ELECTROMYOGRAPHIC STUDY ON LARYNGEAL ADJUSTMENT FOR WHISPERING

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ABSTRACT

In order to clarify laryngeal adjustments for whispering, an electromyographic study of the intrinsic laryngeal muscles was conducted. Subjects were two native Japanese speakers.

Posterior cricoarytenoid muscle (PCA) showed higher background activity during whispering than during ordinary phonation. Furthermore, there were additional segmental activities which seemed to contribute not only to keeping glottis open, but also to performing necessary gesture for relevant phonemes.

The activity patterns of the other intrinsic laryngeal muscles are also discussed.

1. INTRODUCTION

It has been said that whispering is an aphonic laryngeal action[1]. It's means that there is no vocal hold vibration. However, even during whispered speech, one can distinguish the difference between "voiced" and "voiceless" segment as well as accent patterns[2]. There have been only a few reports dealing with the activity of the intrinsic laryngeal muscles during whispering[3,4]. In order to elucidate the laryngeal adjustment, an electromyographic(EMG) study was performed.

2. PROCEDURE

Subjects were two native speakers of Tokyo dialect of Japanese. EMG activity was recorded from PCA, Cricothyroid muscle (CT), lateral cricoarytenoid muscle (LCA), vocalis muscle (VOC) and interarytenoid muscle (INT). For EMG recordings, hooked wire electrodes were used. The electrodes were inserted perorally to PCA and INT, while inserted transcutanously to the other muscles. The method of verification of electrodes location described elsewhere[5]. As an indication of articulatotory gestures, intraoral pressure was also recorded on an FM data recorder with EMG signals.

The subjects were required to utter nonsense words of /CV̂CV/ form in whispering and in ordinary speech with different accent patterns.

The test words were:

/teꜜte/, /te teꜜ/, /te te/
/deꜜde/, /de deꜜ/, /de de/
/seꜜse/, /se seꜜ/, /se se/
/zeꜜze/, /ze zeꜜ/, /ze ze/.

Each test word was embedded in a carrier sentence "i: /CVCV/ desu" (It is a good /CVCV/), and uttered more than ten times in whispering and in ordinary speech.

After the recordings, EMG signals were rectified and computer-processed in order to obtain an average indication of each muscle activity. As the line-up point for averaging EMG signals, the onset of abrupt drop of the intraoral pressure during consonant closure was taken so as to identify the oral release.

3.RESULT and DISCUSSION

Figure 1 shows the averaged EMG patterns for whispering (dotted line) and ordinary phonation (solid line) in subject KT. In ordinary phonation, PCA activity decreases for abduction of vocal folds for phonation from higher activity

level for inspiration. On the other hand, in whispering, there is no suppression of PCA activity but rather increment of the activity for utterance. Furthermore, in addition to the elevated activity level, PCA showed segmental pattern related to each phoneme. (Top panel of the Fig.1)

Each EMG peak which is corresponding to a phoneme is smaller for the whispering than for the ordinary phonation. This difference in EMG peak amplitude between whispering and ordinary phonation is clearly seen on the LCA and CT trace. However, the pattern of the perturbation is similar in both modes of phonation.

Whispering has been defined as "aphonic laryngeal gesture". From this point of view several studies have been conducted to describe laryngeal gesture during whispering mainly by using the fiberscope[6]. These studies conclude that during whispering, the glottis kept open to prevent vocal fold vibration.

The increased PCA activity throughout the utterance as the upward shift of the base line may represent the applied force to open the glottis.

Interestingly, PCA activity showed the segmental pattern which is corresponding to each phoneme. In other words, during whispering PCA showed compatible EMG patterns to the ordinary speech except for higher base line activity. The higher base line activity may contribute to change the speaking mode from the ordinary phonation to the whispering mode. Even in the whispering mode, the general laryngeal attitude to distinguish each phoneme would be preserved. This hypothesis can explain the difference in EMG patterns for the production of "voiced" and "voiceless" segment uttered in whisper. Figure 2 shows the difference in EMG patterns for the production of /tete/ and /dede/. We can see higher activity of PCA for "voiceless consonant /t/" than for "voiced consonant /d/" just before the line-up point.

On the other hand, there is high PCA activity at the beginning of utterances around 300 msec before the line-up point. Judging from the intraoral pressure curve (at the bottom panel), this high activity of PCA is supposed to be related to the first syllable of the carrier sentence /i:/. This observation is contradictory to the previous finding, that is, in whispering PCA becomes active for "voiceless" segments and less active for "voiced" segments. To explain this controversial phenomenon, we have to consider that this segment /i:/ is located at the utterance initial. Probably, this particular phonetic condition may cause a different laryngeal gesture. We can speculate that for /i:/ at the utterance initial, since the adductor muscles become highly active, PCA should be prove this speculation, a fiberoptic study is mandatory.

4.Conclusion

For the production of whispering, PCA activity level becomes higher to prevent vocal fold vibration. In general, the intrinsic laryngeal muscles including PCA still have segmental activity patterns which are compatible to laryngeal gestures observed in ordinary phonation. At the very initial of the utterance, laryngeal gesture for whispering may special.

