On Tensity of Korean Fricatives (Electropalatographic Study)

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ABSTRACT

An Electropalatographic (EPG) study was conducted to investigate the articulatory characteristics which determine the distinction between the Korean lax fricative [s] and tense fricative [s']. This study also intended to test if an increase in the degree of tensity (lax fricative [s] < tense fricative [s']) induces a decrease in coarticulatory vocalic effects. The results indicated that the increase in the tensity of Korean fricatives is closely related to the increase in the narrowness of the groove width (wider contact at the place of articulation), the forward shifting in the place of articulation, and the longer duration of the constriction (longer maintenance in the manner of articulation). It was also found that coarticulatory vocalic effects on Korean fricatives are affected by Recasens' two rules of constraint (1983) : spatial and temporal constraints.

Keywords : EPG, tensity, fricatives, coarticulation

1. Introduction

During speech production, the movement of the lips and the lowering of the jaw are visually observable. It is difficult, however, to investigate most movements of the tongue. To investigate and demonstrate these activities, specially designed tools are needed. EPG is one of the tools that provide information on the degree, position, and extent of the lingual-palatal contact made during speech production.

In an EPG study on the tensity of Korean stops by Baik (1997), it was suggested that the increase in tensity of Korean stops is closely related to the spatial increase (contact width) and the temporal increase (duration of complete closure), and that coarticulatory vocalic effects on Korean stops vary inversely

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with the degree of contact width and duration of complete closure.

The aim of this study was to define articulatory characteristics which determine the articulatory distinction between the lax fricative [s] and the tense fricative [s'] in reference to space and time, and to test the hypothesis that coarticulatory vocalic effects on Korean fricatives vary inversely with the degree of spatial and temporal increase. Unlike Korean stops which have three categories (lax, aspirated, and tense) based upon their tensity, Korean fricatives have only two categories (lax and tense).

2. Instrumentation

To accomplish the aim of this study, Kay's Palatometer 6300 (PAL 6300), which utilizes EPG, was selected. PAL 6300 is a computer-assisted system, possessing a custom made artificial palate which has a much denser placement of contact sensors than other models. The 96 sensors of the artificial palate detect tongue contact, and the PAL 6300 converts the tongue contact, in real-time, to a graphic, dynamic image of lingual-palatal contact. The PAL 6300 can also record and print this information for further analysis.

3. Experimental Method for Articulatory Distinction

As a native speaker of standard Korean, the author acted as the informant for this study. His father and mother are from Kyungki Province and Seoul, and both speak the same standard dialect of Korean as the author.

The selected EPG data indicate that tongue movement occurs only in the production of the target consonants [s s']. This eliminates the coarticulatory effects from the articulation of [s s']. Specifically, [s s'] are produced in words with bilabials and the open vowel [a]. For example, the selected EPG data for [s s'] are [sam] 'life' and [s'am] 'stuffed leaves'. Using an artificial palate, he recorded the EPG data ten times in a fairly coarticulation-free context, "kɨ saram _____ paraponta", 'the man is watching _____.' Among ten recordings for each EPG datum, only three were selected based on the evenness of their tempo and whether or not the palatograms of the [s s'] consonants at a point of maximum contact (PMC) were consistent and accurate.

4 Results of Articulatory Distinction

In comparing the palatograms of the lax and tense fricatives, the differences fell under the following areas: 1) groove width (spatial measurement), 2) location for groove width (spatial measurement), and 3) duration of constriction (temporal measurement). The two spatial measurements were expressed in millimeters and a temporal measurement, with number of frames. Subsequently, the average is represented in Tables 1 - 3.

Groove Width

The groove width represented in Figure 1 is defined as the narrowest and most posterior passageway distance. Fricatives involve a narrow groove through which air is forced. Various phonetic studies by researchers such as Baik (1995), Fletcher (1989, 1992), Fletcher & Newman (1991), Michi, Yamashida, Imai, Suzuki & Yoshida (1993) have suggested that the size and location of the groove are significant.

