FIBEROPTIC OBSERVATION OF THE LARYNX IN SINGING

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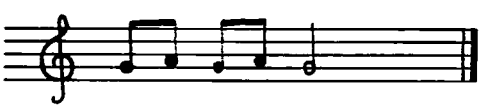
Various types of voice in singing have been labelled differently, based mainly on subjective concepts of singers or voice-trainers. Some of them are called in traditional ways as, for example, "voce bianca, " "covered voice" and so on. Husler[1,2] classified singing voices into seven types and named them "Ansatz" types 1, 2, 3a, 3b, 4, 5, and 6. The "Ansatz" types were primarily based on the singer's sensation of "placing" the tone to some part of his body during voice production. He described the voice quality and the configuration of the vocal organs for each "Ansatz" type, based on his subjective judgments as an expert in the field. Table I presents Husler's specifications for each "Ansatz" type. The purpose of the present study is to observe the laryngeal and pharyngeal configurations during singing in each "Ansatz" type by means of a fiberscope, in order to offer some objective description of the physiological conditions.

Experimental Procedure

One of the present authors, a baritone singer, served as the subject. He was trained under Husler and was able to identify any type of "Ansatz" subjectively. With a fiberscope[3] inserted through the nose, the subject sang the following passage in each different "Ansatz" type:



Photographs were taken through the fiberscope when the subject was singing the final sustained tone in the passage. For comparison, similar pictures were also taken when the subject uttered sustained vowels in speech at the same pitch as in the samples of singing voice. Five Japanese vowels, /a, i, u, e, o/ , were used and each vowel was sung and uttered three times. Consequently, 120 pictures were obtained. The acoustic signal was recorded simul-

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Table I. Description of each "Ansatz" type by Husler.

"Ansatz" type	Place	Voice quality	Configuration of the vocal organs	Muscles in prominent action
No. 1	edges of the upper or lower front teeth	shallow colorless white voice no volume	constricted pharynx tight closure of the vocal folds high positioned larynx	lateralis transversus thyreo-hyoideus
No. 2	upper edge of the sternum	full of vitality open	tight closure of the vocal folds low positioned larynx	lateralis transversus sterno-thyreoideus
No. 3a	root of the nose	full voice	forward and downward tipping of the thyroid open nasal cavity vibration of the vocal folds in the entire length and breadth so-called "open" vocal organs	vocalis crico-thyreoideus
No. 3b	the upper jaw above the teeth, or anterior part of the hard palate	mezza voce (half voice)	vibration of the edges of the vocal folds	thyreo-vocalis ary-vocalis
No. 4	top of the head, or above the soft palate	pure head tone voluminous but breathy covered voice	the venticle bands drawn apart vertical raising of the epiglottis open nasal cavity protrusion of the lips stretched and thin vocal folds open glottis in singing low positioned larynx	sterno-thyreoideus palato-laryngeus crico-thyreoideus
A 5	the forehead	falsetto	small elliptical gap in the glottis slightly high positioned larynx	thyreo-hyoideus crico-thyreoideus
A 6	back of the neck or back of the throat	full tone of head voice	maximally stretched and tautened vocal folds slightly open glottis low positioned larynx	crico-pharyngeus

taneously. The samples for vowels /a/ and /o/ were later excluded from our analysis because the laryngeal lumen could not be visualized due to an overhang of the epiglottis. Type 5 was also excluded because the pitch was unnatural for this type. Thus, 63 pictures were examined, by projecting them onto a screen and tracing crucial lines of the image for measurements. Fig. 1 illustrates representative examples of such tracings for each Ansatz type and speech. All data here pertain to an articulation of the vowel /i/. The measurement was made on the following quantities as shown in Fig. 2.

a) Width of the base of the epiglottis. The value was taken as an indication of the depth of the larynx or the distance between the tip of the fiberscope and the larynx. *

b) Distance between the tuberculum of the epiglottis and the arytenoid. This was measurable only for vowel /i/ and taken as an indication of the longitudinal dimension of the cavity above the glottis.

c) In the case of the vowel /u/, item (b) was not measurable due to the overhanging of the epiglottis. Therefore, the distance between the laryngeal surface of the epiglottis and the arytenoid was measured and designated in place of (c).

d) Distance between the false cords on both sides.

e) Distance between the posterior pharyngeal wall and the arytenoid, representing the anteroposterior dimension of the pharyngeal cavity.

