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ACTIVITY OF THE THYROARYTENOID MUSCLE IN THE PRODUCTION OF KOREAN STOPS AND FRICATIVES

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Introduction

In Korean, stop consonants having the same place of articulation can be classified into three different types with respect to manner of articulation. The three types are generally referred to as "forced", "lax" and "aspirated". All stop types may occur in the syllable-initial position to be realized as voiceless, while in the medial position, the lax stops are usually manifested by voiced allophones. In syllable-final position, the three stop types are phonetically realized as voiceless "applosives", being characterized by the absence of oral release.

Similar manner classifications are also applied to affricates and fricatives in Korean, with affricates classified into the same three types. Fricatives are classified into two types, i.e. "forced" and "lax", although the latter type is referred to as "aspirated" by some investigators.

The present study aimed at examining the laryngeal adjustments for Korean stops both in the syllable-initial and syllable-final positions with special reference to the activity of the thyroarytenoid muscle. Observations on the laryngeal adjustments for the fricatives are also performed.

Procedures

Electromyographic (EMG) signals from the thyroarytenoid (VOC) muscle were recorded in three native Korean speakers of Seoul dialect using hooked-wire electrodes while the subjects repeatedly read meaningful test words containing different types of stops and fricatives placed in different phonological environments. The EMG signals were subsequently reproduced and computer-processed to obtain the average time curve of the EMG activity relative to the acoustic signals which were recorded simultaneously.

Test words were prepared so as to place the stops and fricatives in different phonological conditions. They were all meaningful words with one exception. Those test words which appear in the figures of the present report are presented as examples below in phonetic orthography, with the "forced" type written as geminates.

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1) Syllable-initial stops and fricatives

"k^hul" (nonsense word) "sirɯm" ("anxiety")

"kul" ("oyster") "ssirɯm" ("wrestling")

"kkul" ("honey")

These words were uttered in the frame "ike__ita (that is ___)".

2) Syllable-final stops (applosives)

"kyət^h" ("side")

In this series, a similar word ending in a vowel was added for reference.

"kyə" ("bran")

These were uttered in the frame "ike__".

3) Syllable-final applosives followed by the syllable-initial stops. In this case, initial "lax" stops are said to become "forced" stops.

"pɛk kaci" ("a hundred kinds") "tɛk k^hi" ("your key")

"pɛk kkaci" ("up to a hundred") "kyɔt^h kaci" ("nearby branch")

Here, test words with forced syllable-initial stops were added for reference and were uttered in frame "ike__ta".

"pɛ kkaci" ("to the boat")

Sound spectrographic analysis was carried out on the same speech samples used for the EMG data assessment.

Results

In general, VOC activity patterns in the three subjects appeared to be quite similar to each other for each token type. Therefore, the averaged EMG patterns for one of the three subjects are shown in this report as a representative sample.

1) EMG findings on syllable-initial stops

It was revealed that VOC activity was suppressed for each type of stop consonant examined, the degree of which was slightest for the forced type and most marked for the aspirated type, while it was moderate for the lax type. After suppression, VOC activity increased again toward the voice onset of the postconsonantal vowel. The timing of the reactivation after suppression was earliest for the forced type, followed in order by the aspirated and the lax types. The peak of the reactivation was higher for the forced and the aspirated types than for the lax type (Fig. 1). Incidentally, the vowel preceding the lax stop tended to be laryngealized in this subject.

2) EMG findings on syllable-initial fricatives

EMG patterns of VOC appeared to be very similar to each other with the lax and forced types (Fig. 2).

