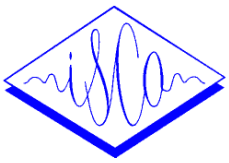

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THE BEHAVIOR OF THE LARYNX IN SPOKEN LANGUAGE PRODUCTION

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ABSTRACT

There is a concensus that the larynx is the organ of voice. Less well recognized is the role it serves in speech production. Recently, it has been shown that the larynx is a major contributor to articulatory adjustments. These laryngeal adjustments are produced by coordinated activities of the intrinsic and extrinsic muscles of the larynx. Since the introduction of fiberscopic and electromyographic techniques to the field of experimental phonetics, the nature of laryngeal adjustments in different languages has been explored in more detail than herefore was possible. Further, the use of different types of glottography and computer-controlled image analysis opened a new scope in laryngeal physiology. In this paper, the physiological correlates of basic features of laryngeal articulatory adjustments are discussed, based on the results obtained using a combination of recently developed experimental techniques.

INTRODUCTION

In the production of human speech, the role of the larynx is quite essential. In order to understand the contribution of the larynx to human spoken language production, it is appropriate to propose several laryngeal features in physiological terms. They are, the abduction vs. adduction of the vocal folds, stretch vs. relaxation along the anterior-posterior direction of the vocal fold, the raising vs. lowering of the entire larynx, and the constriction vs. relaxation of the supraglottal portion. For a precise analysis of these features, different experimental approaches are necessary.

During the past 25 years, marked developments have been achieved in the field of experimental phonetics in physiological terms. They includes: the developments in fiberoptic viewing of the laryngeal configuration [1], in laryngeal electromyography [2], in different types of glottographic techniques, in the use of miniature pressure transducers [3], and developments in computer data processing and image processing [4].

In this presentation, some of the laryngeal behavior in spoken language production will be discussed with special reference to the experimental results obtained using different types of recently developed experimental techiniques.

LARYNGEAL ARTICULATORY ADJUSTMENTS

The feature of abduction vs. adduction of the vocal fold closely relates to the voiced-voiceless distinction of speech sounds and the degree of aspiration.

The abduction and adduction of the vocal folds are based on the movements at the cricoarytenoid joint and are precisely controlled by the abductor and adductor muscles of the larynx.

Based on electromyographic and fiberoptic studies, it was pointed our that for different types of spoken languages the reciprocal activities between the abductor and adductor laryngeal muscles control the size of the glottis and the timing of the glottal movements relative to the oral gestures. Such a reciprocal activity was also observed in the case of aspirated vs. unaspirated segments [5,6,7,8].

In animals, the posterior cricoarytenoid muscle (PCA), the only abductor of the larynx, is known to be activated solely for glottal opening during inspiration. In this sense, the PCA can be regarded as an inspiratory muscle. On the other hand, only in humans, can the PCA be activated during the expiratory phase of speech to open the glottis, allowing the outflow of the airstream from the lung. This adjustment is characteristic of human speech production [9].

In some cases, the cricothyroid muscle (CT), which is primarily a tensor of the vocal fold, appears to participate in the realization of voicelessness in that the CT is more active for voiceless consonant production. It is thus assumed that the CT may contribute to stretching the vocal fold to suppress the vocal fold vibration [10].

Although the adjustment of the vocal fold separation by muscular activity is quite significant, the adjustment of vocal fold separation is only one parameter which determines whether or not the vocal folds will vibrate during a consonantal inteval. In other words, there must be an adequate transglottal airflow for generating vocal fold vibration, and its amount should depend on both the subglottal pressure and on the configuration of the supraglottal articulators. Furthermore, the physical properties of the vocal folds, particularly the stiffness , are important factors that relate to the initiation and cessation, as well as the mode, of vocal fold vibration.

According to our experimental studies on the transglottal pressure difference during consonant production, it appears that there is a hysteresis in the glottal mechanism defined by the initiation and cessation of oscillation. That is, vocal fold vibration tends to be maintained at the implosion of obstruents with relatively favorable physiological conditions for oscillation, while vibration does not start after the voiceless period until more favorable conditions are obtained by a narrowing of the glottis, associated with an elevation of the transglottal pressure difference [11].

OBSERVATION OF VOCAL FOLD VIBRATION DURING SPEECH PRODUCTION

In order to observe the pattern of vocal fold vibration during speech production, a new system for the high-speed digital imaging of vocal fold vibration has been developed in our Research Institute. In this system, a lateral-viewing laryngeal tele-endoscope or a fiberscope is attached to a single-lens reflex camera. A solid-state image sensor is attached to the back lid of the camera. The output video signals

from the image sensor are fed into an image processor through a high-speed A/D converter. Stored images are then displayed on a CRT monitor. At present, frame rates of 2,000/ sec can be achieved. Simultaneous recordings of the vocal fold vibration and the voice signals can be performed satisfactorily [12].

The laryngeal behavior for the production of some Japanese sentences is to be demonstrated during the oral presentation.

THE OTHER DIMENSIONS OF LARYNGEAL ADJUSTMENT

As for the other dimensions of laryngeal adjustment during spoken language production, it is pointed out that stretch vs. relaxation along the anterior-posterior direction of the vocal fold is quite significant, particularly for the control of the fundamental frequency of voice. It is well known that this dimension is controlled by apparently reciprocal activity between the CT and the strap muscles [13,14,15].

As for the raising vs. lowering of the entire larynx, the role of the strap muscles is also very important.

CONCLUDING REMARKS

The larynx is one of the important organs of articulation in spoken language production. Although the mechanism of laryngeal control has been greatly explored in recent years, there are still many questions which remain unsolved. It is hoped that future research will shed further light on the role of the larynx in human speech production.

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