The Adaptation of English /s/ in Korean*

Yoonjung Kang
University of Toronto Scarborough

1. Introduction

In contemporary Korean, English /s/ is adapted as lax /s/ if it precedes a consonant in the English input, as shown in (1a), and as tense /s*/ if it precedes a vowel or occurs word-finally in the English input, as shown in (1b-c) (cf. S. Kim 1999 and Kim and Curtis 2002).

(1) a. Preconsonantal /s/ → Lax /s/[1]

/s̠ɨLLʌmpʰɨ/	'slump'	/s̠mokɨ/	'smog'
/s̠ɨkʰeitʰɨ/	'skate'	/s̠ɨwiŋ/	'swing'
/tʰes̠ɨtʰɨ/	'test'	/mas̠ɨkʰɨ/	'mask'

b. Prevocalic /s/ → Tense /s*/

/s̠*aicɨ/	'size'	/s̠*eLamik/	'ceramic'
/s̠*iŋkɨl/	'single'	/s̠*ain/	'sign'

c. Word-final /s/ → Tense /s*/

/k*as̠*ɨ/	'gas'	/tos̠*ɨ/	'DOS'
/cus̠*ɨ/	'juice'	/t*ɛns̠*ɨ/	'dance'

Kim (1999) and Kim and Curtis (2002) propose that Korean adapters are sensitive to the fricative duration of English /s/ in the mapping of English /s/ to Korean – English /s/ is shorter when it occurs in consonant clusters, so the

* I would like to thank Sarah Costen, David Go, Sohyun Hong, Kevin Heffernan, Pheba Ninan and Seung-Joon Park for their assistance with the research presented in this paper. The research presented in this talk was funded by the Connaught New Staff Start-up grant from the University of Toronto. I would also like to thank the audience of ICKL 2008 for valuable comments and discussion.

[1] /L/ represents the single liquid phoneme of Korean, which alternates between [r] and [l].

Inquiries into Korean Linguistics III

shorter [s] in English is mapped to Korean lax /s/ and the longer [s] in English is mapped to Korean tense /s*/. Ahn and Iverson (2004) interpret this as evidence that Korean lax /s/ and tense /s*/ contrast in duration (i.e., singleton vs. geminate) underlyingly.

In this paper, I examine the phonetic properties of English /s/ and Korean /s/ and /s*/ and conclude that, rather than the duration of the fricative, the voice quality of the vowel following the fricative is better at accounting for the adaptation pattern in Korean and that duration plays a very minor role. The outline of the paper is as follows: the acoustic properties of Korean /s/ and /s*/ are discussed in section 2, section 3 examines the acoustic properties of English /s/, and section 4 concludes the paper.

2. Korean /s/ and /s*/

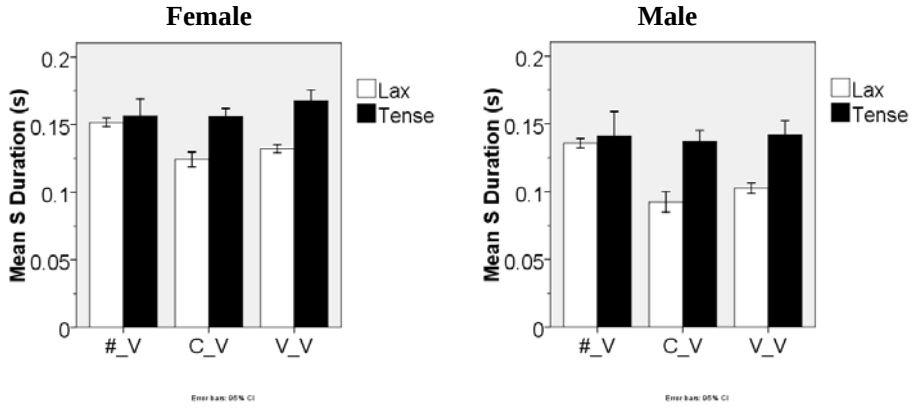
The acoustic data for Korean was drawn from BOLA (The Bank of Language Resources) Korean phonetic database (PBW1). The data used in this study consisted of recordings of a list of 2000 common words, as read by two professional announcers (one male and one female). From the list of 2000 words, there were 557 instances of /s/ or /s*/ in various segmental contexts, and each was examined and measured for various acoustic characteristics proposed to correlate with the /s/ vs. /s*/ contrast in the literature.