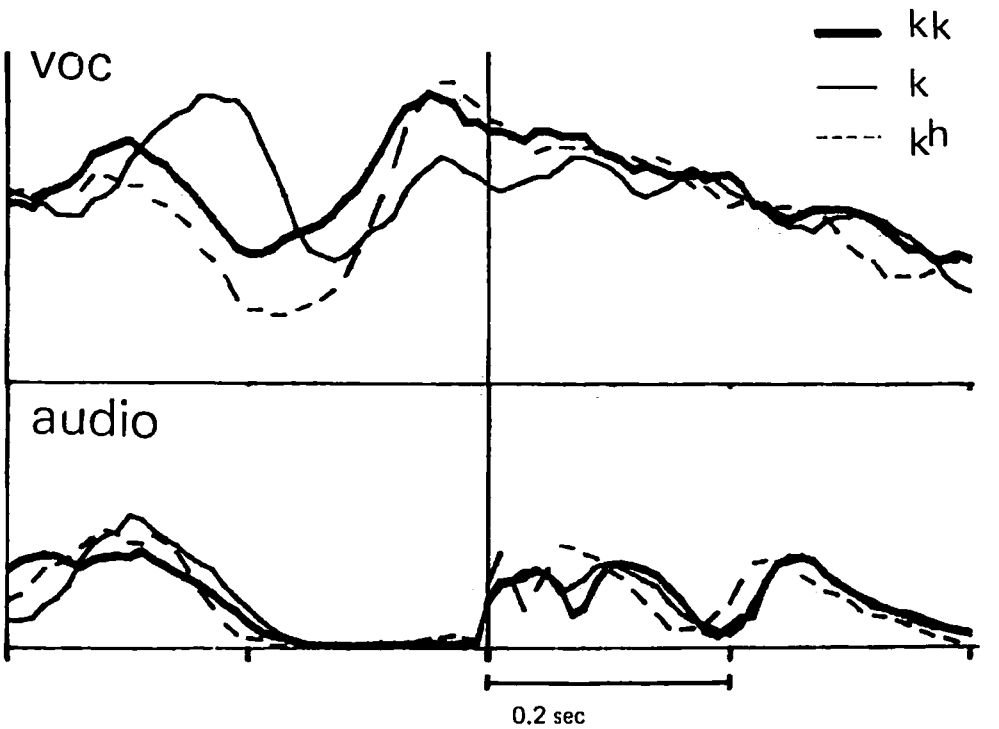

Fig. 1 *Averaged EMG curves of the thyroarytenoid (VOC) for the utterance "ike Culita"– where "C" stands for a forced (thick line), a lax (thin line) and an aspirated (dashed line) stop, respectively. The lower curves are averaged audio-envelopes. The line-up for the averaging was taken at the voice onset of the following vowel.*

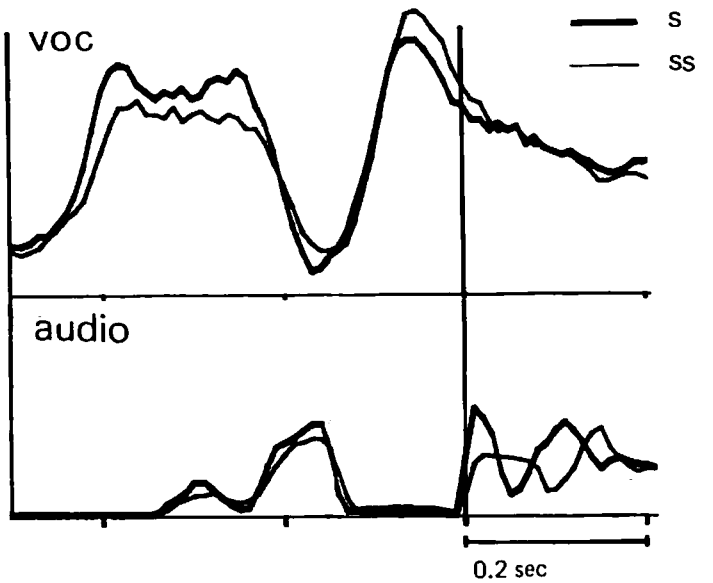

Fig. 2 *Averaged EMG curves of VOC for two types of syllable-initial fricatives. The line up point was at the implosion of the consonant.*

