Articulatory and Acoustic Evidence for the Complete Neutralization of Manner of Articulation in Korean Affrication

Hyunsoon Kim*

ABSTRACT

This study is concerned with articulatory and acoustic experiments about the change of the stop /t/ into its counterpart affricate before derivational and inflectional suffixes beginning with /(h)i/. The present phonetic results show that the stop consonant is articulatorily and acoustically completely neutralized into the underlying plain affricate. Thus this study provides another instance of complete neutralization of manner of articulation in Korean in addition to Kim and Jongman (1996).

Keywords: complete neutralization, Korean affrication

1. Introduction

In this paper I examine the change of the stop /t/ into the plain affricate before the high front vowel /i/ across a morpheme boundary in Korean both articulatorily and acoustically, and compare the phonetic data with that of the underlying plain affricate. Based on the phonetic results of Korean Affrication in comparison with that of the underlying plain affricate, I propose that Korean Affrication is categorical, not gradient and far less variable, and that this is another complete neutralization of manner of articulation in Korean in addition to that in Korean Coda neutralization (Kim and Jongman 1996).

In Korean Affrication, the stop consonants /t, t^h/ are changed into the alveolar affricates [$\widehat{ts}$, $\widehat{ts}^h$], respectively, when followed by derivational or inflectional affixes beginning with /(h)i/.[1] As shown below, the stops /t/ and /t^h/ are affricated when followed by derivational suffixes such as the nominative suffix /i/ (1a), the adverbial

* Sogang Univ. Dept. of English

1) In the literature the change of the stops /t, th/ into their counterpart affricates has been considered as palatalization (e.g., Kim, C-W and Ahn 1983; Ahn 1985). However, Kim (1997) has reinterpreted the change as affrication on the basis of phonetic experiments and reviews of previous studes. See Kim (1997) for more detail.

suffix /i/ (1b), and the causative suffixes /i/ and /hi/ (1c).[2]

(1) Affrication before derivational suffixes

a. before the nominative suffix /i/

/mat+i/	→	[ma.d͡zi]	'first child'
/pʰi put^{h}+i/	→	[pʰi.pu.t͡sʰi]	'one's own child'

b. before the adverbial suffix /i/

/kut+i/	→	[ku.d͡zi]	'firmly'
/kat^{h}+i/	→	[ka.t͡sʰi]	'together'

c. before the causative suffixes, /i/ and /hi/

/kut+hi+ta/	→	[ku(t).t͡sʰi.da]	'to be hardened
/puth+i+ta/	→	[pu(t).t͡sʰi.da]	'to be attached

When the noun-stem final stop /t^{h}/ is followed by inflectional suffixes such as the subject case marker /i/ (2a), the copular /i/ (2b), and the conjunction case marker /ilaŋ/'and' (2c), the stop surfaces as its counterpart affricate [t͡sʰ].[3] For instance, when the noun /pat^{h}/ 'field' takes the conjunctional suffix /ilaŋ/ 'and', the output is [pa.tsʰi.laŋ], as shown in (2c).

(2) Affrication before inflectional suffixes

a. before the subject case marker /i/

/pʰat^{h}+i/	→	[pʰa.t͡sʰi]	'red bean'+subj.
/sot^{h}+i/	→	[so.t͡sʰi]	'kettle'+subj.
/mit^{h}+i/	→	[mi.t͡sʰi]	'bottom'+subj.

b. before the copula /i/

/pʰat^{h}+i/	→	[pʰa.t͡sʰi.da]	'(it) is red bean'
/sot^{h}+i+ta/	→	[so.t͡sʰi.da]	'(it) is a kettle'

c. before the conjunction case marker /ila ŋ/ 'and'

/pat^{h}+ilaŋ/	→	[pa.t͡sʰi.laŋ]	'field and'
/sot^{h}+ilaŋ/	→	[so.t͡sʰi.laŋ]	'kettle and'

---

2) One cannot find roots ending in affricates and fricatives or roots ending in /t'/ in the morphological contexts in (1).

3) There are few nouns ending in the stop /t/ in the Korean vocabulary. The word /tikit/ which refers to the Korean character /t/ is one. But as we will see below, when followed by the vowel /i/, the noun-final consonant /t/ is usually pronounced as [s]. In the literature it is said that noun-final consonants /t/ were replaced by the consonant /s/ in Middle Korean, starting from the middle of the sixteenth century (e.g. W. Huh 1964, 1985) or the beginning of the sixteenth century (e.g. K.-M. Lee 1972).

