The Force of Articulation for Three Different Types of Korean Stop Consonants

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ABSTRACT

The force of articulation is different between voiced and voiceless consonants in the binary opposition system. However, the Korean voiceless stop consonants have a triple opposition system: lenis, aspirated, and glottalized. The aim of this study is to find the primary distinctive feature between the force of articulation and the aspiration for the three different types of Korean stops. Two native speakers of the Seoul dialect participated to this study. The corpus was composed of less than eight syllabic words containing consonants in word-initial position and intervocalic position. Radiocinematography and Mingography were used to analyze the articulatory tension and acoustic characteristics. Korean stops have independent features of articulatory tension and aspiration, in which the indices are different according to position. However, in this system which does not have the opposition of sonority, the force of articulation is the primary distinctive feature and the feature of aspiration is subsidiary.

Keywords: The force of articulation, Radiofilm analysis, Mingographic tracing, Distinctive feature

I. Introduction

The force of articulation can be correlated with the total muscle tension during speech. The degree of articulatory tension is referred to in the phonological theories of distinctive features and it has been accepted as the basic opposition between Fortis/Lenis or Tense/Lax.

Many researchers have studied the phonetic phenomena concerning articulatory tension: peripheral vowel space(Stockwell, 1973), contacting zone of palate (Rousselot, 1924), Kinesthetic factor(Malecot, 1955), intraoral air pressure (Troubetzkoy, 1939; Stetson, 1956), Duration(Denes, 1955; Jakobson, Fant and Halle, 1963; Delattre, 1966; Fischer-Jørgesen, 1968), oral closure(Straka, 1963; Simon, 1968), Position of laryn x(Ladefoged, 1974; Watson,

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1983; Köhler, 1984; Maddison, 1985), Pharyngeal width(Perkell, 1968), Redundant feature according to VOT(Lisker and Abramson, 1964) and supraglottal muscle(Chomsky, 1968; Kent & Moll, 1969).

The Korean stop consonants are classified into four groups according to the place of articulation: bilabial, alveodental, palatal, and velar. For the same place of articulation, there are three different types each in the same manner of articulation: lenis, slightly aspirated, fortis, heavily aspirated and fortis, glottalized.

The purpose of this study is to find the first most primary distinctive features for classifying the three different types of stops between aspiration and the tensity, namely, the force of articulation.

II. Methods

Two adult native speakers of the Seoul dialect, one male and one female, participated in this study. The corpus was composed of less than eight syllabic words containing consonants in word-initial position and intervocalic position. For the analysis of articulatory movements, Radiocinematography was used. Radiofilms were taken by means of a 35 mm Arriflex Camera with a frame speed of each frame being 50 images per second. Fig. 1. shows the croquis. Two fixed points were selected: A, the point of the upper incisor; and B, the posterior point of the vomer and palate. These two points were visible in all images. The distance between these two points was measured by a compass and using this distance two arcs were drawn from each point to intersect at point 0. The horizontal line XX′ and vertical line YY′ were drawn through the intersection point 0.

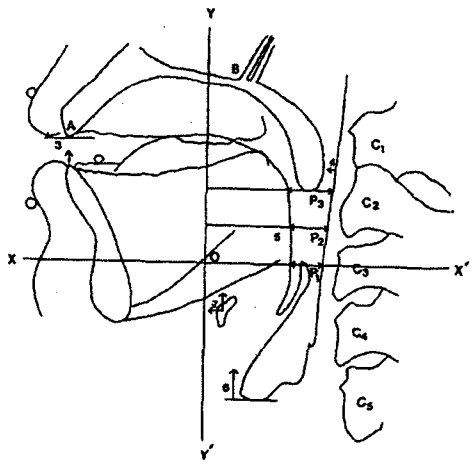


Fig. 1. Measures based on the croquis of the radiofilm.

Measurements of articulatory tension

1. Width of closing contact
2. Degree of closing contact
3. Degree of maxillary opening
4. Width between ridge of tongue and posterior pharyngeal wall at the point of maximum constriction
5. Laryngeal height
7. Position of hyoid-bone

Simultaneously, a four-line Mingography Schlumberger Epi 2c was used. The Mingography simultaneously captured the acoustic signals with three microphones and one oxygen face mask and traced the documents of the wave forms and oral air pressure on four lines with the ink jet Siemens Oscillomink E. Fig 2 shows Lm (the micro larynx), Nm (micro nasal), Bm (micro mouth), and Ba (air pressure of mouth) from top to bottom for the three different types of stop consonants.

