THE RELATION BETWEEN THE OBJECTIVE FREQUENCY OF THE FUNDAMENTAL TONE AND THE SUBJECTIVELY PERCEIVED PITCH AND MELODY OF THE OESOPHAGEAL VOICE

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The substitute esophageal voice is generally considered as the best compensation of alaryngeal aphonia after total laryngectomy. (The basic importance of the upper esophageal mouth as a vicarious glottis was recognized by Seeman as early as 1919; this author was also the first to describe the physiology and pathophysiology of the substitute esophageal phonation.) The sound of the esophageal voice is highly adaptable and serves as a basis for a fluent and intelligible substitute speech with its natural melody, accents and personal vocal timbre.

193 tape recordings of free narrating from 116 superior oesophageal speakers (rehabilitated at the Phoniatric University Clinic in Prague) were chosen for this study; the group consisted of 112 men and 3 women. The results of subjective examination of vocal pitch were correlated with objective sonagraphic analyses.

The fundamental frequency was determined in 113 esophageal speakers. Individual mean frequencies of 109 male speakers ranged from 21.42 cps to 186.00 cps (average frequency 63.57 cps) and of 4 female voices from 98.88 cps to 202.50 cps.

There is, however, a substantial difference between the objective acoustical structure of the voice and its subjectively perceived qualities. According to Sedláček and Sychra, the fundamental tone is not perceived separately and the acoustical components of speech are not analysed one by one, but the global sound of speech as a whole is evaluated by the listener. The perception of the melody of speech and the recognition of vocal timbre are thus attached together and form an inseparable complex of vocal timbre and pitch.

When comparing the results of previous subjective examination of vocal pitch with the objectively measured and calculated mean fundamental frequencies of individual esophageal voices, we very often noticed a striking discrepancy. Higher frequency and intensity prevalence of the second—and sometimes also of the third and fourth formants—resulted in a markedly bright vocal timbre causing a subjectively perceived high pitch of the voice. Our sonagrams demonstrate this fact very clearly. Because of higher formant frequencies and a marked intensity prevalence of

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superior formants, the esophageal voice in Fig. 1 was subjectively perceived as high-pitched, even though its fundamental frequency of 38,11 cps is one octave lower than that of 83,14 cps of the esophageal voice in Fig. 2 which was subjectively perceived as much lower in pitch because of the very low frequency as well as of a marked intensity prevalence of the first formant.

According to Van den Berg and Moolenaar-Bijl as well as Tato and al., the subjectively perceived changes of vocal pitch depend much more upon changes of vocal timbre than on actual changes of fundamental frequency of the esophageal voice.

In 97 esophageal speakers of our series, a comparison of previous subjective examination of pitch changes with the objective measurements of frequency changes—syllable by syllable—was possible. Again, a marked discrepancy was very frequently stated.

Only in 45 speakers, the subjectively perceived pitch variations corresponded to the objectively measured changes of fundamental frequency. Complete agreement was found in 30 cases (as e.g. in Fig. 3), while in the remaining cases, the sense of the variations agreed but the subjectively perceived pitch variations were much greater than the changes of frequency. Correspondence of the subjectively perceived pitch variations and the objectively measured changes of frequency was most frequently found in esophageal voices with relatively high fundamental frequencies (average frequency of this group was 77, 78 cps). On the contrary, the pitch variations did not correspond to the changes of frequency in 52 speakers. In 18 cases, no changes of frequency (except the final decrease on the last syllables of the sentence) were found in the examined utterings. A gradual decrease of frequency—which, however, did not correspond to marked pitch variations—was found in 26 cases and, in the remaining 8 cases, both the pitch and frequency varied but in contrary senses. The subjective impression of increasing or decreasing vocal pitch depended, in the latter 52 cases, almost exclusively upon the changes of the formant pattern of the esophageal voice resulting from intentional brightening or darkening of vocal timbre. Fig. 4 illustrates this fact. Both of the melodic tops of the sentence correspond to syllables displaying the deepest decrease in fundamental frequency; a marked increase in all formant frequencies as well as an upward shift of the sound energy is characteristic of these syllables, however. Average frequency of the 52 voices of the second group was 51,92 cps (the difference is statistically significant).