Affrication does not apply in non-derived environments, as shown in (3):

(3)

a. nouns			
/t͡ʃanti/	[t͡ʃan.di]	*[t͡ʃan.d͡ʒi]	'grass'
/tʰi/	[tʰi]	*[t͡ʃʰi]	'dust'
/t'i/	[t'i]	*[t͡ʃ'i]	'belt'
b. verbs			
/mutita/	[mu.di.da]	*[mu.d͡ʒi.da]	'to be dull'
/pətʰita/	[pə.tʰi.da]	*[pə.t͡ʃʰi.da]	'to endure'
c. adverbs			
/puti/	[pu.di]	*[pu.d͡ʒi]	'please'
/tʰiŋtʰiŋ/	[tʰiŋ.tʰiŋ]	*[t͡ʃʰiŋ.t͡ʃʰiŋ]	'tightly'

In addition, Affrication does not apply in compounds either. When the two nouns, /patʰ/ 'field' and /ilaŋ/ 'ridge' form a sub-compound structure, [patʰ [ilaŋ]$_N$]$_N$ 'ridge of a field', the compound surfaces as [pan.ni.laŋ], not as [pa.tsʰi.laŋ].[4]

Note that Affrication does not apply when the root-final stops /t, tʰ/ are followed by non-high or non-front vowels, as shown in (4).

(4)

/tot+a/	→	[to.da]	*[to.d͡ʒa]	'to rise+ind.'
/kut+ə/	→	[ku.də]	*[ku.d͡ʒə]	'to harden+ind.'
/putʰ+ə/	→	[pu.tʰə]	*[pu.t͡ʃʰə]	'to attach+ind.'
/putʰ+imjən/	→	[pu.tʰi.mjən]	*[pu.t͡ʃʰi.mjən]	'to attach+if'
/katʰ+ɛ/	→	[ka.tʰɛ]	*[ka.t͡ʃʰɛ]	'to be the same+ind.'
/katʰ+u/	→	[ka.tʰu]	*[ka.t͡ʃʰu]	'to be the same+ques.'
/path+esə/	→	[pa.tʰesə]	*[pa.t͡ʃʰe.sə]	'in a field'

On the basis of the above data, we can say that Korean Affrication is a lexical rule according to the definition proposed by Kiparsky (1985): it is sensitive to morphological structure, such as the difference between derived and non-derived environment, as already shown in (1), (3) and (4), and inflectional suffixes as in (2).

Given that there are underlying affricates and that affricates can be derived by virtue of Korean Affrication, the question can arise of whether the derived affricates are completely neutralized or not in phonetics. In order to pursue this question, I make phonetic experiments of the change of the stop /t/ into its counterpart affricate in Korean Affrication in Section 2 and compare the phonetic results with the data of the

4) In the compound structure, the language-particular rule of /n/-insertion applies when the second member of a compound begins with /i/ or /j/, and the stem-final consonant of the first compound member assimilates in nasality to the following inserted nasal /n/ after its neutralization.

underlying affricate.

2. Experiments

In this section I show that the derived plain affricate in Korean Affrication is completely neutralized both articulatorily and acoustically into its underlying affricate.

2.1 Experiment 1: Articulatory Data

As articulatory evidence that the derived affricate in /t+i/ by virtue of Affrication is completely merged with the underlying segment /t͡s/ in articulatory terms, we can compare our palatograms and linguograms of the following words.

(5)

a.	/mat+i/	→	[ma.d͡zi]	'first child'
b.	/pat͡si/	→	[pa.d͡zi]	'pants'
c.	/mat͡s+i/	→	[ma.d͡zi]	'welcome'
d.	/mati/	→	[ma.di]	'knot'

Four native speakers from South Korea -- two male and two female, including myself -- took part in the experiment. They were all students in Paris, in their 20's or 30's. One male subject (M1) was from Taeku, Northern Kyŏngsang. The other male subject (M2) was from Taecŏn, Northern Ch'ungch'ŏng, the middle province of South Korea. One female subject (F1) was myself from Seoul, the capital of Korea and the other female (F2) was from Pusan, Southern Kyŏngsang. The three subjects M1, M2 and F2 had been in Paris for about three years, and speaker F1 for one year when the experiment was done.