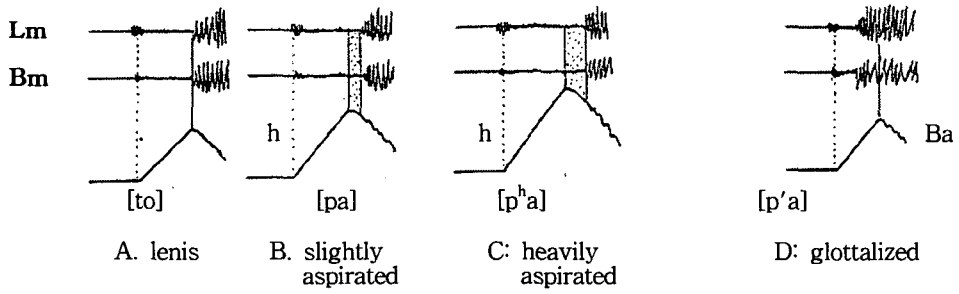


Fig. 2. Acoustic signal of four lines Mingography for the different types of stop consonants.

Measurement parameters of Mingography

1. Expiration duration
2. Aspiration duration
3. Total duration
4. Vowel duration preceding and following stop consonants
5. Height of explosion

III. Results

III.1 Radiofilm analysis

The width of the closing contact with respect to the degree of the maxillary is shown in Table 1. The width of the closing contact was the largest for glottalized stops: 12.2 mm, then, the aspirated stops: 11.5 mm and next the lenis stops: 4.8 mm. The width of the closing contact was related to the articulatory tension of three different types of stops: the glottalized stops were the strongest, the aspiraetd stops were medium next strongest and the lenis were the weakest. The degree of the maxillary opening was almost the same for all three different types of stops. However, the degree of the maxillary opening decreased as the tongue moved toward the back position, except for velar sounds: velar>bilabial>alveodental>palatal.

Table 1. Average values of the width of the closing contact and the degree of the mandible.

	width and degree of the closing contact	degree of maxillary
lenis	4.8 mm	3.0
aspirated	11.5 mm	3.3
glottalized	12.2 mm	3.1

The configuration of the pharyngeal cavity corresponds to the position of the articulatory organs at a given moment. The distance from the root of the tongue to the pharyngeal wall in the oropharynx varied according to the different types of articulation. The three points of measurement were 1 cm apart with the horizontal reference lines P1, P2, and P3 and maximum pharyngeal constriction Pm. Table 2 shows the variation of the distance between the back of the tongue and the pharyngeal wall at three levels.

Table 2. Pharyngeal width from root of the tongue to the pharyngeal wall at the level of P1, P2, P3 and maximum pharyngeal constriction Pm in parentheses. Left side: intra oral stop sounds, right side: extra oral stop sounds.

	P1	P2	P3	Pm
lenis	14.1/15.0 mm	13.1/13.8 mm	12.8/13.0 mm	(12.9 mm)
aspirated	14.1/14.9 mm	13.2/13.4 mm	12.4/12.7 mm	(12.3 mm)
glottalized	14.5/15.1 mm	13.0/13.4 mm	12.6/12.5 mm	(12.0 mm)

The average values of P1, P2 and P3 for the three different types of stops showed only a small differences. However, maximum pharyngeal constriction Pm decreased in the following order: lenis(12.9 mm), aspirated(12.3 mm) and glottalized(12.0 mm).

The hyoid-bone depression occurs together with the depression of the larynx because it is closely linked with the thyroid membrane. The movement of the middle hyoid-bone was measured by its position toward the vertical direction and the horizontal direction at the movement of maximum closing contact of the three different types of stops (Fig. 3). Toward the vertical direction, the middle hyoid-bone moved higher for the lenis and the aspirated than for the glottalized. Toward the horizontal direction, the middle hyoid-bone moved to the posterior with respect to the articulatory tension. The glottalized was located in the extreme posterior position. The lenis was located in the extreme anterior position and the aspirated was located in the middle position between the lenis and the glottalized. The dispersion zone is shown also in relation to the articulatory tesnion. The fortis stops showed a reduction of the dispersion zone; however, the lenis stops showed an extended dispersion zone. The fortis stops which engaged in more articulation energy appeared as the strong muscle constriction within the boundary target position. This means that the fortis articulation asserted itself; however, the lenis articulation could easily be influenced by the contiguous phonemes.

