STUDIA PHONOLOGICA V (1970)

Factor Analysis of Hoarseness

Nobuhiko ISSHIKI and Yoshio TAKEUCHI

Department of Otorhinolaryngology, School of Medicine, Kyoto University
(Head : Professor Masanori Morimoto)

Hoarseness is frequently the sole symptom of diverse laryngeal diseases. The terminology "hoarseness" includes, however, a wide variety of deviation from the normal voice. Differentiation or classification of hoarseness may be utilized as an adjunct diagnostic means for laryngeal diseases. Furthermore, classification of hoarseness established on the objective basis, together with the clinical findings of the larynx corresponding to each type of hoarseness, would contribute to elucidating the mechanism of hoarse voice production, of which very little is known now. Clinically, classification and gradation of hoarseness would be useful for judging the effect of treatment.

The bases on which hoarseness can be classified would be 1. source disease 2. mechanism of hoarse voice production or 3. acoustic features.

As mentioned above, the purpose of classification of hoarseness is to contribute to differential diagnosis of laryngeal disease and to a better understanding of the mechanism for hoarse voice production. Therefore, classification of voice should be made on the basis of acoustic features of voice, independently of the other findings. If a voice is classified as aspirate based on the laryngoscopic finding, i,e, imperfect closure of the glottis, the classification would be nothing but a change of expression, providing no new information. Classification of hoarseness should be based on acoustic features of hoarseness.

Now, no instruments are comparable to the human ears, so far as the comprehensive judgment of tone quality such as speech sound is concerned. The classification should be made first on the basis of auditory impression. In this study, we have adopted a semantic differential method (Osgood et al.[1]) to subject auditory impression of hoarseness to quantitative measurement.

Experimental Procedures

1. Voice Sample

A set of test samples of voice used in this study consist of 16 hoarse voices /UOAEI/, 8 each for male and for female. They were selected from the hoarse voice records which were collected for the last 2 years at our clinic, so as to impartially include wide variety of hoarseness in degree, quality ,and source disease. The voice samples were edited so that a voice sample is repeated 19 times with 1 second interval.

Nobuhiko ISSHIKI (一色信彦), Yoshio TAKEUCHI (竹内義夫) : Department of Otorhinolaryngology, School of Medicine, Kyoto University (Head : Professor Masanori Morimoto)

