AN INVESTIGATION OF THE VERTICAL MOVEMENT OF THE LARYNX IN A SWEDISH SPEAKER

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The vertical movement of the larynx has been measured on a lateral x-ray cine-film showing the laryngeal and pharyngeal regions of the subject. The present film** was originally obtained in an attempt to investigate the possibility of tracking the movements of the laryngeal cartilages in speech. However, the cartilages in the present subject did not produce any easily determinable reference points. On the other hand, the contour of the laryngeal ventricles was in most utterances visible on the film, which made it possible to estimate the vertical movement of the upper margin of the vocal folds.

This movement was measured frame by frame along the direction parallel to the spinal column and in the plane crossing the vocal folds approximately at the vocal process of the arytenoid. In the present report, the larynx height (L^h) was defined as the distance in this vertical plane between the level of the vocal fold and that of the lower margin of the fifth cervical vertebra, the latter serving as a fixed reference level for the measurement. The measurement was made in reference to a calibration scale (see Fig. 1).

The test material was composed of nonsense words of the forms [C_1a:C_2en] and [C_1aC_2:en] where C=[b, p, g, k], $C_1=C_2$, each word being uttered with accent I and accent II, and nonsense words of the form [VC:a] where V=[i, a], C=[t, d, k, g, n, ŋ] uttered only with accent II (grave accent). All test words were uttered in the carrier sentence "säga — igen" [seja — ijən]. Also sus-

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** The film was taken at Tokyo University Hospital in September, 1968.

tained phonations with rising and falling fundamental frequency were recorded. A male adult native speaker of Stockholm dialect served as the subject. The x-ray film was taken at a rate of 24 frames per second. Fundamental frequency contours and acoustic segmentations of the utterances were derived from sound spectrograms of the simultaneously recorded speech signal.

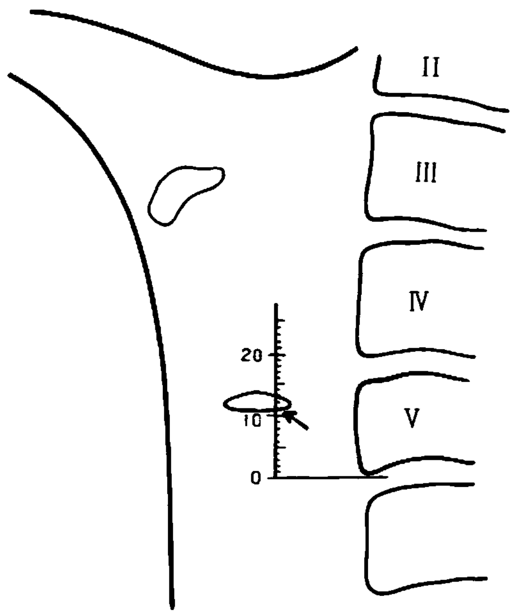

Fig. 1. A tracing from the x-ray film showing a scale (in mm.) along which larynx height (L^h) was measured. The scale was derived from a reference scale attached to the submental region of the subject. The measurement was made from the level of the lower margin of the fifth cervical vertebra (level 0) to that of the upper margin of the vocal fold, which is indicated by an arrow in the figure.

Results

The subject had a tendency to produce glottal stops at the boundaries of the test words. When a glottal stop occurred the contour of the ventricles disappeared on the film due to the constriction of the larynx. Except when that was the case the upper margin of the vocal folds was clearly visible and could be measured with an estimated error of about ± 1 mm. In rest position the measured point was at a level around 11 mm above the lower margin of the fifth vertebra. During the vowel segments the larynx was always above this level by an average of 7 mm. Fig. 2 shows some typical time courses of L^h for the utterances containing long consonants /t/ and /d/. The plotted points represent L^h in consecutive frames. In the figure, it is seen that there is a considerable variability in respect to L^h among different utterances of the same word. In general, the pattern of the larynx movement can be characterized by an elevation of the larynx at the beginning of the utterance and by a lowering of the larynx both for the consonants in the test words and towards the end of the utterance.

In order to compare L^h for different kinds of consonants, the mean of the three lowest consecutive values during a given consonantal segment was taken as a representative value of L^h for that consonant. For comparison, L^h during the vowel segments was also measured by taking the mean of the three highest values in consecutive frames. Table I presents the averaged values of L^h for the different consonants and vowels in the test words of the type /VC:V/, where the final vowel was always [a] and the accent type was II. It is clear that the larynx tends to be lowered more for the voiced stop consonants than for the voiceless stops and the nasals.

Table I. Mean larynx height for the consonants and vowels in the VC:V words.