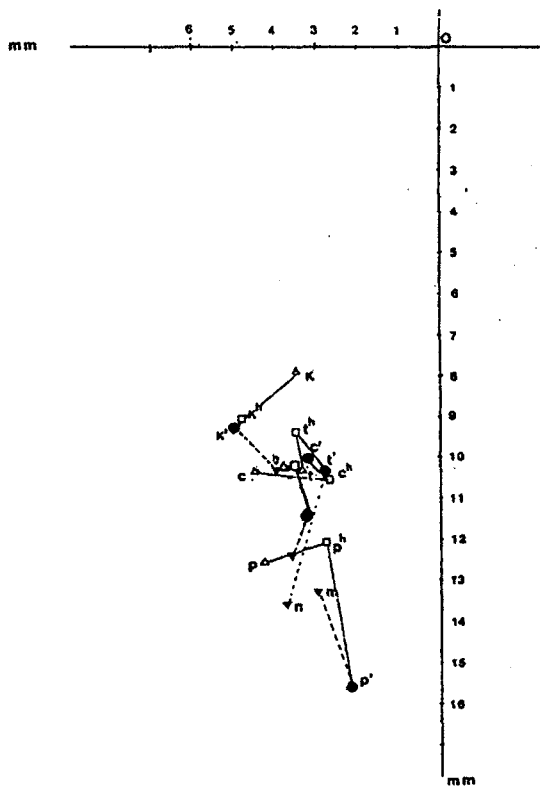


Fig. 3. Position of the hyoid-bone toward the vertical and the horizontal direction for three different types of stop consonants.

The laryngeal height is formed at the lowest part of the central larynx on the level with the 5th vertebra to the 0 point. The average values showed that the position of the larynx for the glottalized stops (37.1 mm) was lower than for the non-glottalized stops (lenis, 36.3 mm; aspirated, 35.0 mm). These results corresponded with Fujimura's explanation about the sharply lowered larynx at the same time as the glottalized adduction. When the voice is initiated, the pitch of glottalized stops is higher than the other two types, which show a higher laryngeal position in the same environment.

III.2 Mingographic analysis

III.2.1 Explosion duration in word initial position (Table 3)

The total duration of explosion was 40 ms for lenis, 64ms for aspirated and 19 ms for the glottalized. The explosion durations between the lenis and the aspirated were almost the same; however, the aspiration duration of aspirated was twice as long as that of the lenis. I hypothesize that the aspiration is relevant when the total duration of explosion exceeds 30 ms. and the aspiration duration varies according to the place of articulation: $p^h > t^h > c^h > k^h$. The vowel duration following the three different types of stops was the shortest before the aspirated: 52 ms, longer before the lenis: 58 ms and longest before the glottalized: 75 ms. The explosion height was remarkably high for the aspirated stops.

Table 3. Average duration and height of explosion for the three different types of stops in word initial position.

	duration(ms)				exp. height (mm)
	explosion	aspiration	total	fw. vowel	
lenis	26	14	40	58	13.9
aspirated	29	35	64	52	34.6
glottalized	19	0	19	75	8.6

III.2.2 The duration of the oral closure in the intervocalic position

Table 4 shows the variation of the consonantal duration (oral closure, explosion, and aspiration) and the vowels' durations with height of explosion for the three different types of stops between all vowels. The duration of oral closure is related to the articulatory tension. The duration of oral closure for the glottalized stop was the longest, then the aspirated stop, and finally the lenis stop was the shortest. The duration of oral closure varied according to the place of articulation. The oral closure of alveodental had the longest duration among the place of articulation.

Vowel duration preceding the aspirated was the shortest, however, vowel duration preceding the lenis was the longest.

Table 4. Average consonant and contiguous vowels duration with height of explosion for three different types of stops in word intervocalic position.

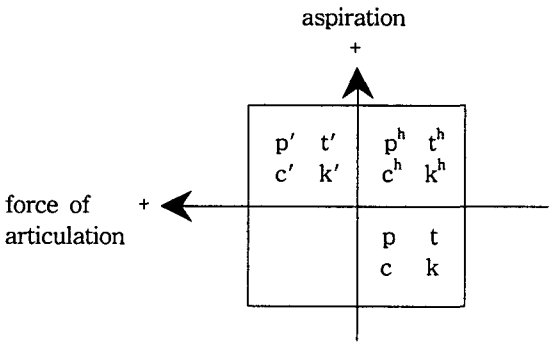
	duration(ms)						exp. height (mm)
	pr.vowel	hold	explosion	aspiration	total	fw vowel	
lenis	73	61(58)	27	0	88(58)	101	10.8
aspirated	49	111	33	9	154	64	26.7
glottalized	57	123	25	0	148	73	10.8

IV. Conclusion

The three different types of Korean stops based on the experiment studied were classified by the degree of articulatory tension and the degree of aspiration for the distinctive features:

(1) voiceless, lenis, slightly aspirated /p, t, c, k/
(2) voiceless, fortis, heavily aspirated /p^h, t^h, c^h. k^h/
(3) voiceless, strong fortis, glottalized /p', t', c', k'/

The functional opposition of the three different types of stops showed the following special articulatory indices:



As a result, Korean stops have independent features of articulatory tension and aspiration, in which the indices are different according to position. However, in this system which does not have the opposition of sonority, the force of articulation is the primary distinctive feature, and the feature of aspiration is subsidiary.

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