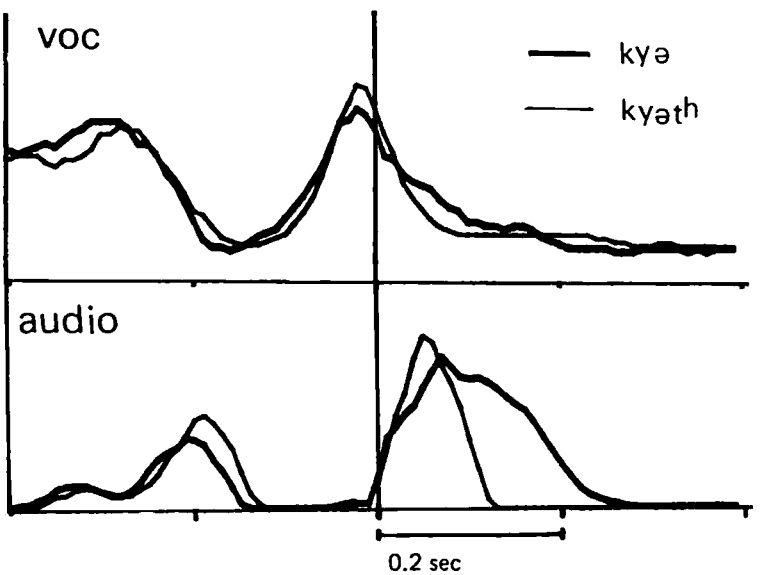

Fig. 3 *Averaged EMG curve of VOC for a syllable-final applosive stop (thin line) compared to that for a similar word ending with a vowel (thick line). The line up was taken at the onset of the vowel of the syllable nucleus.*