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Figure1

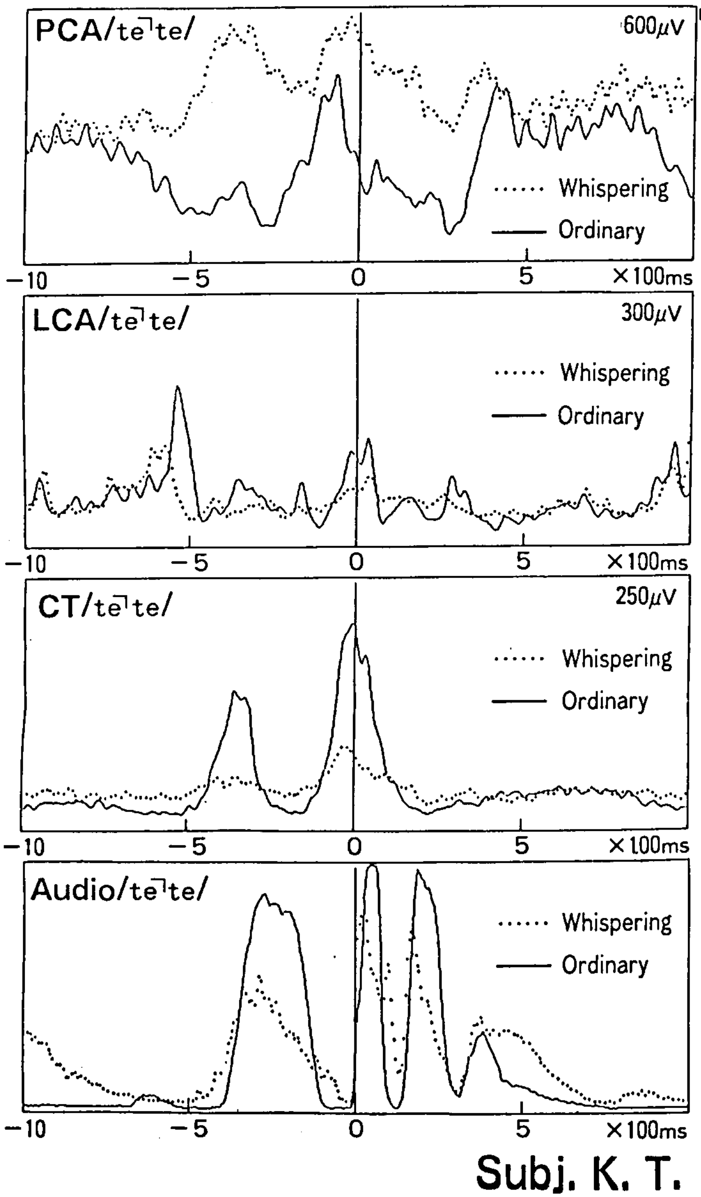
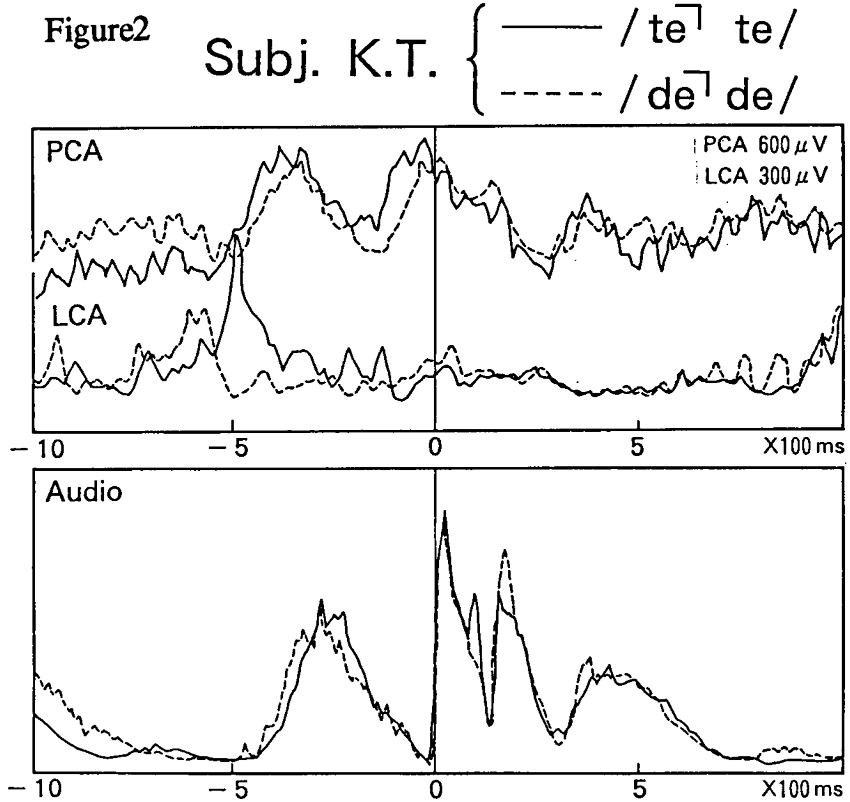


Figure2



References

[1] LUNCHSIGER, R (1965), "Whispering and aspiration", Voice-Speech-Language.Wadsworth Publishing Company.
[2]TARTTER,VC. (1989) "What's in a whisper?", Journal of the Acoustical Society of America, 86:1678-1683.
[3] FAABORG-ANDERSEN, K.(1957) "Electromyographic investigation of intrinsic laryngeal muscles in humans", Acta Physiologica Scandinavica,41, Suppl. 140,1-149.
[4]SAWASHIMA,S. and HIROSE,H. (1973) "Laryngeal Gestures in Speech Production", In MacNaeilage,P (Ed.), The Production of Speech. Springer-Verlag.
[5]HIROSE,H.(1977)"Electromyography of the larynx and other speech organs."In M.Sawashima and F.S.Cooper, (Ed.), Dynamic Aspects of Speech Production. Univ.of Tokyo Press.
[6]WEITSMAN,R. SAWASHIMA,M HIROSE,H and USHIJIMA,T.(1976) "Devoiced and Whispered vowels In Japanese",Ann.Bull.RILP, 10:61-79.