First, the duration of the fricative tended to be shorter for lax /s/ than for tense /s*/, as shown in Figure 1, in agreement with previous studies (Ahn 1999, Cho et al 2002, and Chang 2008). However, the present data showed that this difference was systematic only when /s/ and /s*/ occurred in word-medial position, and not in word-initial position.[2] Previous studies disagree on whether the duration is significantly different in word-initial position with some studies finding a significant difference (Cho et al. 2002 and Chang 2008) and others finding no significant difference (Ahn 1999). Our results were compatible with the findings of H. Kang & S. Kang (2002, as reported in Kang and Yoon 2005) that, whereas the duration of the fricative plays a role in the perception of the /s/ vs. /s*/ contrast in word-medial position, it does not affect the perception of the fricative contrast in word-initial position. Also, it should be noted that even Kim

[2] In the present data, the aspiration portion was included in the measurement. Excluding aspiration from the measure of duration would likely make the difference between the two segments significant.

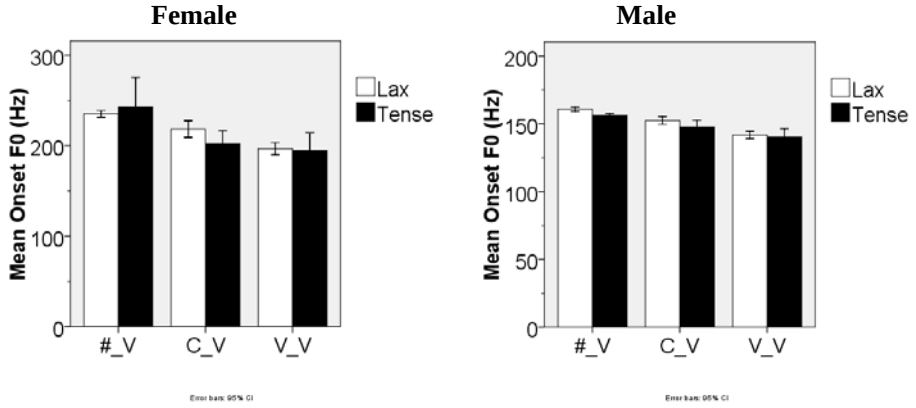
& Curtis (2002) note that, when asked to categorize word-initial /s/ into Korean /s/ and /s*/ based solely on the duration of the fricative, the subjects found the task very difficult.

Figure 1. Duration of lax /s/ and tense /s*/



Secondly, the fundamental frequency of the onset of the vowel following /s/ and /s*/ was examined and no systematic difference was found, which is in agreement with most previous studies (Kagaya 1974, Cho et al. 2002, and Chang 2008)[3], as Figure 2 illustrates.

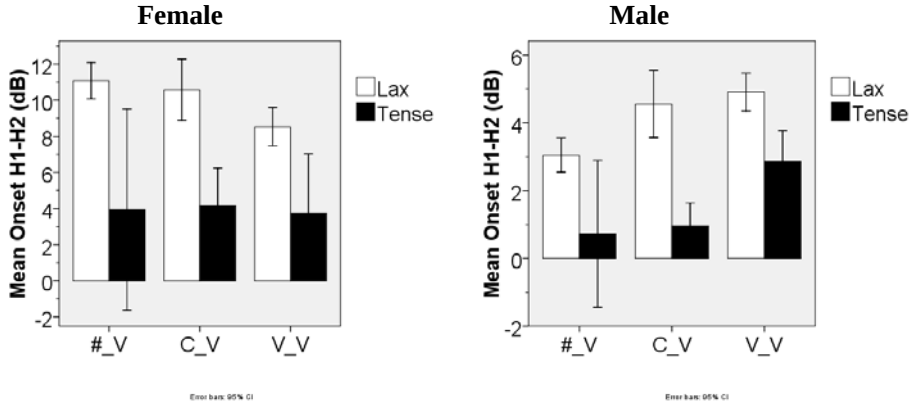
Figure 2. F_0 of the onset of the vowel following lax /s/ and tense /s*/



[3] Ahn (1999) found a statistically higher F_0 for /s*/ than /s/ in word-initial position.