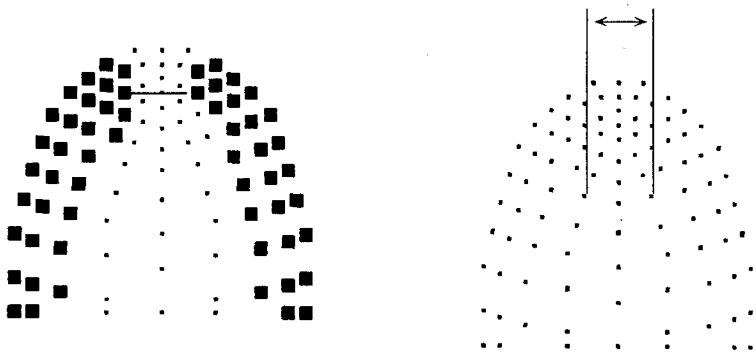

Figure 1. Groove Width

Table 1. Average of Groove Width

Narrow	s'	(4.0)
Wide	s	(12.0)

As can be seen from Table 1, the increase in the tensity of Korean fricatives necessitates the increase in the narrowness of groove width. As for Korean stops, this implies that if the tensity of Korean fricatives is increased, the number of on-electrodes at the place of articulation is also increased. In other words, the increase in the tensity of Korean fricatives requires spatial increase at the place of articulation; that is, the tenser the consonant, the wider the contact at the place of articulation.

Location for Groove Width

The location for the groove width, as represented in Figure 2, is defined as the distance from a horizontal line running through the farthest front electrode on the center line, to a horizontal line running through the groove width. Thus, the location for the groove width is the distance to the place of articulation for the target fricative consonant.

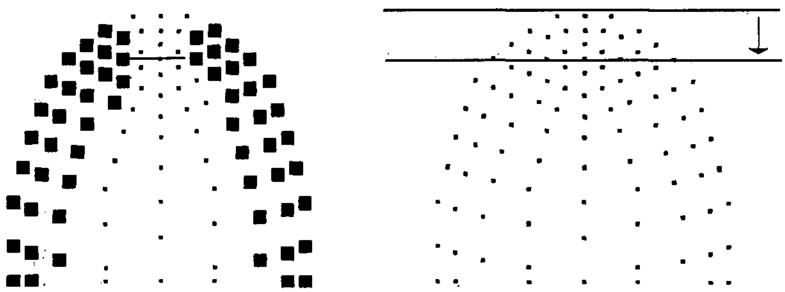

Figure 2. Location for Groove Width

Table 2. Average of Location for Groove Width

Front	s'	(6.0)
Back	s	(7.0)

As can be seen from Table 2, [s'] is articulated slightly more frontal than [s]. In other words, the place of articulation for [s] is moved to a farther frontal position with the increase of its tensity.

Duration of Constriction

The duration of the constriction can be described as the number of grooved palatograms indicated, where the domain of their groove widths is positioned inside the constriction passageway point shown in Figure 3. Figure 4 shows ten grooved palatograms represented in frames 0.90 - 0.99, whereby the temporal increment between the contiguous palatograms is 10 msec.