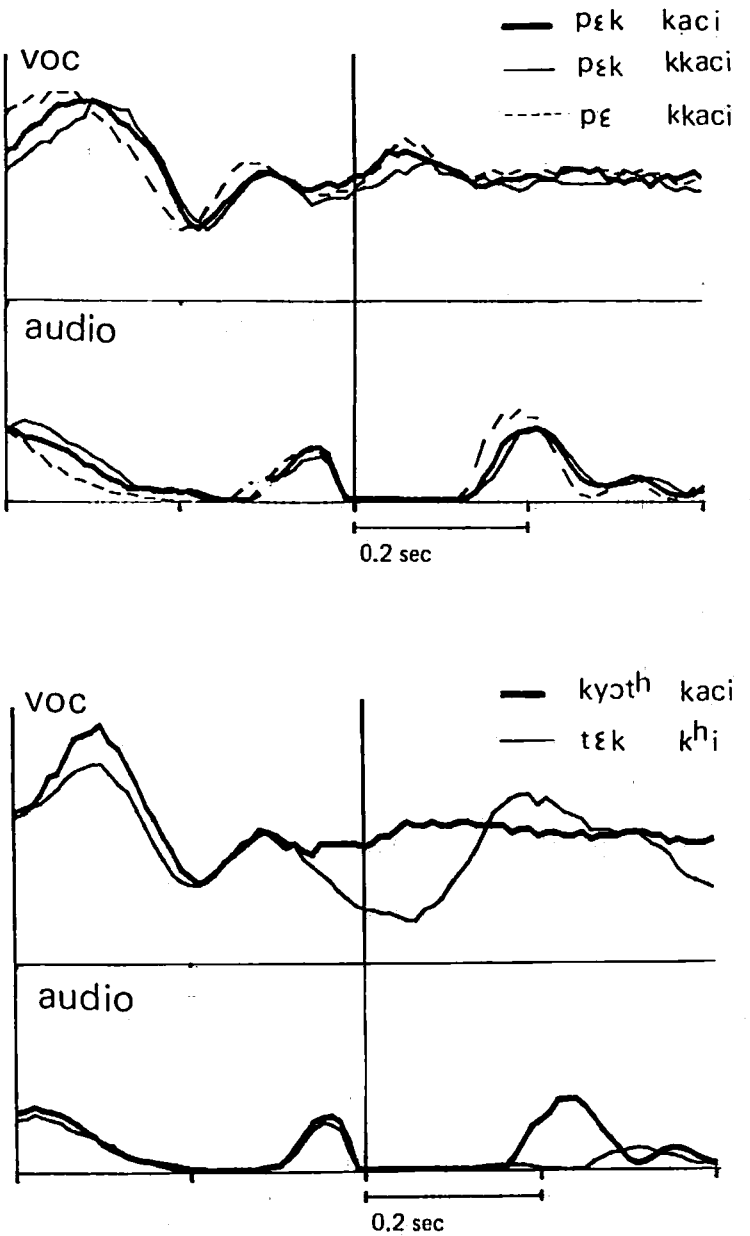

Fig. 4 *Above, averaged EMG curves of VOC for the utterances "ike p k kacita" (thick line), "ike p k kkacita" (thin line), and "ike p kkacita" (dashed line). Below, "ike ky t^h kacita" (thick line) and "ike t k k^hita" (thin line) are included below for comparison.*

3) EMG findings on syllable-final applosives

When compared to the EMG pattern for the test word ending with a final vowel, VOC activity appeared to decline abruptly after peaking for the vowel preceding the applosive stop (Fig. 3).

4) EMG findings on syllable-final stops followed by syllable-initial stops

It was found that the pattern of VOC activity for those utterance samples containing final stop followed by a syllable-initial lax or forced stop was very similar to that for an initial forced stop in terms of the degree and timing of VOC suppression for the consonant segment and of the reactivation of VOC for the postconsonantal vowel. In contrast, when the final stop was followed by an aspirated stop in the syllable-initial position, the pattern resembled that for the single syllable-initial aspirated type (Fig. 4).

Discussion

The present study revealed that the three types of Korean stops in the syllable-initial position are characterized by different patterns of VOC activity. For the production of the aspirated stop, VOC is markedly suppressed and then reactivated for the following vowel. Such activity patterns seem to correspond to a marked abduction followed by a quick adduction gesture of the vocal folds, which has been observed in fiberscopic studies.

EMG patterns for the lax stop type can be considered to correspond to the glottal abduction gesture for this type, in which a moderate degree of glottal opening is always observed in fiberscopic studies. A relatively less marked reactivation of VOC after suppression in this case may be due to the fact that the glottal opening is moderate and that the F_0 of the following vowel is relatively low. The apparent increase in VOC activity preceding the consonantal suppression in the case of the initial lax stop shown in Fig. 1 is considered to be due to the laryngealization of the preceding vowel.

It has been observed by fiberoptic study that the glottal opening is smallest for the forced type among the three stop types, and that the glottis tends to close earlier relative to the voice onset of the following vowel in this case. Apparently, the minimum suppression and early reactivation of VOC activity found in the present study for the syllable-initial forced stop seem to correspond at least to the temporal features of the glottal dynamics for the forced type stop. However, the increase in VOC activity preceding the voice onset of the vowel following the forced type stop, the degree of which is relatively high, cannot be explained solely by the simple dimension of glottal abduction-adduction. Rather, as already suggested by Hirose et al. (1974), the relatively steep increase in VOC activity for the forced stop type must be taken as a characteristic feature of this type of Korean stop. This activity pattern may correspond to the acoustic feature of "laryngealization" as described by Abramson and Lisker (1972) and Ladefoged (1973), and could be a physiological correlate of the rapid build-up in intensity after the stop release which was found to be characteristic for the forced stop type by Han and Weitzman (1970).

Even so, the degree of increase in VOC activity observed in the three subjects in the present study was less marked than that found in our previous study reported in 1974. The difference may be due to a dialectal difference among the experimental subjects. In our previous study, a subject of the Taegu dialect was examined, in whom the distinction between the forced and lax stops could not be made on the basis of a difference in VOT value. On the other hand, the distinction was actually possible on the basis of the VOT value in the present subjects who were speakers of the Seoul dialect.