The values in dimensions of (b), (c) and (d) were normalized in reference to the ratio of value (a) in the given picture to that in speech, which was taken as a standard, since these values could also be affected by the depth of the larynx. Even though this normalization is not to be considered quantitatively accurate, the data thus obtained serve as a semi-quantitative basis for the following discussions.

In addition, the expansion of the pharyngeal cavity was visually estimated in terms of the size of semicircular configuration of the posterolateral wall of the pharynx in the picture.

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* This indication can be somewhat fallacious if, for example, the larynx moves forward.

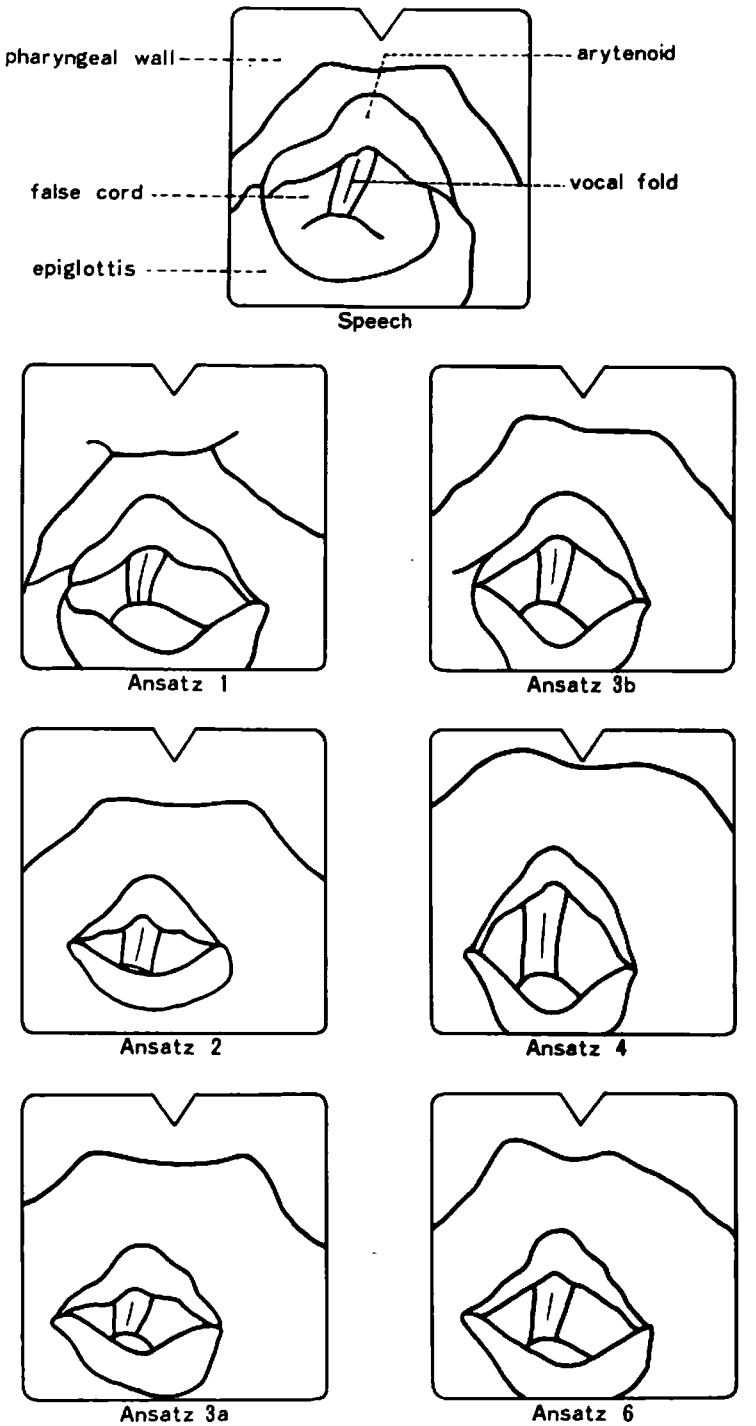

Fig. 1. Representative traces of the laryngeal pictures for each "Ansatz" type in vowel /i/.