	Mean larynx height(mm)	range(mm)	number of utterances
t	16.6	14 — 17.8	5
d	15.2	14 — 16.8	5
n	17	15.2 — 19	3
k	18.4	17.3 — 20	4
g	16	15 — 16.8	4
ŋ	18.4	16 — 19.8	5
a	19.9	18 — 22.5	14
i	19.5	18.3 — 21.7	12

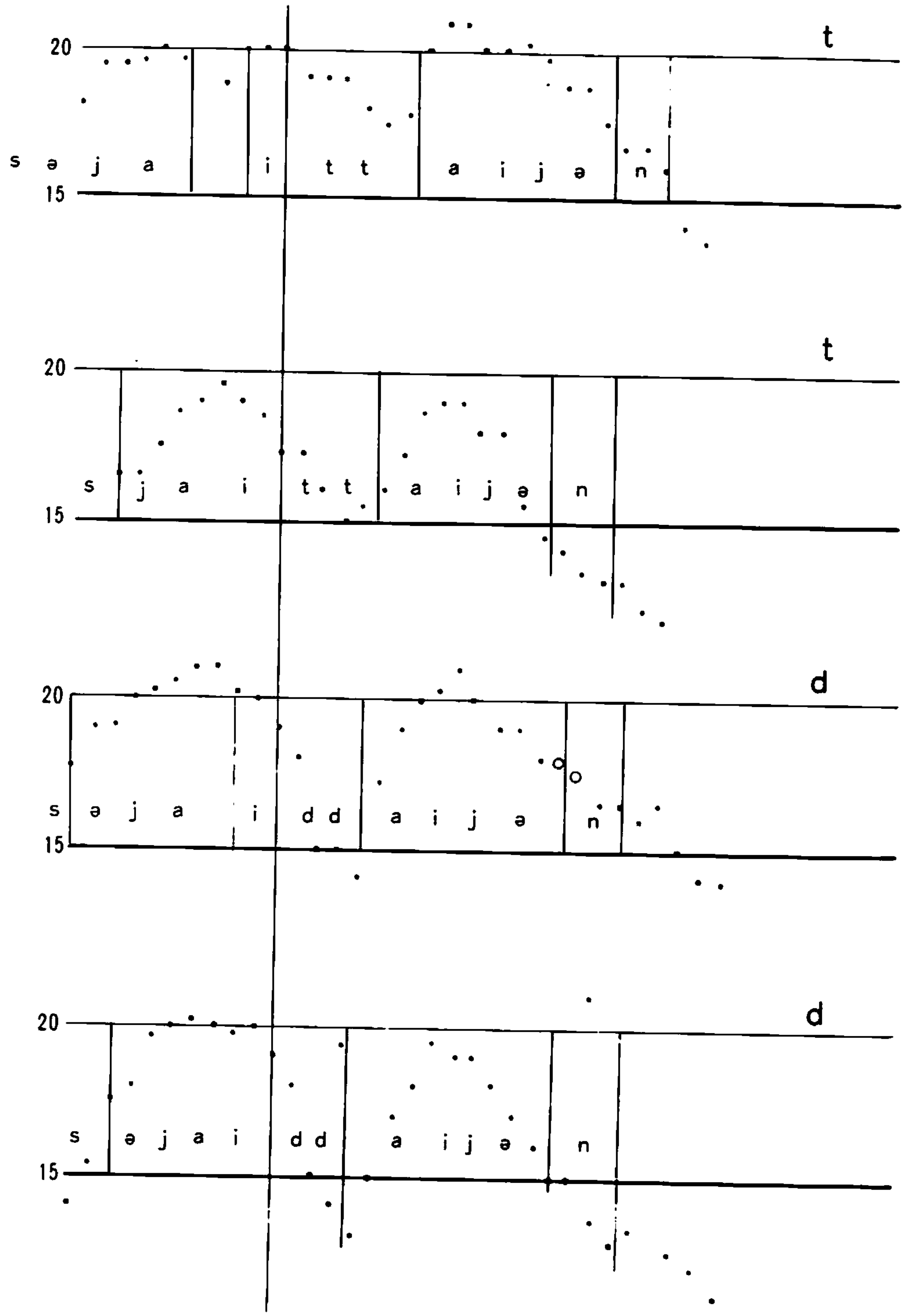

Fig. 2. Examples of time courses of L^h for the utterances containing long consonants /t/ and /d/. The plotted points represent L^h in consecutive frames.