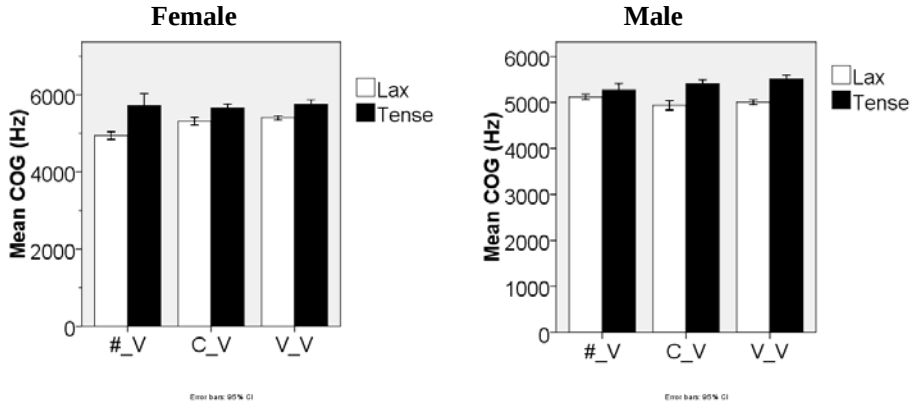
Next, the voice quality of the vowel following /s/ and /s*/ were examined. Specifically, the difference in the amplitude of the first two harmonics (H1-H2) at the onset of the following vowel was measured, which indicates the breathiness of the vowel, with a higher H1-H2 value indicating a breathier voice quality. The results, summarized in Figure 3, show that the H1-H2 is systematically higher for lax /s/ than for tense /s*/, in agreement with previous findings in the literature (Cho et al. 2002, Ahn 1999, and Chang 2008).

Figure 3. H1-H2 of the onset of the vowel following lax /s/ and tense /s*/



Finally, the mean frequency of fricative noise (i.e., COG=Centre of Gravity) was measured and tense /s*/ showed a systematically higher COG value than lax /s/, which is in agreement with Cho et al. (2002), as illustrated in Figure 4. This is also in agreement with Kim et al. (2005)'s findings that the position of the tongue blade differs for obstruents of different laryngeal categories, with tense segments having the highest tongue blade position. The intensity of fricative noise was also measured (not shown here), but there was no systematic difference.

Figure 4. COG of the fricative noise for lax /s/ and tense /s*/



To summarize, the duration of the fricative is fairly good at differentiating the two segments in word-medial position, but not in word-initial position. On the other hand, the voice quality (H1-H2) of the onset of the following vowel and the frequency of the fricative noise (COG) systematically differentiates the two fricative categories in Korean in word-initial, as well as in word-medial, position. No systematic difference was found between the two segments in their pitch at the onset of the following vowel (F_0). Table 1 summarizes the results, along with the findings from previous acoustic studies on /s/ and /s*/.

Table 1. Acoustic characteristics of Korean /s/ and /s*/

		BOLA	Cho et al. (2002)	Ahn (1999)	Chang (2008)
Fricative duration	Word-initial	Not significant (including aspiration)	**Significant (excluding aspiration)**	Not significant (including aspiration?)	**Significant (including aspiration)**
	Word-medial	**Significant**	**Significant**	--	--
H1-H2	Word-initial	**Significant**	**Significant**	**Significant**	**Significant**
	Word-medial	**Significant**	(Significant)	--	--
F0	Word-initial	Not significant	Not significant	**Significant**	Not significant
	Word-medial	Not significant	(Not significant)	--	--
COG	Word-initial	**Significant**	**Significant**	--	--
	Word-medial	**Significant**	(Significant)	--	--