We may thus conclude that the subjective perception of pitch variations in the course of fluent esophageal speech substantially depends upon two respective factors. In esophageal voices with higher fundamental frequencies, the subjective impression of pitch variations depends mainly upon the changes of the fundamental frequency. In esophageal voices with low and very low fundamental frequencies, the subjective impression of pitch variations corresponds mainly to the variations of vocal timbre.

DISCUSSION

Lehiste:

I was interested in the difference in the average fundamental frequencies of the esophageal voices of men and women. Is there a physiological reason, or is there a psychological reason, the women making a greater effort to reach a socially acceptable pitch level?

Sovijärvi:

Could you briefly tell us which are the cues of the timbre changing the subjective melody patterns of oesophageal voice?

Handzel:

Manche unserer Kehlkopflosen behielten nach der Rehabilitierung die regionale Sprache, in der die Veränderung der Intonation während des Sprechens, z. B. des Wortes „Lwow" (als „Lwowa" oder „Lwowie") subjektiv perzepiert wird. Auf Grund unserer Forschungen tritt hier nicht nur eine Veränderung der Höhe von einzelnen Formanten ein, sondern auch der Höhe des Grundtons, also der Melodie.

Vrtička:

ad Lehiste: I do not think there is a substantial difference between male and female substitute glottis responsible for higher fundamental frequencies of female esophageal voices. However, a high-pitched esophageal voice—which is socially more acceptable—was trained intentionally in all our female laryngectomees. On repeated tape recordings and sonographic analyses in one of them, we were able to demonstrate that the average fundamental frequency rose, in the course of vocal rehabilitation, from initial 49,00 cps to 98.88 cps.

ad Sovijärvi: According to our findings, the subjective impression of increasing or decreasing vocal pitch results from intentional brightening or darkening of the vocal timbre of the esophageal voice i.e. from shifting the resonance bands and changing the respective intensities of formants (shifting the sound energy maxima) by means of exaggerated articulation movements.

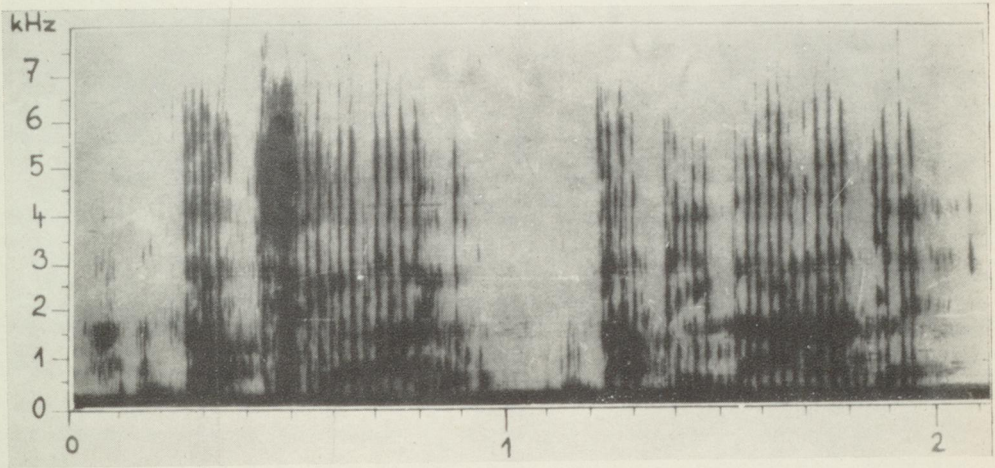

Fig. 1.