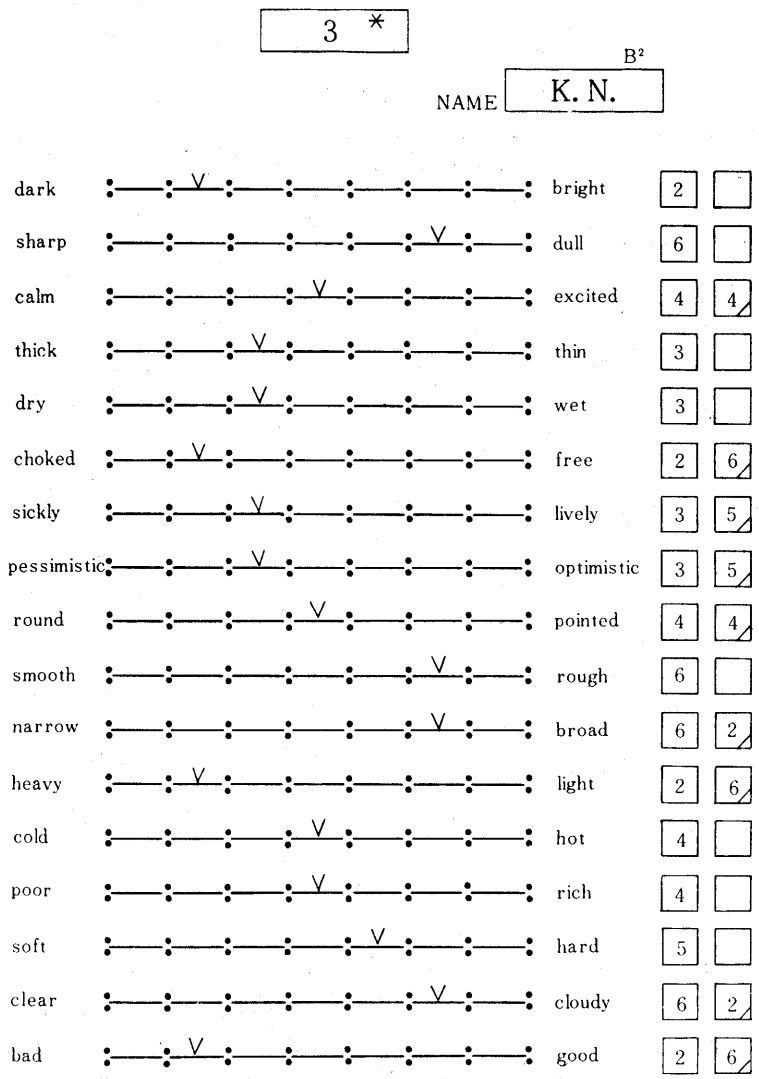

Figure 1

2. Semantic Differential

At the first step, 260 adjectives were picked up from dictionaries, and literatures on semantic differential method. From these, 17 semantic scales, defined by polar-opposite adjectives, were selected, 3 each representative of evaluation, potency, and activity, and the other 8 seemingly related to hoarseness. Figure 1 represents a test sheet (originally in Japanese) used in this study. In order to avoid artificial factors, 8 different kinds of test sheets were prepared, with the order of scales, both vertical and left-right, randomly arranged. Sixteen sheets of test paper were also randomly arranged by the use of random number table, making a set of test sheets for 16 voice samples.

3. Judges

Two panels of judges independently evaluated the 16 hoarse voice samples on the scales, one consisting of 34 nurse students and the other of 6 voice specialists.

Prior to judgment, 3 different representative hoarse voices were presented twice each to the judges without any description of the voices, so as to make the judges grasp the extent of difference in various hoarse voice.

A factor analysis of the intercorrelation between scales was made by D-factorization.

Results

The results of factor analysis of the judgments by the specialists are chiefly described. As a result of factor analysis, 4 factors were extracted. Figure 2 is the profile illustrating the characteristics of each of the 4 factors. The first factor is characterized by the following adjectives: dull, thick, heavy, broad, cloudy, rough, and bad. This factor appears to correspond to the factor which had been called rough, rumbling or rattling. This factor may tentatively be referred to as factor "R". The second factor can be represented by the distinctively loaded