3. Acoustics of English /s/

In this section, I examine three acoustic properties of English /s/ – fricative duration, H1-H2, and COG – in preconsoantal vs. prevocalic contexts to determine which of the three properties can best account for the loanword adaptation data. The phonetic data for this preliminary study comes from the *American English Spoken Lexicon* (AESL) (available at https://online.ldc.upenn.edu/aesl/). AESL is a phonetic database containing audio files for more than 50,000 of the most common words in English, as read by an adult female native speaker of American English. I first discuss the duration of the fricative and then the H1-H2 and COG.

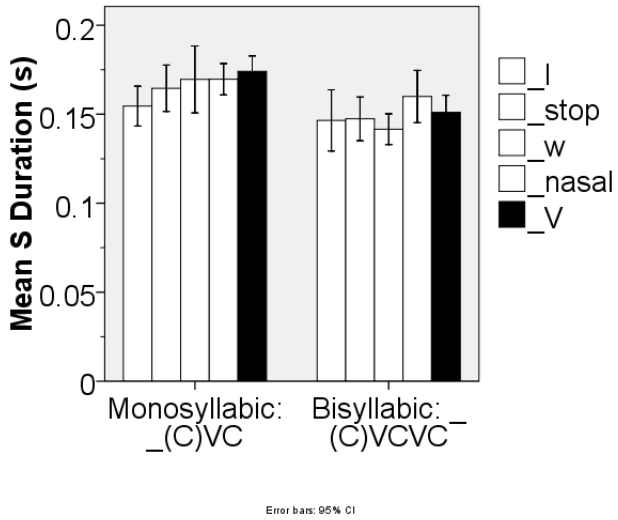
3.1. Duration of English /s/

The duration-based account of /s/ adaptation is based on the observation that English /s/ is shorter when it occurs as part of a consonant cluster (Haggard 1972, Klatt 1973, 1974, and Lee and Iverson 2007), and it hypothesizes that the duration of the fricative is the main factor in determining the adaptation pattern. However, Kim and Curtis (2002) only studied [s] in an [st] cluster (e.g., *sack vs. stack*), a context where shortening is likely most severe, according to Klatt (1973), and it is not clear whether the duration of /s/ in other contexts differ as much as the duration-based account of the adaptation pattern predicts. Also, other factors are known to affect the duration of /s/ in English, such as stress, domain boundaries, morphemic status, and the number of syllables in the word, among others (Klatt 1974, Crystal and House 1988, and Walsh and Parker 1983). However, these other factors do not seem to play a role in the adaptation pattern. Also, the fact that the duration of the fricative does not systematically distinguish the two categories of Korean fricatives in word-initial position, as discussed in section 2, is also problematic.

To examine the length of English /s/ in various phonological contexts, I chose mono- and bi-syllabic words with initial /s/ followed by a variety of segments (20 words of the shape s'VC, 57 sC'VC, 20 s'VCVC, and 50 sC'VCVC). According to the duration-based account of the loanword adaptation pattern, we would expect /s/ to consistently be shorter before a consonant than before a vowel. The results, however, do not show a consistent difference between preconsonantal vs. prevocalic /s/, contrary to the predictions of the

duration-based account. Figure 5 shows the average duration of the fricative of word-initial /s/ when followed by different types of segments.

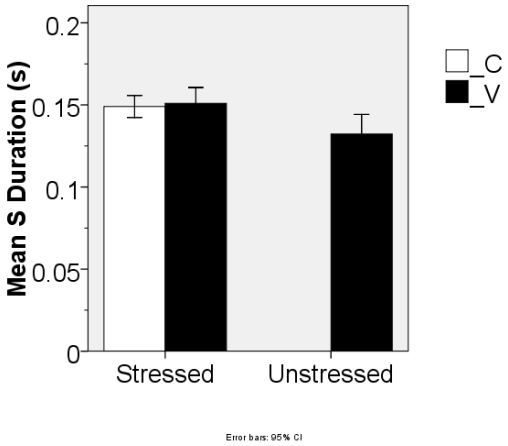
Figure 5. Duration of word-initial /s/ with different following segments