I employed direct palatography and linguography in which no false palate is used.[5] To get palatograms, I painted the upper surface of each subject's tongue from the tip to the center with a black paste made of vegetable oil, black vegetable charcoal powder and an equal amount of chocolate powder for taste. Then the subject was asked to say a word as naturally as possible, thinking of its meaning. The tongue's contact with the roof of the mouth during the articulation of the targeted consonant leaves a black mark. I then put a mirror in the subject's mouth and photographed the roof of the mouth using color film for three subjects and black and white for the other.

With respect to linguograms, I painted the roof of the mouth of each subject from the upper teeth to the soft palate with the same mixture used for the palatography.

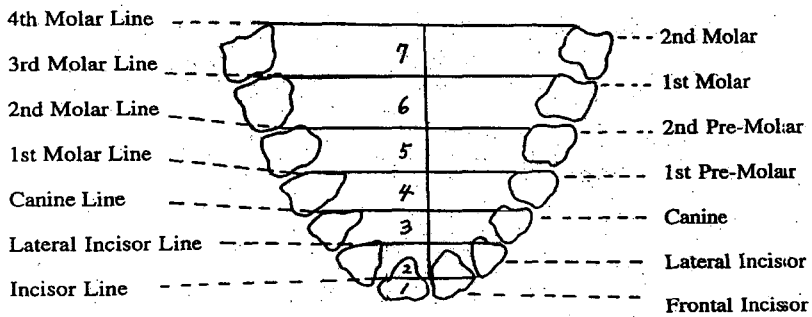
---

5) The experiment using palatograms and linguograms was done under the guidance of Professor Nick Clements, with technical help from the engineer Bernard Gautheron at the Institute of Phonetics, ILPGA, University of Paris III.

After the subject read a target word as naturally as possible, as in the palatogram experiment, he/she was asked to stick out his/her tongue as far as possible so that we could photograph the whole of the upper surface of the tongue.

Figure 1 presents a dentition plan (a) and articulatory subdivisions on the palatal surface (b), both taken from Firth (1948) for the discussion of palatograms in this study.[6]

a. The dentition plan



b. articulatory subdivisions on the palatal surface

horizontal lines	zones
1. Incisor line	dental
2. Lateral incisor line	dentalveolar
3. Canine line	alveolar
4. First Molar line	palato-alveolar
5. Second Molar line	alveolo-palatal
6. Third Molar line	mid-palatal
7. Fourth Molar line	post-palatal

Figure 1. The dentition plan with articulatory subdivisions on the palatal surface (Firth, 1948)

I will use the terms--dental, denti-alveolar, alveolar, palato-alveolar, and alveolo-palatal--exactly as in Figure 1 (b). But for sounds whose tongue contact or constriction lies somewhere behind the second molar line, I will use the term "palatal" instead of the terms mid-palatal and post-palatal in Figure 1 (b).

With respect to the anatomical distinctions of the active articulators forming the

6) The terms palato-alveolar and alveolo-palatal replace the terms post-alveolar and pre-palatal employed by Firth (1948), respectively.

With respect to the anatomical distinctions of the active articulators forming the lower surface of the vocal tract, I refer to Catford (1977:143), according to whom the upper surface of the tongue is divided into five parts: (a) the rim; (b) the tip (or apex), the central point of the forward edge of the tongue; (c) the blade (lamina) running back about 1 to 1.5 cm behind the tip, lying opposite the teeth and the alveolar ridge when the tongue is at rest; (d) the dorsum divided into the antero-(that is, front) dorsum and the postero-(that is, back) dorsum; and (e) the root (radix), the last third of the back part, as shown in Figure 2 (a). Figure 2 (b) represents the lower articulatory zones with the prefixal terms used to designate them.