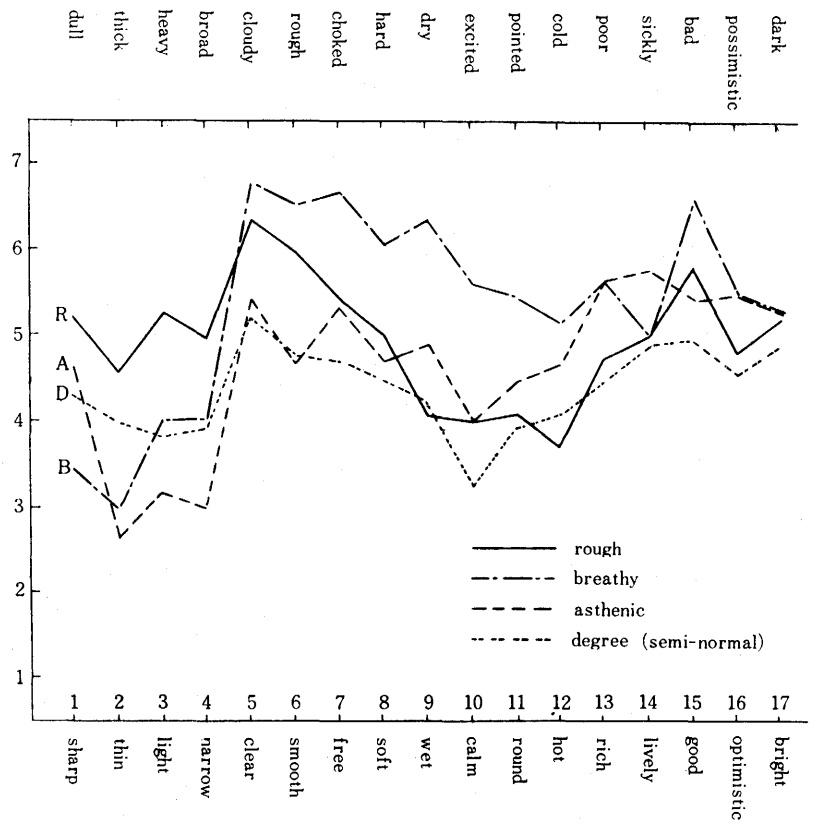

Figure 2

scales: dry, hard, excited, pointed, cold, choked, rough, cloudy, sharp, poor, and bad. The second factor therefore seems to correspond to breathiness previously described, and is tentatively called factor "B" in this study. The third factor has high loading on the following scales: thin, sickly, poor, light, and bad. These adjectives indicate that the third factor may be related to the voice previously described as asthenic and therefore is expressed as factor "A". The fourth factor can be represented, in a relative sense though, by the adjectives: good, clear, soft, calm, free and rich. Dominance of the fourth factor (Voice No 2, 6, 8, 10) means that the voice is close to normal or only slightly hoarse (factor N).

The 4 factors extracted are represented by R, B, A, N respectively but it is obvious that each of the factors can be expressed by no single adjective but only by the profile as shown in figure 2. One should also be aware of the fact that factor B (breathiness) does not necessarily mean imperfect closure of the glottis during phonation or unmodulated air flow. Whether the voice classified as B is always accompanied by imperfect closure of the glottis or not remains to be investigated.

Figure 3 illustrates the results of factor analysis of the judgments by nurse students. The same 4 factors were extracted and there were no essential differ-

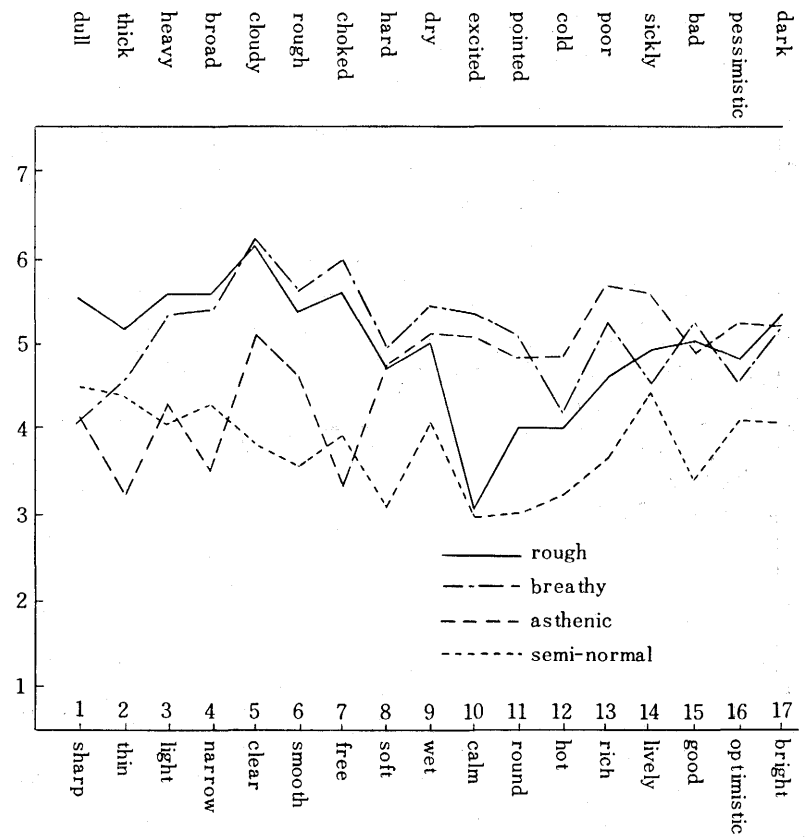

Figure 3

ences between the results by the voice specialists and those by the nurse students. However, the judgments by the nurse students were generally not so critical as those by the specialists, as demonstrated by the profile where the 4 factors come closer