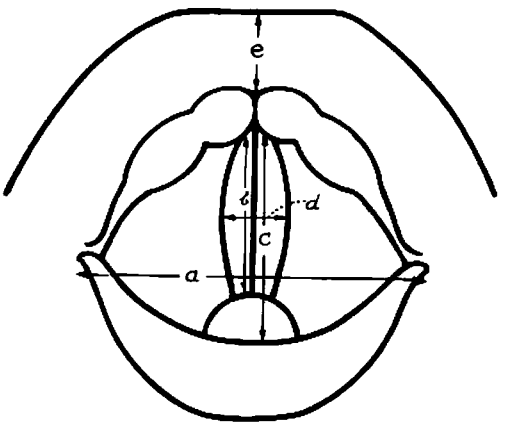

Fig. 2. Quantities measured on the trace.
- a: Width of the base of the epiglottis
- b: Distance between the tuberculum of the epiglottis and the arytenoid
- c: Distance between the laryngeal surface of the epiglottis and the arytenoid
- d: Distance between the false cords
- e: Distance between the posterior pharyngeal wall and the arytenoid.

Results and Discussion

It was revealed that the configurations of the larynx and the pharynx appeared to be fairly consistent for a given type when the three attempts of the same type were compared. The measurement error, including tracing inaccuracy, was estimated as negligible by checking duplicate measurements through independent retracings of some selected identical pictures. Therefore, the data were obtained by measuring three pictures for each type and taking the mean value.

Fig. 3. shows the final results of the measurement. Graph (a) (the top part of the figure) illustrates the width of the base of the epiglottis, thus indirectly representing the height of the larynx. The position of the larynx shows the highest value in speech. In singing voices, the larynx is lower in types A2, A3a, A4 and A6, while relatively higher in types A1 and A3b.