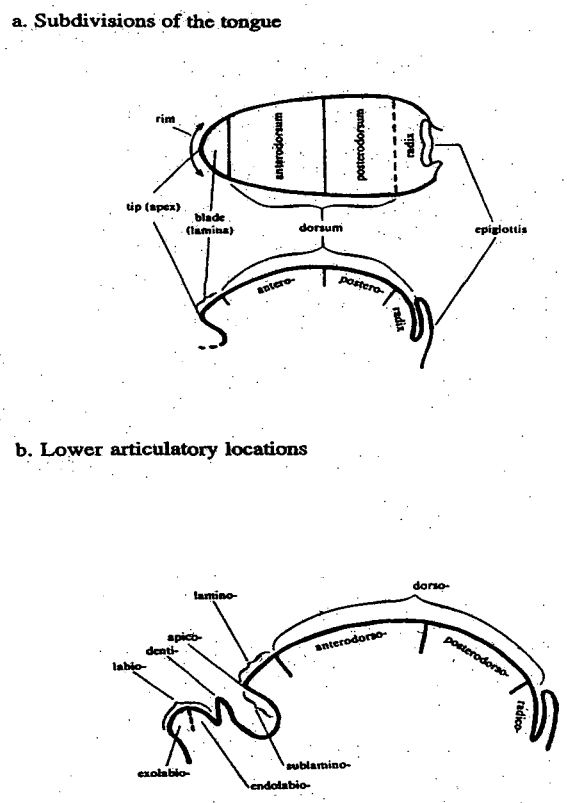


Figure 2. Subdivisions of the tongue and lower articulatory location (Catford, 1977)

Figure 3 presents the palatograms and linguograms of /t/ in the word /mat+i/ 'first child' in (5a) from the four subjects --two male and two female. The palatograms and linguograms of the underlying affricate /t͡s/ in /pat͡si/ 'pants' (5b) and /mat͡s+i/ 'welcome' (5c) are in Figure 4. Figure 5 presents the palatograms and linguograms of the stop /t/ in /mati/ 'knot' (5d).

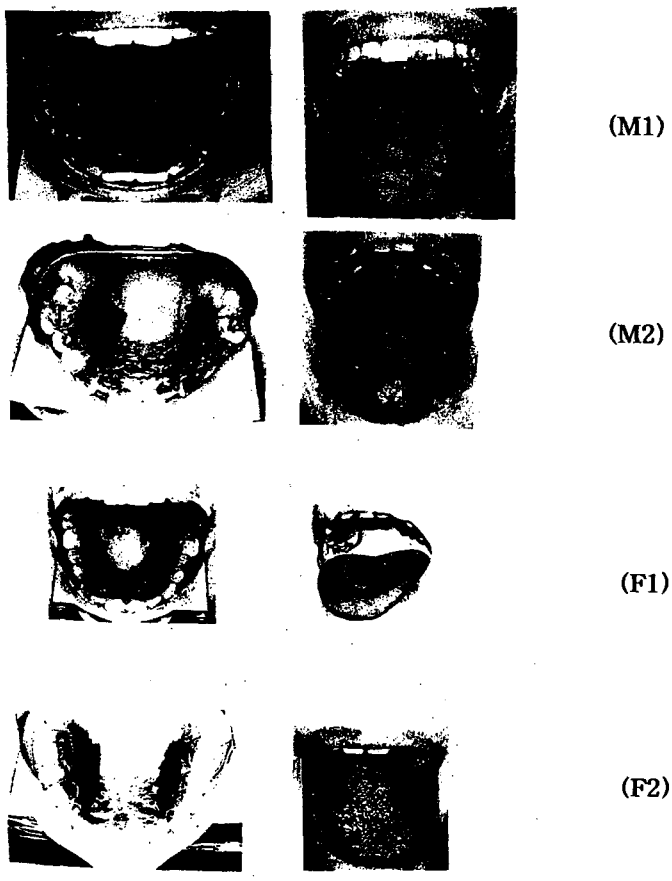


Figure 3. Palatograms and Linguograms of /t/ in /mat+i/ 'first child'

When we compare palatograms and linguograms in Figure 3 to Figures 4 and 5, we see that the palatograms and linguograms of the stop /t/ in /mat+i/ 'first child' are similar to those of the underlying affricate /t͡s/ in /pat͡si/ 'pants' and in /mat͡s+i/ 'welcome' in Figure 4. The palatograms in Figure 3 demonstrate that the central oral occlusions (incomplete in subjects M1 and F2) occur from behind the frontal incisors up to the canines, where the zone is alveolar. In the linguograms of the same target consonant, we can see that the central contact of the oral occlusion is made with the blade, not involving the tip of the tongue among any of our four subjects. The palatograms and the linguograms in Figures 3 and 4 do not show any consistent differences: (a) in the palatograms, subjects M2 and F1 had complete oral occlusions, and subjects M1 and F2 had incomplete oral constrictions from behind the frontal incisors up to the canines, where the zone is alveolar; (b) in the linguograms, the

subject F1 had the central contact of the oral occlusion made with the blade, not involving the tip of the tongue, with subjects M1 and F2 having slight oral constriction by the same articulator.