Our fiberscopic study revealed that there was no significant difference in the time curves of the glottal gestures between the syllable-initial forced and lax fricatives (Sawashima et al., 1980). The present study also failed to disclose any conceivable difference in VOC activity between the two types.

Kagaya (1974), reported a considerable difference in the time course of the glottal closing gesture in syllable-initial forced and lax types of fricatives, the latter being called "aspirated" in his categorization. The gestures of the two types of fricatives in syllable-medial position were similar to each other. In his experiments using a fiberscope, Kagaya used isolated CV syllables without any preceding carrier so that he observed the glottal gestures for the production of fricatives in absolute initial position. Since the syllable-initial fricatives were uttered with a preceding carrier in the present study, the apparent discrepancy between his results and ours regarding the glottal closing gesture may be explained, at least in part, by the different phonetic conditions in the two studies.

As for the syllable-final applosives, VOC activity showed an abrupt decline which may correspond to the transient glottal abduction confirmed by our fiberoptic observation on this type of stop (Sawashima et al., 1980). Iwata et al. (1979) reported that in Fukienese, a southern Chinese dialect, syllable-final applosive stops were associated with a marked adduction of the false vocal folds. Most probably, this type of glottal constriction is produced with a marked increase in VOC activity. In fact, a significant increase in VOC activity is often observed in Japanese and in American English immediately after the cessation of a string of utterances where a tight glottal constriction is confirmed by fiberoptic observations. In any case, the mechanism for the production of applosive stops appears to be completely different in Korean and Fukienese.

The results of the present study indicate that the pattern of VOC activity for Korean clusters consisting of a syllable-final applosive and a syllable-initial forced or lax stop is quite similar to that of the syllable-initial forced stop. It was also shown that the pattern of VOC activity for the cluster type consisting of a syllable-final applosive and a syllable-initial aspirated stop resembles that of the syllable-initial aspirated type. These results are compatible with our fiberoptic observations (Sawashima et al., 1980). Thus, the laryngeal feature of the final stop seems to be assimilated by the following syllable-initial stop, regardless of the difference in place of articulation.

The role of the VOC in speech production has not been completely clarified as yet. It has been claimed that this muscle contributed to vocal fold adduction, glottal constriction, laryngealization and creaky voice production. In contrast, its activity is suppressed in vocal fold abduction and—at least for Japanese and American English—for consonantal segments irrespective of the voiced-voiceless distinction

(Hirose and Gay, 1972; Hirose and Ushijima, 1978). In singing, it has been reported that the VOC plays an important role in producing "heavy" register (Hirano et al., 1970).

The increase in VOC activity observed for the Korean forced stop seems to indicate an "extra strong tensing" (Fischer-Jørgensen, 1977) of the VOC, producing a creaky voice character. In general, creaky voice—or laryngealization—gives a harsh voice quality with a comparatively low pitch. However, in the case of the Korean forced stops, the postconsonantal vowel usually starts with a high F_0. Our preliminary EMG study on the activity of the cricothyroid (CT) muscle revealed that CT activity always increases together with VOC activation for the forced stop type. Thus, the state of the vocal folds for forced stop production may be characterized by a stiffening of its "body" and a strong medial compression associated with relatively high longitudinal tension, resulting in creaky voice quality with a high F_0. Further study is needed to elucidate the nature of the synergetic actions of the laryngeal muscles in the articulatory adjustments for different types of speech sounds, including Korean stops. Possible dialectal differences should also be taken into consideration.

Summary

1) Thyroarytenoid (VOC) activity patterns appeared capable of characterizing the three different types of Korean stops known as "forced", "lax" and "aspirated".

2) In particular, for the production of the forced stop, the VOC shows a marked increase in activity with relatively early timing before the onset of the following vowel. Based on these findings, the state of the vocal folds for the production of this type of stop was discussed.

3) The syllable-final applosive stop is characterized by a steep decline in VOC activity.

4) There is no difference in VOC activity for the two types of Korean fricatives.

5) When a final stop was followed by a syllable-initial stop, the EMG pattern for the cluster resembled that of the syllable-initial consonant.

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