean speakers as lax [s] and a vowel with low F0.

Figure 4 also shows that there is some difference between percent identifications of O[s]+[l,m,n] and MT[s]+[l,m,n] as tense [S*], which shows the effect of different consonantal properties of English [s] in identifying the consonant types.

(13) a. original word: O[s]+[l,m,n]
b. combined word: MT[s]+[l,m,n]

	No. of sonorant pulses			
Types	2	4	6	8(full duration)
O[s]+[l,m,n]	12	7	2	5
MT[s]+[l,m,n]	40	24	8	11

Figure 4. Percent Identification of a stimulus as tense [S*] as the function of sonorant duration

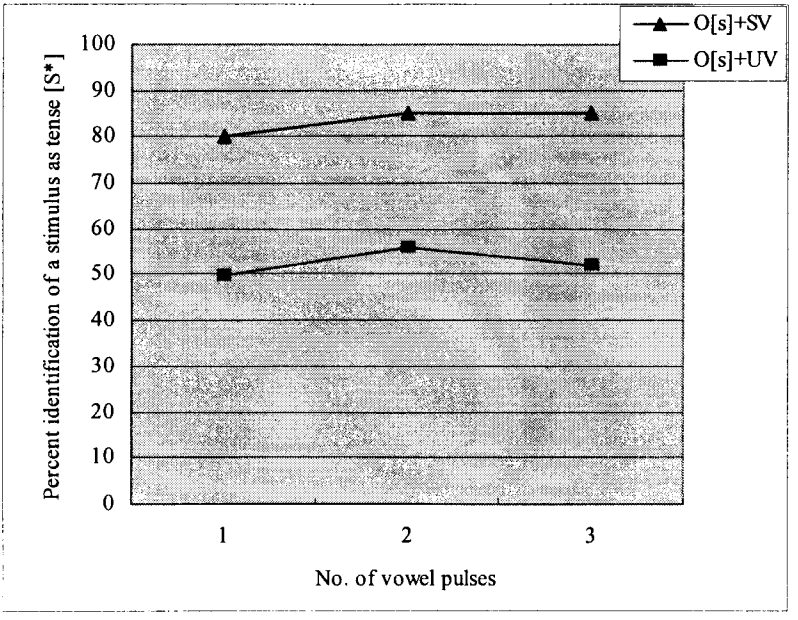


Our last perception test concerns the percent identification of English [s] before unstressed vowels as tense [S*]. The results are given in (14).

(14) a. original word: O[s]+SV
b. original word: O[s]+UV

	No. of vowel pulses		
Types	1	2	3
O[s]+SV	80	85	85
O[s]+UV	50	56	52

Figure 5. Percent Identification of a stimulus as tense [S*] as the function of the vowel duration



As we see in Figure 5, the percent identification of a stimulus as tense [S*] does not increase even if a vowel pulse is added to it if the vowel pulse comes from the unstressed vowels. That is, it is not the addition of the vowel pulse but rather the addition of a vowel pulse from a stressed vowel that makes a sharp increase in the percent

identification of a stimulus as tense [S*]. This clearly shows that in identifying fricative types, it is not the vowel pulse itself but the F0 of the following segment that affects the percent identification of a stimulus as tense [S*]. Still the percent identification of a stimulus as tense [S*] for English [s] with the following unstressed vowel is over 50 percent which explains why [s] in 'supporter' is still adapted as tense [S*] in loanwords.

3. Conclusion

In this paper, we have investigated whether the systematic adaptation we observe in (1) and (2) has any phonetic basis. The perception experiments we have conducted show that the systematic adaptation does in fact have phonetic bases. Specifically, we have shown that the segment that follows the fricative, not the fricative itself, has more significant effect on the identification of the fricative types. Specifically, the experiments showed that F0 plays an important role in identifying consonant types: The following stressed vowel greatly increases the percent identification of a stimulus as tense [S*] whereas the following unstressed vowel does not increase it a lot. For a stimulus with English [s] that is followed by another consonant, we again suggested that F0 plays a key role in identifying the consonant as one of the Korean fricatives. As soon as the subjects hear the burst of the stop or a sonorant consonant, Koreans perceive an imaginary vowel for English [s] as examples in (2d, e) show. The syllable with no real vocalic element or a syllable with an imaginary vowel with low F0 is perceived as a syllable without high F0, and thus, the preceding fricative is perceived as lax [s], not tense [S*].

It is also interesting to note that one of the vocalic properties, namely H1-H2, which distinguish tense stops from lax stops, does not seem to play a role in loanword perception. English vowels do not have the same value of H1-H2 as those that follow tense stops or fricatives in Korean. Rather, H1-H2 of English vowels shows similar value to that of lax vowels in Korean. However, in the perception tests we

conducted, H1-H2 does not seem to interfere with the perception of the preceding fricative as a tense fricative [S*]. In future study, we need to investigate why H1-H2 of the vowel qualities does not play an important role in loanword adaptation.

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