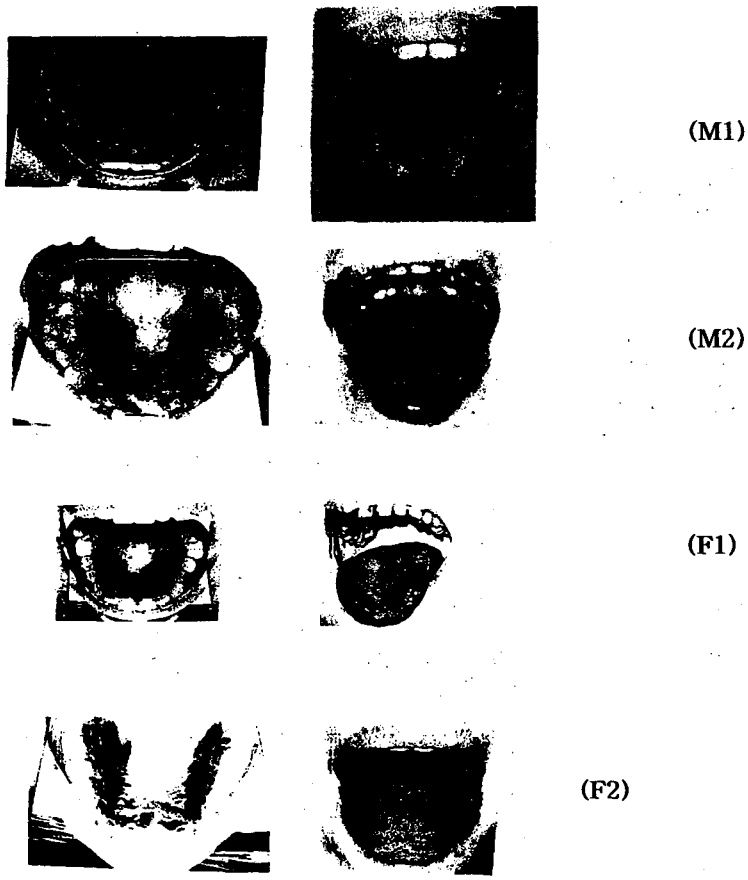


Figure 4 (a). Palatograms and Linguograms of /ts/ in /patsi/ 'pants'

On the other hand, when we compare palatograms and linguograms in Figure 3 to Figure 5, we see that the palatograms and linguograms of the simple stop /t/ in /mat+i/ 'first child' are not similar to those of the simple stop /t/ in /mati/ 'knot'. The palatograms of the stop /t/ in Figure 5 show a complete central contact in the denti-alveolar zone ranging from the base of the upper teeth to the lateral incisors. The linguograms in Figure 5 show that the stop /t/ in /mati/ has a central contact with the tip and also with the blade.

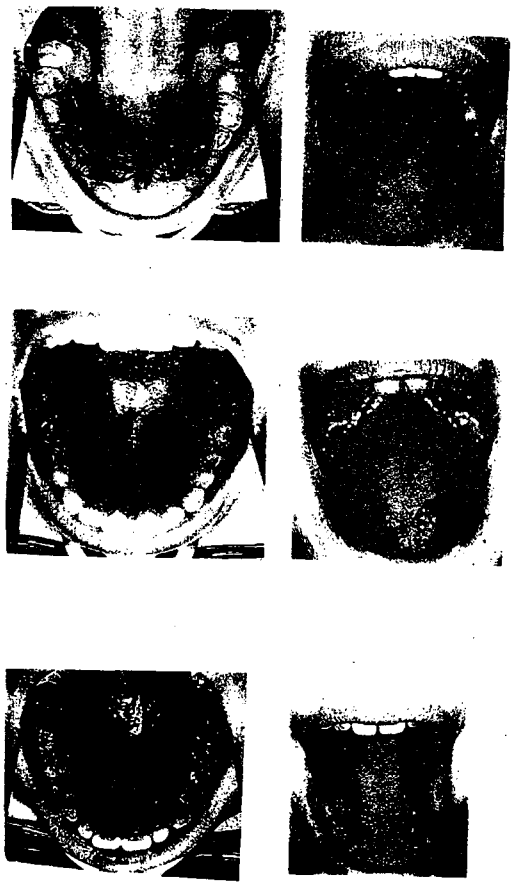


Figure 4 (b). Palatograms and Linguograms of /ts/ in /mats+i/ 'welcome'

