

The mechanism and representation of the two-way phonation contrast in Korean /s, s'/: ePGG, Pio, airflow and acoustic data

Hyunsoon Kim^a, Shinji Maeda^b, Kiyoshi Honda^c and Lise Crevier-Bushman^d
^a Hongik University; ^b CNRS LTCI; ^c Tianjin University; ^d CNRS-UMR7018

This paper is concerned with the speech mechanism and representation of the two-way phonation contrast in Korean fricatives /s, s'/ based on a new non-invasive technique called external lighting and sensing photoglottograph (ePGG) as well as Pio (intra-oral air pressure), airflow and acoustic data. From the data, the following investigations were made: (a) the relative timing between glottal opening onset and peak; (b) how high the peak of glottal opening occurs; (c) the timing relations between a Pio onset and the beginning of a Pio plateau and between the end of a Pio plateau and a following vowel onset; (d) how long a Pio plateau sustains; (e) how much airflow resistance occurs at the beginning and end of the Pio plateau; (f) what acoustic conditions arise in accordance with the two-way phonation contrast.

All the ePGG, airflow and acoustic data were simultaneously recorded using Dash8x at a soundproof recording room. The adduction-abduction movement of the glottis during the production of the fricatives /s, s'/ in the context /_a_a/ was monitored with light emitting diodes (IR LEDs) placed on the neck exterior surface between the hyoid bone and the thyroid cartilage, as shown in Figure 1. Normally, two IR LEDs are placed on the sides of the larynx to illuminate the hypopharyngeal wall. When a subject has a thick layer of the subcutaneous fatty tissue, the LED light tends to transmit through the fatty layer without sufficient lighting the cavity. In this case, the LED is placed on the midline neck surface to illuminate the base of the epiglottis reducing the light transmission through the fatty tissue. The IR light illuminates the cavity above the glottis, which allows glottal transillumination to be detected by a photodiode placed on the neck surface below the cricoid cartilage. Compared with previous photoglottograph (PGG), our new ePGG technique is non-invasive and applicable to unrestricted speech materials. Airflow rate was also measured by the principle of pressure-difference anemometry using a protection mask made of soft tissue and a differential pressure sensor. The use of the soft-tissue mask permits both measurement of air pressure inside the mask relative to the atmosphere pressure and speech recording with minimal audio distortion. The relation between air pressure and airflow rate is established by a calibration procedure on the individual mask using a 1 liter syringe. Pio was measured by inserting a pressure probe to the pharyngeal cavity via the nostril with the help of a medical doctor and also obtained simultaneously with airflow and acoustic data of the Korean fricatives using Dash8x. Two native speakers (2 male) of Seoul Korean in their mid twenties participated in the experiment. The two fricatives in /_a_a/ were embedded in the frame sentence /næka __ palimhapnita/ 'I pronounce __' and randomized. The subjects read them five times at a normal speaking rate.

The results of our experimental data have shown that average glottal opening is wider in /s/ than in /s'/ in word-initial position and a little bit narrower in /s/ than in /s'/ in word-medial position. The average glottal opening of /s/ is significantly reduced in word-medial position, as compared to that in word-initial position. Yet, that of /s'/ has no significant difference across the contexts. The same is true of airflow at the peak of glottal opening. We have also found that the duration of a Pio plateau and airflow resistance at the onset and offset of a Pio plateau are independent of glottal opening, such that the former sustains longer, and the latter is higher in /s'/ than in /s/ across the contexts.

As for the phonation-type specific duration of a high Pio plateau and airflow resistance, we propose that they are correlated with the tensing of the primary articulator (i.e. the lips, the tongue blade or dorsum) and the vocal folds (Kim, Maeda and Honda 2010, 2011) (see Kim and Clements 2015 for the literature review of [tense]). That is, due to the tenseness of the fricative /s'/, a Pio plateau sustains longer, resulting in a longer frication duration than in /s/, and airflow resistance is higher than in /s/ at the onset and offset of a Pio plateau in both word-initial and word-medial positions. The tenseness of the fricative /s'/ also gives rise to the shorter transition from a Pio onset to the beginning of a Pio plateau and from the offset of a Pio plateau to a following vowel onset than in /s/ across the contexts in the present

study, such that aspiration tends to be shorter before and after /s'/ than /s/ across the contexts. Hence, the fricative /s'/ is specified for [+tense] like aspirated and fortis plosives and the other /s/ for [-tense] like lenis plosives, as in (1a). We also suggest that the context-dependent glottal opening of /s/ results from the laxness of /s/, as in lenis plosives which are specified as [-tense]. In contrast, the average glottal opening of /s'/ is consistent across the contexts. Given that the average glottal opening of /s/ and /s'/ is narrower than that of aspirated plosives across the contexts and that the pattern of glottal opening is incorporated to the binary articulator-bound laryngeal feature [\pm spread glottis] (henceforth, [\pm s.g.]), using the feature in Halle and Stevens (1971) (Kim, Maeda and Honda 2010, 2011), we propose that the fricatives /s/ and /s'/ are specified for [-s.g.] like lenis and fortis plosives, and the aspirated plosives for [+s.g.] in both word-initial and word-medial positions, as in (1b).

It is concluded that the ePGG, Pio, airflow and acoustic data on the Korean fricatives /s/ and /s'/ in the present study provide empirical evidence for the articulator-bound laryngeal features [\pm tense] and [\pm s.g.], supporting Kim, Maeda and Honda (2010, 2011).

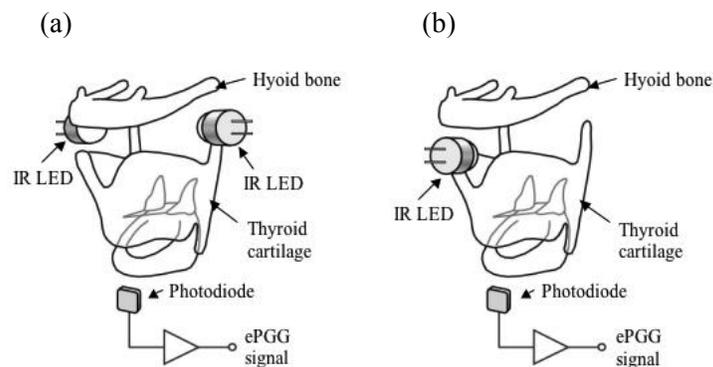


Figure 1. External lighting and sensing photoglottograph (ePGG) system with a high-power light emitting diode (LED) on the surface of (a) a side and of (b) the front of the neck of a subject.

(1) The laryngeal feature specification of Korean fricatives /s, s'/ (i) in comparison with the three-way phonation contrast in plosives (ii)

	i.		ii.		
	/s/	/s'/	lenis	aspirated	fortis
a. [tense]	-	+	-	+	+
b. [s.g.]	-	-	-	+	-

Selected references

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