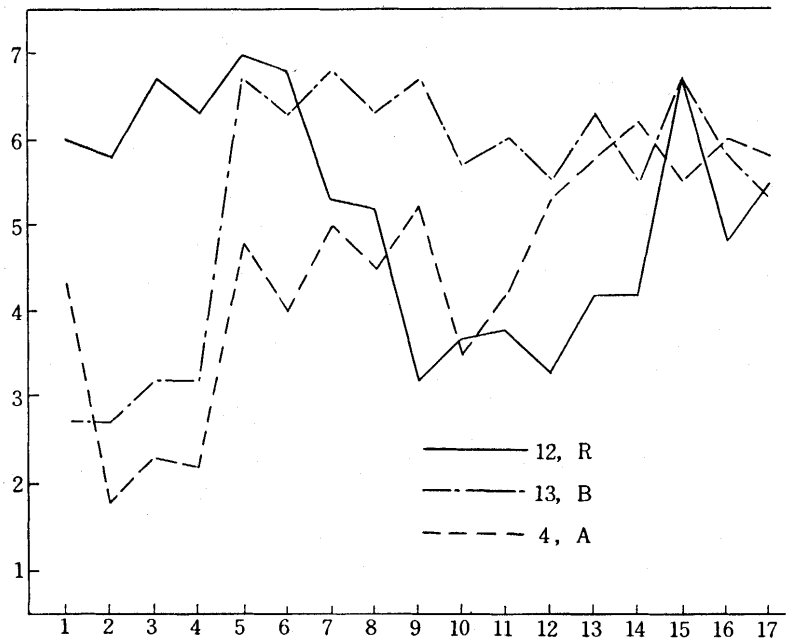

Figure 4

Table 1. Hoarseness as analyzed on 4 factors

Degree of Hoarseness	No. of the Samples	Clinical Diagnosis	Ranking by the Factors				Classification
			R	B	A	N	
Severe	12	vocal cord polyp	1	10	16	16	R
	4	tumor on the post. wall of the glottis	16	9	1	14	A
	13	laryngeal polyposis	14	1	3	15	B
Moderate	3	recurrent n. paralysis	2	6	14	6	R
	11	laryngeal cancer	4	3	8	13	R
	5	struma	7	2	10	12	B
	16	spastic dysphonia	13	4	2	11	A
	1	vocal cord nodule	6	15	5	9	R
	7	vocal cord atrophy	8	5	13	7	R
	9	mutational dysphonia	5	7	12	5	R
	15	vocal cord polyp	3	8	15	8	R
	14	recurrent n. paralysis	9	12	6	10	A
Slight	2	vocal cord nodule	15	13	7	1	N
	10	recurrent n. paralysis	11	11	11	2	N
	6	〃	12	16	4	3	N
	8	laryngeal cancer	10	14	9	4	N

one another near the neutral line (4 level).

It was noted that classification of hoarseness into R. B. A. factors is easy to make for severe hoarseness but not for slight one. The profiles on the scales for severe hoarse voices, representative of R, B and A factors, are presented in figure 4. Table 1 shows the final results of 16 voice samples of diverse laryngeal diseases. The voices were ranked in regard to the 4 factors and thereby classified into R, B, A, N, type.

Additional Experiment

Analysis of individual hoarse voice on 17 scales is too time-consuming work to be applied at our clinic. Some simplification is required for the classification to be put into clinical use. Instead of using the 17 scales, hoarse voices were rated directly on the 4 factors RABN. As for the factor N, it is easier for the judges to rate the voice in regard to the degree of hoarseness than in regard to normality or how close to the normal voice. Therefore, the factor N, as extracted in the S.D. experiment was replaced in the additional experiment by factor D (degree of hoarseness), which is reciprocal to factor N. The same 16 voice samples were sent to university medical centers or hospitals in Japan, asking for rating the samples. The voices were evaluated in two different ways. First, one of the 4 factors was selected by the judges for each voice sample (single entry method). Second, the voices were rated in terms of 4 factors (quaternary rating), utilizing 4 point scale (O=none, 1=slight, 2=fair, 3=extreme).

Thirty-four persons at different institutes, mostly laryngologists, kindly participated in the project.

Results

The results of these simplified methods by a larger number of subjects are summarized, in comparison with the results of original S.D. experiment, in Table 2.