While, on average, /s/ is shorter when followed by a consonant (white bars) than a vowel (black bar), the difference is neither consistent nor significant enough to provide a satisfactory explanation for the categorical adaptation pattern, where all instances of preconsonantal /s/ pattern together and are mapped to lax /s/ in Korean (e.g., [s̲ɨnou] *s̲now*, [s̲ɨpʰai] *s̲py*, [s̲ɨpʰiŋkʰɨs*ɨ] *s̲phinx*, [s̲ɨllaitɨ] *s̲lide*, and [s̲ɨwim] *s̲wim*) and all instances of prevocalic /s/ are mapped to tense /s*/ in Korean (e.g., [s̲*aikʰɨl] *c̲ycle* and [s̲*ikɨnal] *s̲ignal*).

Also problematic for the duration-based account is the fact that other factors known to affect the duration of /s/ do not have any systematic effect on the loanword adaptation pattern. Here I examine two of these factors – stress and word length – using data from AESL. When I compared the duration of English word-initial /s/ in bi-syllabic words with initial (20 s'VCVC) vs. final stress (20 sVC'VC), /s/ in a stressed syllable was longer than in an unstressed syllable and the difference was highly significant ($F_{(1, 38)}$=6.527, p=0.015), as Figure 6 shows.

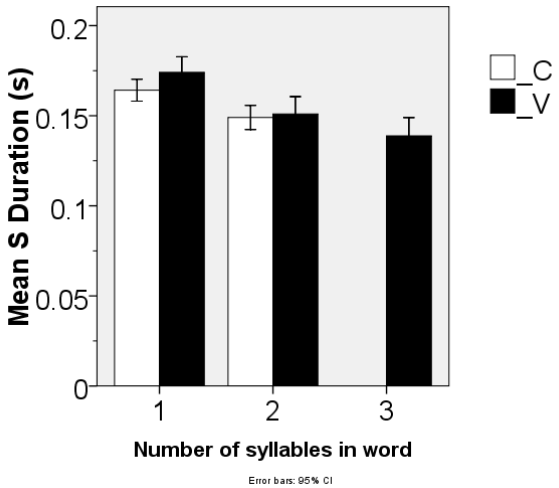
Figure 6. Duration of word-initial /s/ in bi-syllabic words (s(C)VCVC) with different stress patterns



Also note that the duration differed more systematically when conditioned by stress (compare the second and the third bars in Figure 6), rather than by the following segments (compare the first and the second bars in Figure 6). In loanword adaptation, however, a prevocalic /s/ maps to a tense /s*/, regardless of the number of the stress pattern (e.g., [**s***ɛllʌri] *sálary* vs. [**s***eramik] *cerámic*).

To examine the effect of word length, I compared the duration of word-initial /s/ in 20 monosyllabic (s'VC), 20 bi-syllabic (s'VCVC) and 20 tri-syllabic (s'VCVC) words. The results, summarized in Figure 7, showed that there was a significant effect for word length ($F_{(2, 27)}$=15.578, p<0.001) and a post hoc Bon Ferroni test showed that /s/ was significantly longer in monosyllabic words than in bi-syllabic (p<0.005) or tri-syllabic words (p<0.001), while the difference between the bi-syllabic and tri-syllabic conditions were not significant (p=0.188).

Figure 7. Duration of word-initial /s/ in words of different length



Also note that the duration of the fricative differed more systematically when conditioned by word length (compare the difference among the dark bars) than by the following segments (compare between each pair of dark and white bars). Again, in loanword adaptation, however, preconsonantal /s/ and prevocalic /s/ map to lax /s/ and tense /s*/, respectively, regardless of the number of syllables in the word (e.g., [**s***ain] *sign* vs. [□*****ɛllʌri□ *salary*).