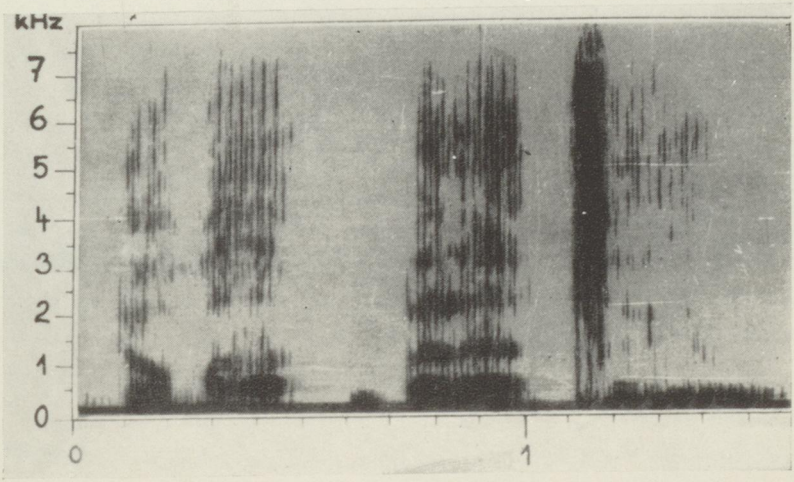

Fig. 2.

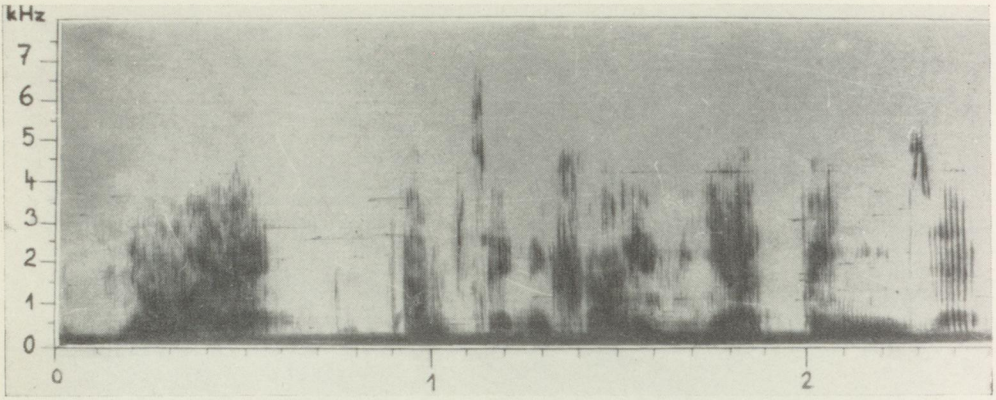

Fig. 3.

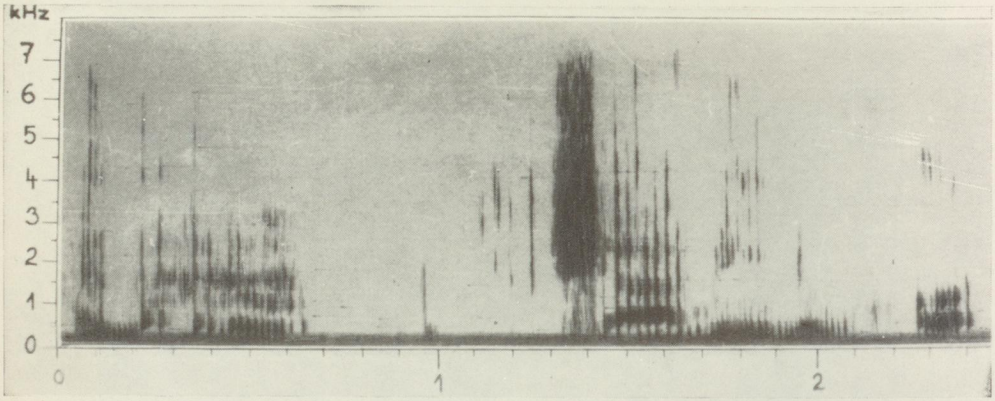

Fig. 4.