Single Entry Method:

When the single entry method was used, a fairly high consistency was noted among the judgments by different subjects, particularly so for severe hoarseness (over 90% for No. 9, 12, 13, 15). It was also noted that judgment of factor R tends to be quite consistent among subjects, while that of factor A seems rather difficult to make and relatively diverse even for the typical asthenic severely hoarse voice (judgment of No. 4 as A was 74%). Comparison of the results of the single entry method with those of the original S.D. experiment revealed that the final results were consistent with each other except for one case No. 16 the hoarseness of which was of moderate degree and judged diversely.

The fact that the classified type of hoarseness by the single entry method was quite consitent among different judges and furthermore with the results by the semantic differential method seems to justify to some extent the clinical use of this

Table 2

No. of voice samples	Results of S.D. Method	Results of single Entry*	Results of Quaternary Rating				
			Mean Rating				Conversion
			R	B	A	D	
1	R	R (44%) A (31%)	*1.4*	0.7	0.9	1.6	R
2	N	N (82)	0.5	0.3	0.4	*0.8*	N
3	R	R (74)	*2.2*	1.5	0.7	2.3	R
4	A	A (74)	0.4	1.4	*2.2*	1.8	A
5	B	B (80)	1.7	*2.3*	1.2	2.9	B
6	N	N (62)	0.7	0.5	0.9	*1.1*	N
7	R	R (87)	*2.3*	1.3	0.6	2.6	R
8	N	N (60), (R24)	1.1	0.6	0.6	*1.4*	N
9	R	R (92)	*2.5*	0.6	0.5	2.1	R
10	N	N (51), R (31)	1.2	0.4	0.5	*1.4*	N
11	R	R (84)	*2.5*	1.3	1.0	2.6	R
12	R	R (95)	*2.9*	1.4	0.7	2.9	R
13	B	B (90)	1.5	*2.7*	1.0	2.9	B
14	A	A (73)	1.0	1.3	*1.9*	2.0	A
15	R	R (97)	*2.6*	1.1	0.5	2.5	R
16	A	R (55)	*1.5*	1.0	0.8	1.7	R

* The per centage after the factor, N (82) for instance, indicates that 82% of the judges entered N for the voice.

simple method. The single entry method, however, has a disadvantage that a more delicate shade of hoarseness or mixed type has to be disregarded. The quaternary rating method was devised to compliment the above drawback of the single entry method, when necessary. Mean ratings of R B A D for each voice sample were shown in Table 2. First, the results of the single entry method are compared with those of the quaternary rating method. If the voice is represented by the factor which obtained the highest rating among RBA or by N factor when the rating of N is below 1.5, then the results of quaternary rating are converted into single entry form as described in the rightmost row. It is shown that the converted results are exactly the same as the results of single entry method and also of the original S.D. method except for the sample No. 16. The single representative factor as described in rightmost row obtained mostly the rating higher than 2.0 in quaternary method. Voice No. 1, and 16 are a kind of borderline type which is difficult to classify into a single factor. On the basis of these experimental results, we have applied the quaternary rating method to 150 hoarse voice samples of various laryngeal diseases, and the detailed results were already reported elsewhere.[2]

Summary

1. Analyses of 16 various hoarse voice samples by semantic differential method revealed that hoarseness consits of 4 factors, which may be represented by R (rough),

B (breathy), A (Asthenic), and N (semi-normal). Factor N can reciprocally replaced by factor D (degree of hoarseness.)

2. Two simple methods of assessing hoarseness as regard to the 4 factors mentioned above were devised. The results of single entry method, the method to represent hoarseness by one of the 4 factors demonstrated high consistency among different judges and with those of the semantic differential method. The quaternary rating method in which the voice is rated on the 4 factors has an advantage to disclose more detailed content of the 4 factors. Conversion of the results by the quaternary rating into single entry form confirmed high consistency between the two methods.

Acknowledgment

The authors express their sincere gratitude to assistant professor, Kojiro Sumita for his kind advise and help in the use of semantic differential method.

Reference

1. Osgood, C.E., Suci, G.J., and Tannenbaum, P.H. The Measurement of Meaning, University of Illinois Press, Urbana, 1957
2. Isshiki, N., Okamura, H., Tanabe, M. and Morimoto, M. Differential Diagnosis of Hoarseness, Folia phoniat. 21 : 9–19, 1969

(Jan. 15, 1970, received)