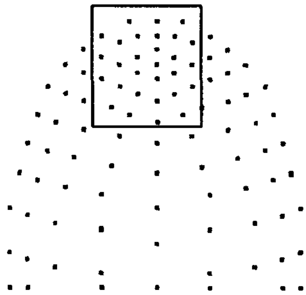

Figure 3. Constriction Passageway Point

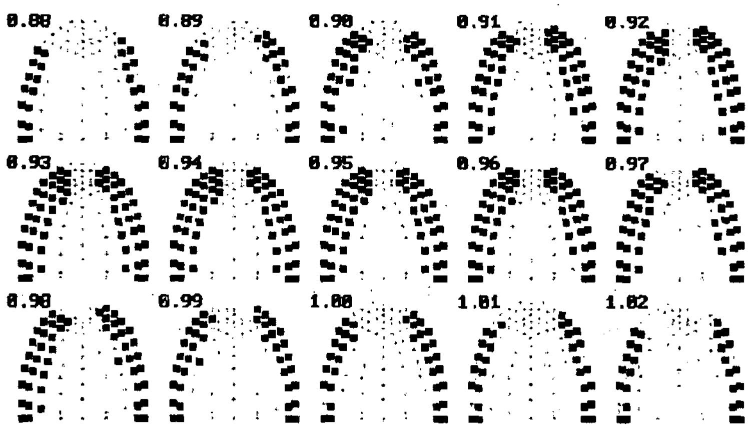

Figure 4. Duration of Constriction

Table 3. Average of Duration of Constriction

Short	ṣ	(10.0)
Long	s'	(15.7)

As can be seen from Table 3, the two fricatives are distinguished from each other by the duration of the constriction. On average, [s'] has a longer duration of the constriction than [s]. An examination of the relationship between tensity and the duration of the constriction suggests that the increase in the tensity of Korean fricatives, such as Korean stops, requires longer maintenance in the manner of articulation.

5. Experimental Method for Coarticulation

The spatial and temporal measurements of [s s'] at the PMC in a neutral environment can be understood as idealized positions and extents of [s s'] which the speaker tries to attain while speaking. In most cases however, these idealized positions and extents are not realizable outside of the neutral environment, from which breaking away causes spatial and temporal displacements.

In order to represent the spatial and temporal displacements of [s s'] in coarticulatory vocalic environments, three Korean vowels [i a u] were arranged symmetrically for [s s']. For example, the EPG data for coarticulation were [isi], [is'i], [asa], [as'a], [usu], and [us'u]. Procedures were repeated that were similar to those followed for the spatial and temporal measurements of [s s'] in the neutral environment. The spatial and temporal measurements of [s s'] in the neutral environment were compared with those in the [i a u] environments.

6. Results of Coarticulation (1)

The numeric comparisons, represented in Tables 4~6, provide the spatial and temporal displacements of [s s'] caused by the secession from the neutral environment. In Tables 4~6, [s] and [s'] represent [s s'] in the neutral environment, and the symbol (-) or (+) indicates that the averages of the spatial and temporal measurements of [s s'] in the [i a u] environments are below (-) or above (+) the averages of the spatial and temporal measurements of [s s'] in the neutral environment.

Table 4 : Comparison of Groove Width

Order	: [s]	=	[asa]	=	[isi]	>	[usu]
Average	: 12.0		12.0		12.0		11.0
Difference	: 0.0		0.0		0.0		-1.0

Order	: [s']	=	[as'a]	=	[is'i]	=	[us'u]
Average	: 4.0		4.0		4.0		4.0
Difference	: 0.0		0.0		0.0		0.0

Table 5 : Comparison of Location for Groove Width

Order	: [isi] >	[s] =	[usu] =	[asa]
Average	: 11.0	6.0	6.0	6.0
Difference	: +5.0	0.0	0.0	0.0

Order	: [s'] =	[as'a] =	[is'i] >	[us'u]
Average	: 7.0	7.0	7.0	6.8
Difference	: 0.0	0.0	0.0	-0.2

Table 6 : Comparison of Duration of Fricative Groove

Order	: [isi] >	[usu] >	[s] >	[asa]
Average	: 24.0	12.0	10.0	7.7
Difference	: +14.0	+2.0	0.0	-2.3

Order	: [is'i] >	[us'u] >	[s'] >	[as'a]
Average	: 28.7	16.3	15.7	13.3
Difference	: +13.0	+0.6	0.0	-2.4

The difference in the spatial and temporal measurements between [s s'] in the neutral environment and [s s'] in the [i a u] environments implies that the increase in the degree of tensity induces the decrease in coarticulatory vocalic effects. Moreover, it suggests that the coarticulatory vocalic effects on [s s'] in the [i] environment are fairly great, while the coarticulatory vocalic effects on [s s'] in the [a u] environments are not detected or are very minimal.