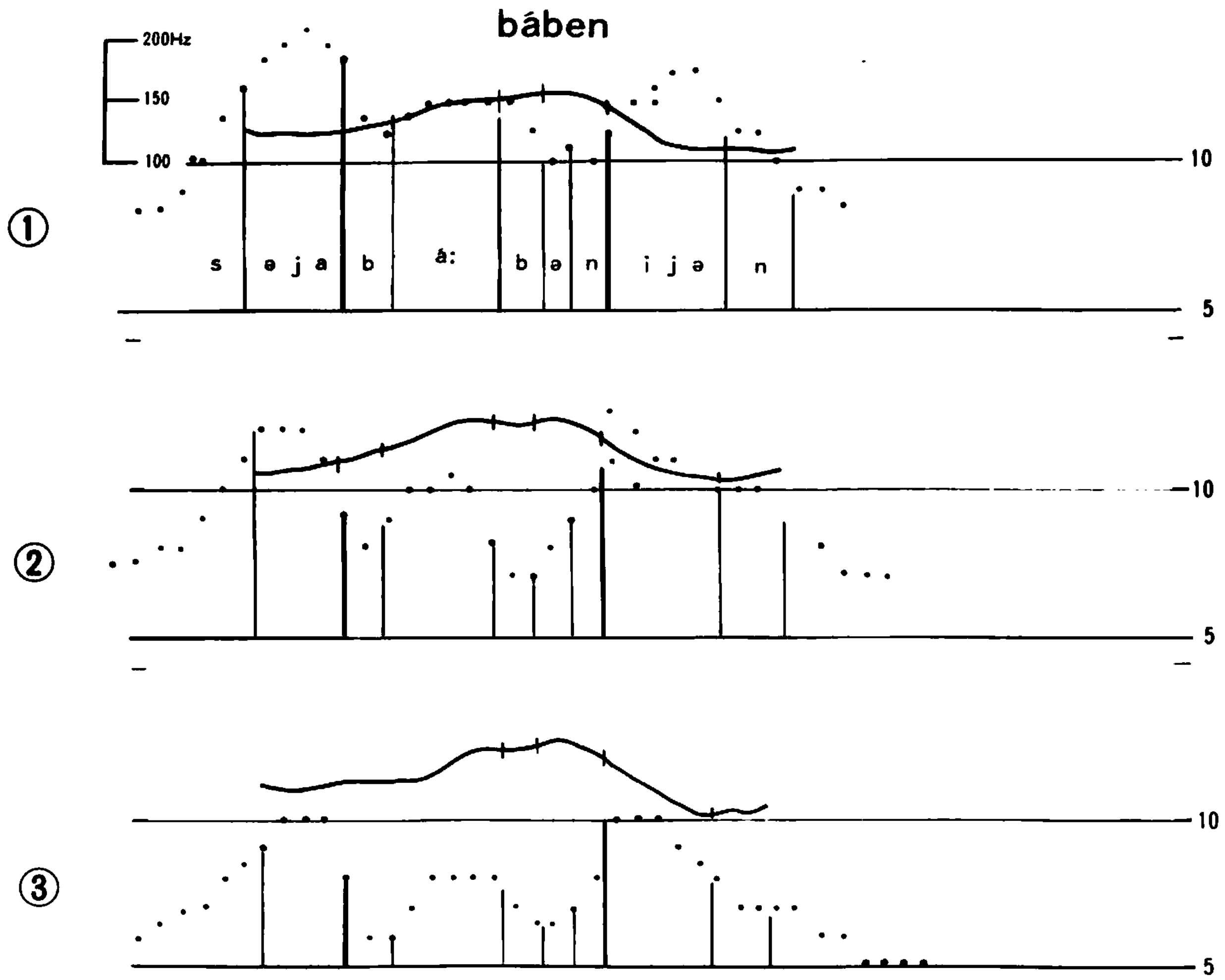

Fig. 3. Time courses of L^h for the test words uttered with accent I. The contour of the fundamental frequency (F_0) for each utterance is also given by a solid curve.