In short, the place of the central occlusion is the same, and the same articulation is involved in realizing the stop /t/ in the context __+*i* in Figure 3 and in the underlying affricate /ts/ in Figure 4. As a result, the articulatory data shows that the stop consonant /t/ in the context __+*i* is completely merged with the underlying affricate /ts/ in phonetics.

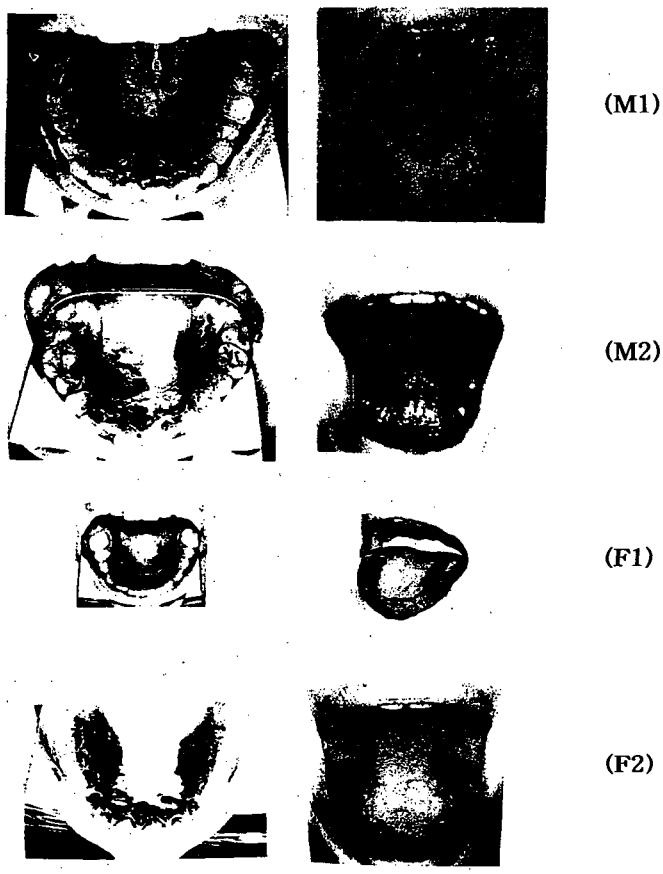


Figure 5. Figure 4 (b). Palatograms and Linguograms of /t/ in /mati/ 'knot'

2.2 Experiment 2: Acoustic Data

An acoustic analysis of wide-band spectrograms also provides evidence that the derived plain affricate in the sequence /t+i/ is neutralized into the underlying affricate /ts/. Relevant evidence comes from closure and frication durations.

The target words in (5) were embedded in the frame sentence /əsə____ haseyo/ 'Say____ please.' On a page, sentences with the target words were randomized with two filler sentences on the top and the bottom to reduce any bias in pronunciation. The four native speakers who participated in the articulatory experiment with palatograms and linguograms also took part in this experiment. Each subject familiarized him/herself with test words by reading them a few times before recording and was asked to read them as naturally as possible during recording. They were then asked to read the sentences five times at normal speed, and were tape-recorded in a sound-treated room at the Institute of Phonetics, ILPGA, University of Paris III.

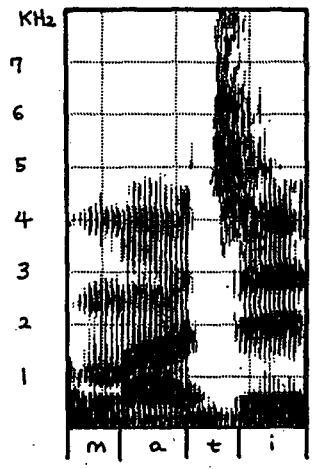


Figure 6. The wide-band spectrogram of the stop /t/ in /mat+i/ 'first child'

As closure/frication durational evidence, we can compare wide-band spectrograms of the stop /t/ followed by the nominal marker /i/ in /mat+i/ 'first child' with those of the simple stop /t/ in /mati/ and the affricate /t͡s/ in /mat͡s+i/ 'welcome' and /pat͡si/ 'pants'. The wide-band spectrogram given in Figure 6 is representative of the five repetitions done by our male subject M1. As for the other three wide-band spectrograms of /mati/ 'knot', /mats+i/ 'welcome' and /patsi/ 'pants', we refer to Figure 7 (a), (b) and (c), respectively.