There are discrepancies among the analyses of the spatial and temporal measurements of [s] in the [i] environment. For example, the tensity of [s] in [isi] is far weaker than the tensity of [s] in the neutral environment according to the analysis of the location for the groove width ([s] 6.0 < [isi] 11.0). On the other hand, the tensity of [s] in [isi] is stronger than the tensity of [s] in the neutral environment according to the analysis of the duration of the constriction ([s] 10.0 < [isi] 14.0). The discrepancies can be understood as the [s] being palatalized in [isi], so that [s] in [isi] is articulated quite differently.

The fact that the [s'] in [is'i] does not undergo palatalization indicates that the coarticulatory vocalic effects on Korean fricatives vary inversely with the degree of spatial and temporal increase. The palatalization occurring on only [s] in the [i] environment is supported by the palatographic comparisons shown in Figures 5~6.

7. Results of Coarticulation (2)

In order to show the coarticulatory vocalic effects on [s s'] using palatograms, the frequency and place of the on-electrodes for [s s'] in the [i a u] environments are represented in Figures 5 - 6 based on Gibbon's method (1991) : ● indicates three time on-electrodes, ▨ indicates two time on-electrodes, ⊘ indicates one time on-electrodes, and ⊙ indicates zero time on-electrodes. These palatograms have boundaries drawn by linking the on-electrodes presenting at least two time on-electrodes.

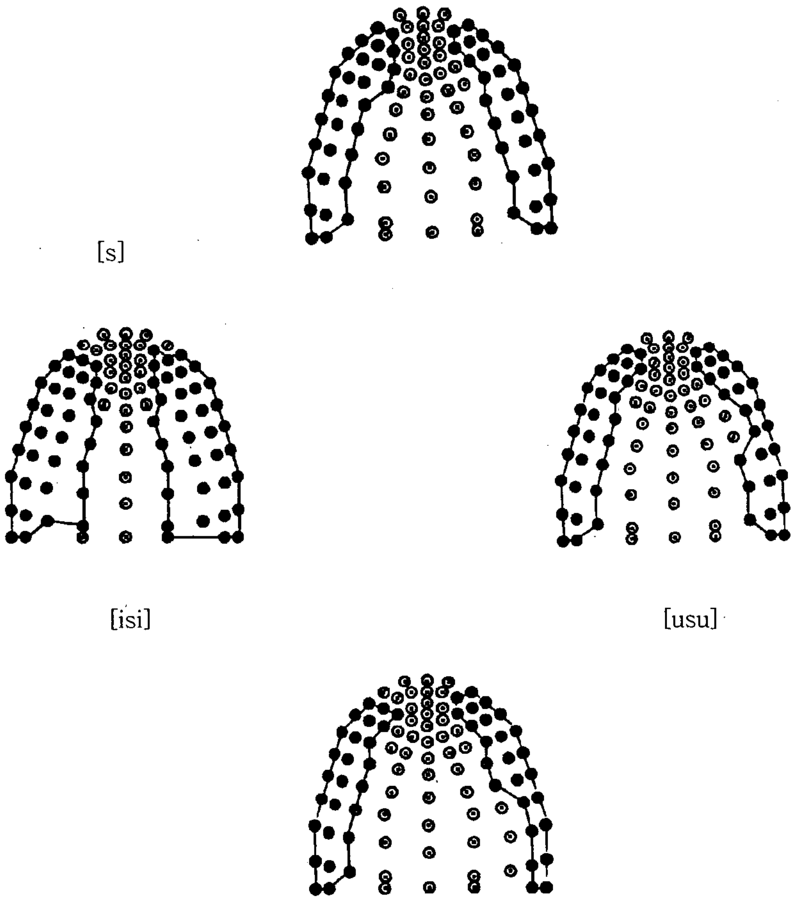

Figure 5. Palatographic comparison between [s] in a neutral environment and [s] in coarticulatory vocalic environments