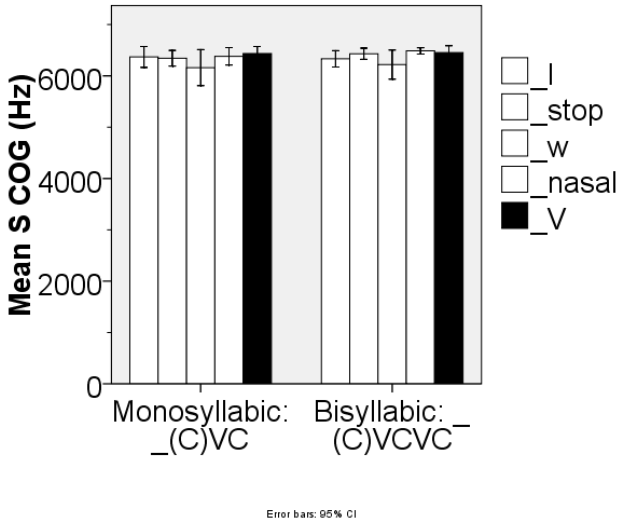
To summarize, a preliminary study of the duration of English /s/ revealed that the difference in duration between preconsonantal vs. prevocalic /s/ in English was not systematic enough to account for the Korean loanword adapatation pattern. Also the loanword adaptation pattern is insensitive to other factors, such as stress and word length, which have a systematic effect on the duration of /s/. These results cast serious doubt on the claim that the adaptation of English /s/ into Korean is guided by durational cues.

3.2. Frequency of fricative noise (COG) in English /s/

Now we turn to the COG of English /s/ in preconsonantal vs. prevocalic position. If COG was the primary cue guiding the adaptation pattern, we would expect the COG of prevocalic /s/ to be systematically higher than that of preconsonantal /s/. Figure 8 shows the mean COG of English word-initial /s/

when followed by different types of segments, based on the same set of words as those for Figure 5 above. The COG is on average slightly higher for prevocalic /s/ than for preconsonantal /s/, showing a difference in the right direction, but the difference is neither systematic nor significant.

Figure 8. COG of word-initial /s/ with different following segments



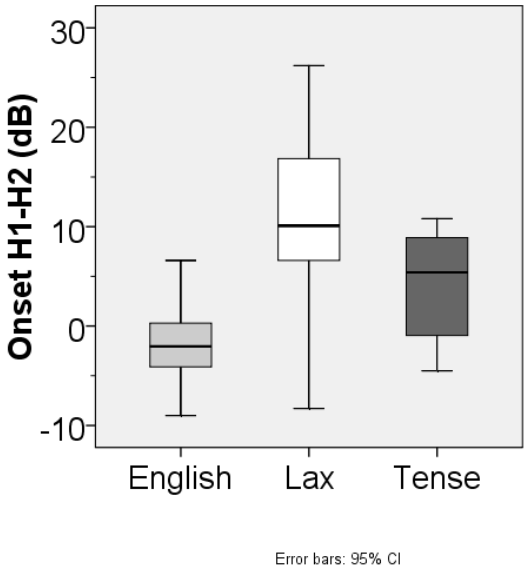
Moreover, a comparison of the COG value for English /s/ with that of the Korean female speaker (from Figure 4) shows that the COG values of both preconsonantal and prevocalic /s/ of English fall within the tense /s*/ range of the Korean speaker, although this comparison is based on single speakers from each language from recordings from two different databases.

3.3. Voice Quality (H1-H2) of the onset of the vowel following English /s/

The final acoustic property examined was the voice quality of the vowel following English /s/, which can be measured by the difference in amplitude between the first two harmonics (H1-H2). Since, by definition, preconsonantal /s/ is not followed by any vowel, we can only examine and compare the H1-H2 value of prevocalic /s/ in English. Figure 9 compares the range of H1-H2 values for English word-initial prevocalic /s/ (with various word lengths and stress

patterns, for a combined total of 80 words) and Korean /s/ (160 tokens) and /s*/ (7 tokens) in word-initial position.