The underlying stop /t/ in /mat+i/ 'first child' is acoustically manifested as the sequence of an oral closure phase plus a frication phase, instead of just an oral closure followed by a brief release as in /mati/ 'knot' in Figure 7 (a).

Table 1 below shows the averages of the five repetitions, speaker by speaker, for all four test words.

Table 1. The averages of closure and frication duration of the five repetitions of the test words (cl: closure duration; fr: frication duration)

	/t/ in /mat+i/	/t͡s/ in /mat͡s+i/	/t͡s/ in /pat͡si/	/t/ in /mati/
M1	cl: 32 ms	32 ms	37 ms	59 ms
	fr: 46 ms	44 ms	40 ms	8 ms
M2	cl: 46 ms	50 ms	42 ms	53 ms
	fr: 39 ms	58 ms	60 ms	31 ms
F1	cl: 52 ms	55 ms	49 ms	69 ms
	fr: 48 ms	43 ms	57 ms	13 ms
F2	cl: 52 ms	49 ms	45 ms	97 ms
	fr: 65 ms	61 ms	64 ms	19 ms

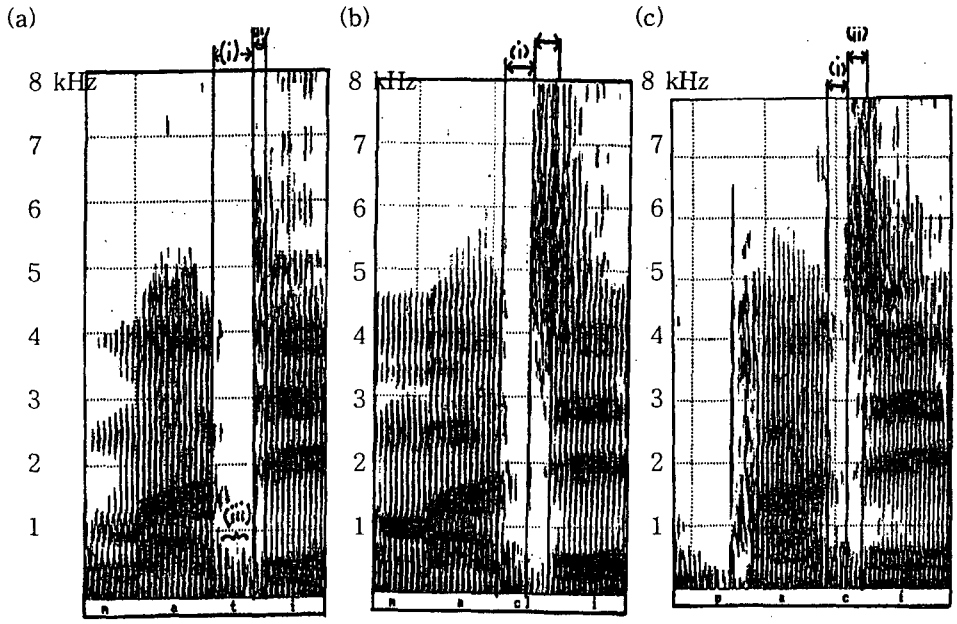


Figure 7. The wide-band spectrogram of the stop /t/ in /mati/ 'knot' (a), /mat͡s+i/ 'welcome' (b) and /pat͡si/ 'pants' (c)

When we compare the pooled closure/frication duration of the targeted affricates in the three words /mat+i/ 'first child', /mat͡s+i/ 'welcome' and /pat͡si/ 'pants' spoken by our four subjects in five repetitions, a t-test shows that differences in the closure and frication durations among the targeted consonants are not statistically significant across our subjects, as illustrated in Table 2.