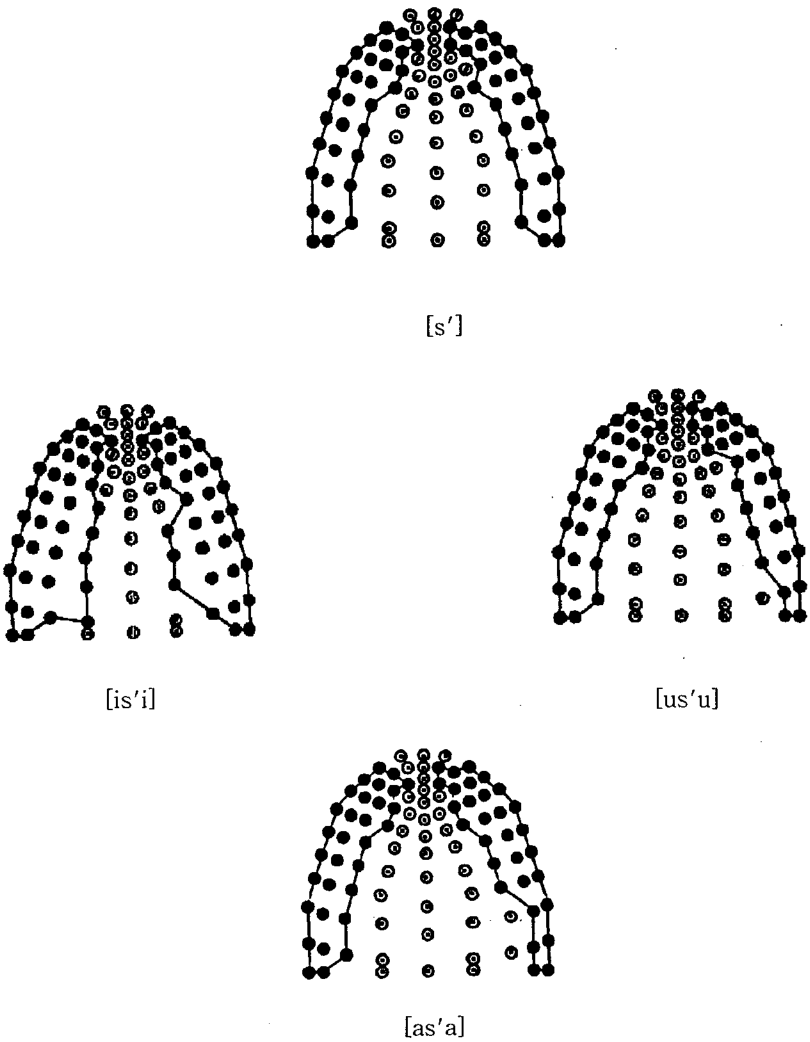

Figure 6. Palatographic comparison between [s'] in a neutral environment and [s'] in coarticulatory vocalic environments

Coarticulatory vocalic effects on [s s'] are found in the opening size of the palatal passage. For example, the opening size of the palatal passage for [s s'] in the [i] environment is much smaller than the corresponding size for [s s'] in the [a u] environments. On the other hand, the opening size of the palatal passage for [s s'] in the [a] environment is almost equal to the corresponding one in the [u] environment. Therefore, the degree of coarticulatory vocalic effects on [s s'] in the opening size of the palatal passage is [i] > [a] = [u].

8. Conclusion

The results of articulatory distinction indicate that the tensity of Korean fricatives is closely related to the spatial and temporal dimensions. More precisely, if the tensity of fricatives is increased, their groove width is narrowed and the duration of the constriction is increased. Also, the increase in the narrowness of the groove width tends to accompany the forward shifting in the place of articulation. It appears, therefore, that the articulatory characteristics of the increase in tensity of Korean fricatives, as suggested in the EPG analysis of Korean stops, can be summarized as the wider contact at the place of articulation and the longer maintenance in the manner of articulation.

In addition, the examination of the relationship between tensity and the coarticulatory vocalic effects on Korean fricatives reveals the implication that the increase in tensity induces the decrease in coarticulatory vocalic effects. Therefore, the discussion on the articulatory mechanisms involved between the tensity and coarticulatory vocalic effects leads to the conclusion that the coarticulatory vocalic effects on the articulation of Korean fricatives are the result of the co-occurrence of environment-independent and environment-dependent articulatory mechanisms.

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