Figure 9. Box plot of H1-H2 (dB) at the onset of the vowel following word-initial /s/ and /s*/



The results showed that the H1-H2 value of English word-initial /s/ was in general quite low, and based on H1-H2, English /s/ could be considered to be more similar to Korean tense /s*/ than lax /s/, which is in agreement with the categorical adaptation of English prevocalic /s/ to Korean tense /s*/ in loanwords. Again, since the data from English and Korean are based on single speakers and are from recordings from two different databases, and also given the small number of tense /s*/ tokens, any conclusions we can draw from this comparison are only tentative.

While voice quality may explain the adaptation of prevocalic English /s/ to Korean tense /s*/, we still need to account for the adaptation of English /s/ in non-prevocalic position, where H1-H2 cues are not available. Here, I propose that voice quality still plays a role, albeit indirectly. Korean does not allow consonant clusters and /s/ is not allowed in coda position – a preconsonantal /s/ is always followed by an epenthetic vowel [ɨ] in Korean adaptation (e.g., [sɨtʰik]

'stick', [sɨ̲llʌmpʰɨ] 'slump', [sɨ̲wiŋ] 'swing', [tʰesɨ̲tʰɨ] 'test' etc.) In Korean, high vowels are prone to devoicing when following aspirated stops and lax /s/ in Korean (Jun and Beckman 1994 and Jun et al. 1997). As a result, the epenthetic vowel [ɨ] is realized as breathy and devoiced following lax [s], which is less distinct from ∅ and makes a better epenthetic vowel than non-breathy [ɨ] which has a clear formant structure. Crucially, devoicing applies following /s/ but not following tense /s*/. Therefore, English [s∅]lump, for example, is more similar to Korean [sɨ̥llʌmpʰɨ] than to Korean *[s*ɨllʌmpʰɨ]. In other words, the mapping of English preconsonantal /s/ to lax /s/ of Korean achieves a better perceptual correspondence between the English input and the Korean output by creating a non-salient epenthetic vowel (cf. HEAD-DEP of Alderete 1995, Shinohara 1997, Kenstowicz 2007, and Kang 2008).

The adaptation of word-final /s/ still requires explanation. Similar to preconsonantal /s/ of English, word-final /s/ is always adapted with an epenthetic vowel following /s/. Nevertheless, word-final /s/ of English is consistently adapted as tense /s*/ of Korean. I conjecture that in utterance-final position, vowels are often breathy or creaky in general, and a high central vowel [ɨ] may be non-salient even when the preceding consonant is [s*]. Therefore, the English word miss∅ is no more similar to Korean *[misɨ̥] than to Korean [mis*ɨ̥]. As the quality of the epenthetic vowel cannot determine whether /s/ or /s*/ should be used, the choice may be passed down to the duration cue. In a preliminary examination of English /s/ in different positions of the word, based on AESL (which will not be discussed in detail here due to space limitations), word-final /s/ is, in general, twice as long as /s/ in other positions. This is expected as the words in AESL were read in isolation. When the primary cue (H1-H2 and the quality of the epenthetic vowel) is not decisive the secondary cue (duration) may take over and determine the mapping. This proposal suggests that the perceptual cues for a given contrast and their relative functional load may vary from context to context. The proposal put forth in this paper regarding the role of the salience of the epenthetic vowel and the vowel quality in utterance-final position should be examined through a systematic phonetic study of this contrast in various contexts (e.g., different vowel contexts and utterance-medial vs. utterance-final positions) and further verified through perceptual experiments.

4. Conclusion

In this paper, I examined and compared the acoustic properties of English /s/ and Korean lax /s/ and tense /s*/ based on acoustic data from two phonetic databases (*AESL* and *BOLA*). Based on the findings, it is proposed that the duration-based account of the loanword adaptation pattern – that English /s/ of shorter duration maps to Korean /s/ and English /s/ of longer duration maps to Korean /s*/ – is not adequate. Rather, it is proposed that the voice quality of the vowel following the fricative provides a more satisfactory account of the observed adaptation patterns in prevocalic and preconsonantal positions. However, the voice quality may not be decisive in all contexts—in word-final position, where the vowels are in general breathy or creaky, voice quality of the following vowel likely plays a diminished role in determining the mapping and fricative duration may be decisive. In other words, the adaptation of word-final /s/ suggests the possibility that the relative functional load of different perceptual cues may differ from context to context, even for the same phonemic contrast.