On the other hand, a t-test shows that the closure and the frication durations of the targeted coronal consonants in /mat+i/ 'first child' and /mati/ 'knot' are significantly different, as presented in Table 3.

Table 2. T-test of closure and frication duration in

a. /mat+i/ vs. /mat͡s+i/	
closure duration	frication duration
t(19)= -.3; p = .7825	t(19)= -.7; p = .4878
b. /mat+i/ vs. /pat͡si/	
closure duration	frication duration
t(19)= 1.2; p = .251	t(19)= -1.5; p = .141

Table 3. T-test of closure and frication duration in /mat+i/ vs. /mati/

closure duration	frication duration
t(19)= -6.4; p = .0001	t(19)= 7; p = .001

In sum, the underlying stop /t/ in /mat+i/ 'first child' is acoustically manifested just like the underlying affricate /t͡s/, not like the stop /t/. Thus, both the above articulatory and acoustic data shows that the stop /t/ preceding /i/ across a morpheme boundary, as in /mat+i/ 'first child', is completely neutralized with the underlying affricate /t͡s/, as found in /mat͡s+i/ 'welcome' and /pat͡si/ 'pants'.

3. Discussion

So far I have shown that the derived plain affricate in Korean Affrication is completely neutralized into the underlying plain affricate in both articulatory and acoustic respects.

The complete neutralization of the derived affricate into the underlying one indicates that the underlying stop /t/ is affricated before the vowel /i/ across a morpheme boundary before getting into the phonetics. Therefore this leads us to say that Korean Affrication is a process occurring not in phonetics but in a more abstract level called phonology, and that it is a phonological rule which is categorical, not gradient.

In addition, the complete neutralization of the stop /t/ into its counterpart affricate is of interest in that it is another case of the neutralization of manner of articulation in Korean. While in the literature most studies of neutralization have focused on word-final devoicing, Kim and Jongman (1996) have provided acoustic and perceptual data of the complete neutralization of manner of articulation in Korean neutralization wherein the fricatives /s, s'/ are neutralized into [t] in coda position.[7)] The present study of complete neutralization of manner of articulation in Korean Affrication provides another perhaps rare instance of the standard view of neutralization.

4. Conclusion

In this paper I have examined the change of the stop /t/ into the plain affricate before the high front vowel /i/ across a morpheme boundary in Korean both articulatorily and acoustically, and compared the phonetic data with that of the underlying plain affricate. The present phonetic study has shown that the underlying stop /t/ is completely neutralized into the underlying plain affriate /ts/ when followed

7) See Kim and Jongman (1996) for the review of the literature on neutralization.

by the vowel /i/ across a morpheme boundary.

REFERENCES

Ahn, S.-C. 1985. *The Interplay of Phonology and Morphology in Korean.* Ph.D dissertation, University of Illinois, Urbana, Illinois.

Catford, J. C. 1977. *Fundamental Problems in Phonetics. Bloomington,* Indiana University Press.

Firth, J. R. 1948. "Word-palatograms and Articulation (BSOAS 1948)." in reprinted in *Papers in Linguistics 1934-1951.* 148-155. Oxford 1957.

Huh, W. 1964. "Chiumko (the study of Korean dentals)." *Kukomukmunhak 27.*

Huh, W. 1985. *Kuko Umunhak (Korean Phonology).* Seoul: Saem Munhwasa.

Kim, C.-W., and S.-C. Ahn. 1983. "Palatalization in Korean Revisited." Paper presented at the 58th Annual Meeting of the Linguistic Society of America, Minneapolis, MN.

Kim, H. 1997. *The Phonological Representation of Affricates: Evidence from Korean and other languages.* Ph.D dissertation,, Cornell University, Ithaca, N.Y.

Kim, H. and A. Jongman. 1996. "Acoustic and perceptual evidence for complete neutralization of manner of articulation in Korean." *Journal of Phonetics 24,* 295-312.

Kiparsky, P. 1985. "Some consequences of lexical phonology." *Phonology 2,* 85-138.

Lee, K.-M. 1972. *Kukoumunsa Yomku (the historical study of Korean Phonology).* Seoul: Tower Press.

Received : Feb. 25, 1999

▲ English Department
Sogang University
1 Shinsu-dong, Mapo-ku
Seoul, Korea
Tel: (02) 705- 8550 (O), (0344) 907-2718 (H)
email: hskim78@unitel.co.kr