

# Laryngeal Features in Korean three-way Phonation Consonants

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For the past forty years it has been at issue how Korean three-way phonation consonants are represented in terms of features. One of the two main proposals is that lax, aspirated and tense consonants are underlyingly singletons, being differentiated by their specification for the laryngeal features [constricted glottis] ([c.g.]) and [spread glottis] ([s.g.]) (e.g., Kim-Renaud 1974, Cho & Inkelas 1992, 1995, Inkelas & Cho 1993), or for the glottal tension-related features [stiff v.c.] and [slack v.c.] as well as [c.g.] and [s.g.] (e.g., Iverson 1987, Ahn 1999). The other is that, in line with Martin (1982), Korean tense consonants are underlyingly geminates, mainly due to the closure duration twice longer than their aspirated and lax counterparts which are assumed to be singletons, in recent literature (e.g., Silva 1992, Han 1992, 1996). In a geminate analysis of tense consonants, it has been proposed that (a) tense consonants are specified for [c.g.] in phonetics, whereas aspirated ones are underlyingly specified for [s.g.] (e.g., Silva 1992, Han 1992, 1996) or that (b) tense consonants are not underlyingly specified for any glottal nodes, aspirated ones are specified for the Glottal Width node (GW) in phonology and the features [c.g.] and [s.g.] are filled in phonetics (Avery & Idsardi 2001).

In this paper we reconsider whether the phonetic properties per se, that is, closure duration, glottal tension and glottal width are necessarily incorporated with the laryngeal features [c.g.] and/or [s.g.] being provided in phonetics, as suggested in recent studies (e.g., Han 1996, Ahn 1999, Avery & Idsardi 2001). For this, we conducted acoustic and articulatory experiments of the lax, tense and aspirated consonants /t, t', t<sup>h</sup>, t<sup>o</sup>s, t<sup>o</sup>s', t<sup>o</sup>s<sup>h</sup>/. And together with the phonetic data, we reexamined phonological processes involving laryngeal properties in Korean.

First, a cine MRI experiment was performed on a Shimadzu SMT-100GUX. Each MRI image for midsagittal and transverse data of our two native speakers' head and neck has a 256 mm x 256 mm field of view with a 10 mm and 5 mm slice thickness, respectively, mapped on to 256(x) x 256(y) pixels. Each trigger pulse signals the MRI controller to begin the field echo scans (TR=25 ms, TE=10 ms, NEX=1) repeated 52 times every 16.7 ms (60 frames/sec) for one of the 128 gradient magnetic field conditions which is maintained for each 1000 ms period and changed at each trigger pulse. During data acquisition, the subjects repeated the six target words /mata, mat<sup>h</sup>a, mat'a, mat<sup>o</sup>sa, mat<sup>o</sup>s<sup>h</sup>a, mat<sup>o</sup>s'a/ 128 times and the obtained images were displayed on a computer screen with 8-bit gray-scale resolution for analysis.

Our MRI data showed that not only glottal tension but also closure duration results from the coordination of the tongue and the larynx. That is, the movements of the tongue and the larynx varied systematically in accordance with the phonation types of the consonants: (a) the movement of the tongue blade varies from low to high in the order of the lax, aspirated and tense ones; (b) linguopalatal contacts of the tongue apex against the back of the upper teeth and the alveolar vary from short to long in the same order; (c) closure duration which is correlated with the total linguopalatal contacts of the target consonants also varies from short to long in the same order; and (d) glottal height which indicates glottal tension varies from low to

high in the same order, too. Our MRI data also showed that there is no one-to-one correlation between the three-way phonation consonants and their glottal properties: glottal width and constriction as well as glottal tension all contribute to the characteristics of the three-series laryngeal consonants, together with the movements of the tongue and the larynx, in the sense of speech motor coordination.

Second, our acoustic and conventional articulatory experiments of the consonants /t, t', t<sup>h</sup>, t<sup>o</sup>s, t<sup>o</sup>s', t<sup>o</sup>s<sup>h</sup>/ in the contexts /a\_\_a, #\_\_a, a\_\_i, #\_\_i/ partly confirmed the results of our MRI data. Acoustic data of ten subjects of the Seoul dialect showed that closure duration varies in accordance with the laryngeal types of the consonants, as in our MRI data: it was the longest for the tense consonants, which followed in order by their corresponding aspirated and lax ones both word-medially and word-initially. In our direct palatograms and linguograms from twenty subjects including the ten subjects participated in the acoustic experiment, we also found that, regardless of where the consonants are placed in word structure, tongue contacts were longest for the tense consonants, which followed in order by their corresponding aspirated and lax ones, across the subjects, as in our MRI data.

Given the phonetic results that glottal tension and width as well as closure duration and tongue contacts of the three-way phonation consonants are attributable to phonetic correlates of the tongue-larynx coordination, we argue that the closure duration of Korean three-way phonation consonants is not a phonetic correlate of the phonological quantity, as in Turkish and Bengali (Lahiri & Hankamer 1988, Hankamer et al 1989), and that neither closure duration nor glottal tension/opening per se can be incorporated in phonology as a distinctive unit. Rather, we claim that we need abstract entities which are neutral from both articulatory and acoustic properties of the three-way phonation consonants, in order to represent the consonants in phonology. This is because three-way phonation consonants in Korean reflects a planned component of speech movement coordination in achieving the same goal, as shown in our MRI data. Consequently, following the views that features are abstract phonological entities (Halle 1983) and that the laryngeal features are abstract phonological entities for tense and aspirated consonants rather than different degrees in glottal opening per se (e.g., Lombardi 1991), we propose that the laryngeal features [c.g.] and [s.g.] are motivated for the distinction of 'singleton' lax, aspirated and tense Korean consonants in phonology.

The reexamination of the three phonological processes --Korean Neutralization (KN), whereby all the laryngeal distinctions are lost in coda position (e.g., /t<sup>o</sup>sip<sup>h</sup>/ -> [t<sup>o</sup>sip] 'straw', /pak'/ -> [pak] 'outside'), Post-Obstruent Tensification (POT), whereby lax obstruents become tense after another obstruent (e.g., /ip+ko/ -> [ip.k'o] 'to put on'+and) and Aspiration, whereby /h/ is merged into a following onset obstruent (e.g., /noh+ta/ -> [no.t<sup>h</sup>a] 'to put'), provides further phonological evidence for the laryngeal features [c.g.] and [s.g.] in 'singleton' tense and aspirated consonants, respectively, as proposed in the present paper.