REFERENCES

Ahn, H. 1999. An acoustic investigation of the phonation types of post-fricative vowels in Korean. *Harvard Studies in Korean Linguistics* 7: 57–71.

Ahn, S-C. and G. Iverson. 2004. Dimensions in Korean Laryngeal Phonology. *Journal of East Asian Linguistics* 13: 245-279.

Alderete, J. 1999. Head-dependence in Stress-Epenthesis interaction. In B. Hermans and M. van Oostendorp eds., *The Derivational Residue in Phonological Optimality Theory*, Amsterdam: John Benjamins: 29-50.

Chang., B. C. 2008. The acoustics of Korean fricatives revisited. *Harvard Studies in Korean Linguistics* 12: 134-150.

Cho, T., S-A Jun, and P. Ladefoged. 2002. Acoustic and aerodynamic correlates of Korean stops and fricatives. *Journal of Phonetics* 30: 193–228.

Crystal, T. H. and A. S. House. 1988. The duration of American-English stop consonants: an overview. *Journal of Phonetics* 16: 285–294.

Haggard, M. 1972. Abbreviation of consonants in English pre-post-vocalic clusters. *Journal of Phonetics* 3*:* 7–24.

Jun, S-A. and M. E. Beckman. 1994. Distribution of devoiced high vowels in Korean. *Proceedings of the 1994 International Conference on Spoken Language Processing* 1*:* 479–482.

Jun, S-A., M. Beckman, S. Niimi, and M. Tiede. 1997. Electromyographic evidence for a gestural-overlap analysis of vowel devoicing in Korean. *The Journal of Speech Sciences* 1*:* 153–200.

Kagaya, R. 1974. A Fiberscopic and Acoustic Study of the Korean Stops, Affricates and Fricatives. *Journal of Phonetics* 2: 161–180.

Kang, H. and K. 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* 11.3: 407–419.

Kang, Y. 2008. English voiced stops in Korean in the 1930s. A talk presented at the annual meeting of the Montreal-Ottawa-Toronto (MOT) Phonology workshop.

Kenstowicz, M. 2007. Salience and similarity in loanword adaptation: a case study from Fijian. *Language Sciences* 29, 2/3: 316-340.

Kim, H., K. Honda, and S. Maeda. 2005. Stroboscopic-cine MRI study of the phasing between the tongue and the larynx in the Korean three-way phonation contrast. *Journal of Phonetics* 33: 1–26.

Kim, S. 1999. *Sub-phonemic Duration Difference in English /s/ and Few-to-Many Borrowing from English to Korean.* PhD Dissertation, University of Washington.

Kim, S. and E. Curtis. 2002. "Phonetic duration of English /s/ and its borrowing into Korean," *Japanese/Korean Linguistics* 10: 406–419.

Klatt, D. 1973. Duration Characteristics of Word-initial consonant clusters in English. *JASA* 53, 1: 379.

Klatt, D. 1974. The duration of [s] in English words. *Journal of Speech, Language, and Hearing Research* 10: 51–63.

Lee, A. and G. K. Iverson. 2007. Variation in Korean integration of English word-final /s/. *Language Research* 42: 239-251.

Shinohara, S. 1997. *Phonological Analysis of Japanese Adaptations of Foreign Words*. PhD Dissertation, University of Sorbonne-Nouvelle.

Walsh, T. and F. Parker. 1983. The duration of morphemic and non-morphemic /s/ in English. *Journal of Phonetics* 11: 201-206.

Yoonjung Kang
Department of Humanities
University of Toronto Scarborough
1265 Mililtary Trail, H521
Toronto, ON, M1C 1A4
Canada
kang@utsc.utoronto.ca