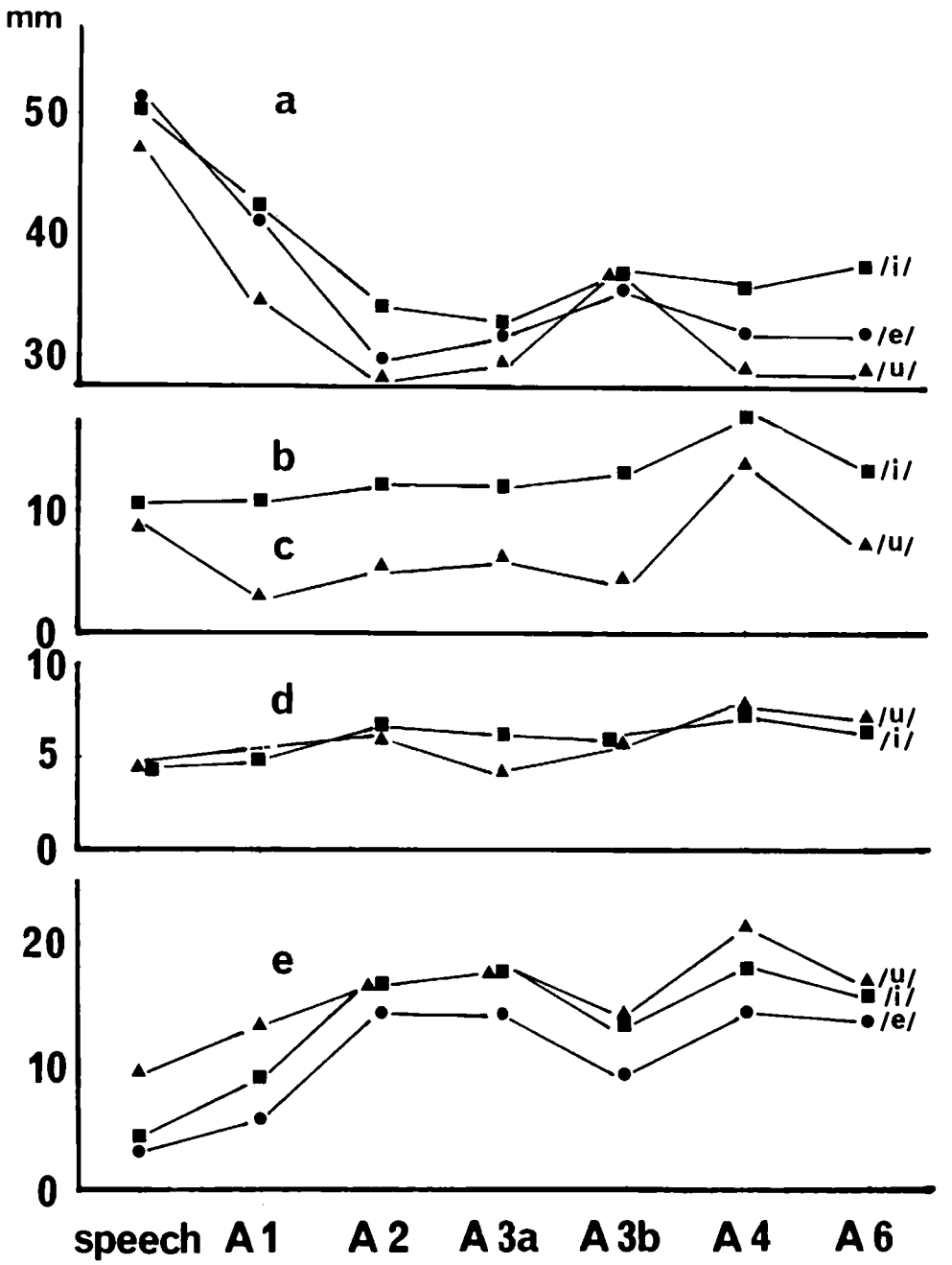

Fig. 3. Comparison of the values between different "Ansatz" types.

In the next part (graphs (b) and (c)), it is shown that the values are largest in type A4. The results indicate that the anteroposterior dimension of the laryngeal lumen just above the glottis is largest in type 4.

It is shown in graph (d) that the distance between both false cords appears to be largest in type 4, although the variation in this dimension is very small among different types.

In graph (e) (the bottom of the figure) it appears that the anteroposterior dimension of the pharyngeal cavity is largest in type 4. The rank order of the value (e) for different types roughly corresponds to that of the expansion of the pharyngeal cavity.

In summarizing, it is conceivable that in type 4, the cavity just above the glottis and the pharyngeal cavity are widest and the position of the larynx is rather low. In contrast, cavities are narrowest and the position of the larynx is highest in speech and in type 1. Further, there is a general tendency at least in this particular subject that the cavity above the glottis and the pharyngeal cavity are wider when the position of the larynx is lower.

Whether the difference in the laryngeal and pharyngeal configurations is a primary factor specifying each type of singing voice cannot be concluded by this pilot study. Further studies are needed to clarify the physiological basis of different types of singing voice.

References

1) F. Husler and Y. R. Marling, Singing, Faber and Faber Ltd., London 1965.

2) Y. Sunaga, "A Study on the Singing Voice," Japan J. of Logopedics and Phoniatrics, Vol. 12, No. 1, 53-61 (1971) (in Japanese).

3) M. Sawashima and T. Ushijima, "Use of the Fiberscope in Speech Research," Annual Bulletin (Research Institute of Logopedics and Phoniatrics, University of Tokyo) No. 5, 25-34 (1971).