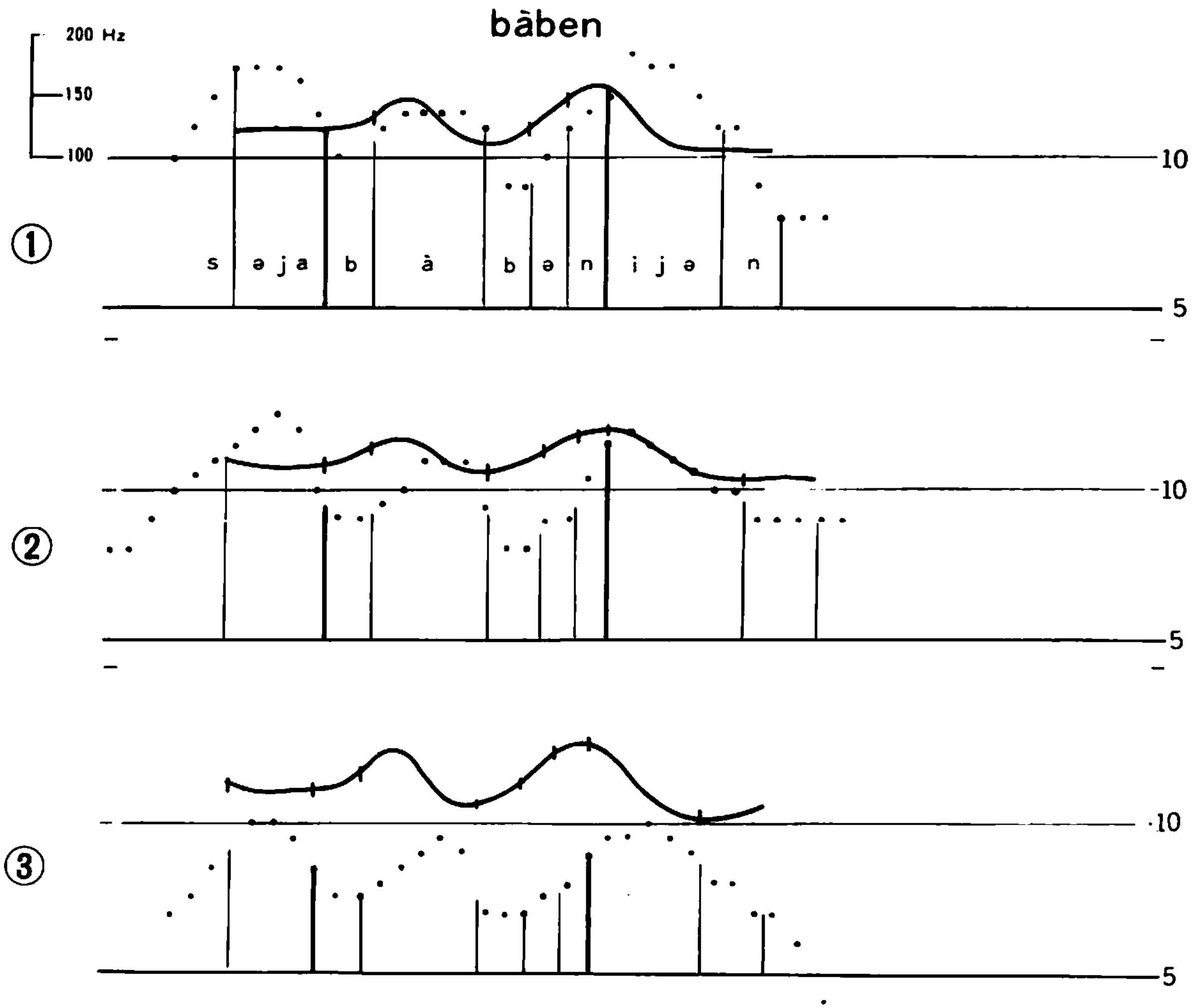

Fig. 4. Time courses of L^h for the test words uttered with accent II.

Figures 3 and 4 show the time courses of L^h for the test words uttered with accent I and accent II, respectively. The contour of the fundamental frequency (F_0) for each utterance is also given in the figures by a solid curve. Although there is again a considerable variation in L^h even for the same word, the F_0 contour appears to be relatively invariable for the utterances with the same accent type. Further, no apparent difference in the time course of L^h could be found between the accent types I and II, whereas there is a clear difference in F_0 pattern between the two accent types.

The data for sustained phonation have not yet been analyzed in detail. However, preliminary inspection of the film showed that there was a tendency for the larynx to elevate when the fundamental frequency was increased.

Discussion

It has often been stated in the literature that the larynx is elevated for high voice (high fundamental frequency) and lowered for low voice[3, 6]. It has also been suggested that the vertical position of the larynx can be used as a good index of pitch adjustment in normal speech[5]. In a more recent investigation, however, it has been claimed that other factors than pitch control may affect larynx height in speech[1, 2, 3]. The data of the present experiment seem to support the latter view in that larynx height appears not to be correlated with the fundamental frequency in speech, or the correlation, if any, is obscured by other much more dominant factors, at least for the present subject. It seems reasonable, then, to assume that the vertical larynx movement in speech is casual rather than causal for the control of the fundamental frequency in speech.

Despite the fact that the subject used in this investigation did not show any correlation between larynx height and fundamental frequency in the speech samples, a positive correlation could be found when inspecting the sample with sustained phonation. This would indicate that the larynx may behave differently for speech and for sustained phonation. Therefore, data from sustained phonation and trained singing, which often are referred to in the literature, may not directly be applied to speech.

The mechanism behind the vertical movement of the larynx in speech is not well understood. In the present study, in particular, the reasons why the larynx is lowered during the consonants are not clear. The fact that the larynx tended to be lowered more for voiced stops than for voiceless stops or nasals could be related to the possibility of reducing the rate of supraglottal pressure build-up during the occlusion and thus facilitating the vocal fold vibration during the closure period of voiced stops. However, whether this is the only mechanism that can explain the difference in larynx height between the different classes of consonants is not likely to be answered by this very limited investigation.

References

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