ACOUSTIC ANALYSIS OF HOARSENESS*

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' Hoarseness' is a general term used by Speech Clinicians and others to describe a variety of perceived voice abnormalities. Hoarseness has been identified as a symptom of abnormal laryngeal condition. Considerable emphasis has been placed on this symptom. Several approaches, including acoustic, cinematographic, aerodynamic and electro-physiological have been utilised to explore the mechanism and pathologic physiology of hoarse voice production. However, the evaluation of hoarseness, the estimation of degree and quality of hoarseness has been made chiefly on the basis of clinicians' subjective perception. This practice has led to the creation of confusing terms to describe similar changes of vocal quality. Terms like harsh, husky, raspy, breathy and strindent are also often used by clinicians' hoarseness. Little is known about acoustical properties of variations of pathologic voices and related dysfunction of the larynx.

Yanagihara (1967a, 1967b) has categorised four degrees of hoarseness ranging from slight hoarseness to severe hoarseness, based on spectrographic analysis. Further, he has observed that the noise components in the formant regions of vowels and loss of harmonic components as the major acoustic factors related to hoarseness. Noise component may originate from the turbulent air flow due to incomplete closure of the glottis during vibratory attitudes of the glottis.

Liberman (1963) has observed pitch pertubations i.e., the small measurable deviations in successive pitch period and suggested that these irregularities might be useful in the detection of laryngeal diseases. He has also noted that speakers with pathologic larynges had larger pitch perturbations than normals.

Iwata and Von Leden (1970) have analysed the hoarse and normal voices taking contour spectiograms and have recommended spectrographic analysis as an objective measure for the acoustic quality as well as degree of hoarseness.

Cooper (1974) has analysed vowels spectrographically and has observed that in dysphonic patients before therapy, higher pitch is accompanied by less hoarseness and low pitch by more hoarseness.

On the basis of acoustic measurements Von Leden, (1968) has concluded that the most common observation in pathologic condition is a strong tendency for frequent and rapid changes in the regularity of the vibratory pattern.

Further, attempts have also been made to note the mean amplitude difference between consecutive periods, in pathological and normal voices.

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Thus the review of literature indicates that a periodic vibration of vocal cords leading to presence of noise in higher frequency range and loss of harmonics, rapid change in frequency (Jitter) and amplitude (Shimmer) as related to hoarseness of voice.

The present study is an attempt to analyse the ' Hoarse Voice ' to note the differences between normal and hoarse voice, using spectrograph. An attempt to observe the relationship between the Fo, intensity of voice (average) and hoarseness of voice using spectrograph has also been made.

Methodology

Subjects: 4 males with different laryngeal pathologies, age ranging from 22-45 years and 1 female, with vocal nodules, 22 years old were used as subjects for the study. All of them exhibited ' Hoarse Voice' as diagnosed by Speech Pathologists.

4 males matched in terms of age constituted control group. All of them exhibited ' Normal Voice.'

Part 1

Voice Samples: All the subjects were requested to say ' a' as long as they could at the pitch which they would use normally and the voice samples were recorded using a hi-fi Uher tape recorder.

Part 2

For all the subjects the optimum frequency was measuied objectively, by using an objective method of locating optimum frequency based on the measurement of natural frequency of vocal tract. (This was done as a part of the routine clinical examination).

Part 3

One of the male subjects was requested to say ' a' at or near his optimum frequency (in this case lowering of pitch). The subject was helped to maintain his Fo at optimum using the Stroboscope with Tacho unit and SPL Meter. The voice sample was recorded on Uher Tape Recorder.

The female subject was requested to phonate ' a' at her optimum (in this case increasing Fo) using the same procedure as mentioned above. Thus in total 11 voice samples were obtained for the purpose of spectrographic analysis.

Spectrographic Analysis

All the 11 voice samples were analysed using spectrograph of voice identification incorporated to obtain wide band, leniar spectrograms. Analysis was also done to obtain average amplitude display for all the samples.

Further, using the pitch analyzer, an optional part of the spectrograph, the changes in frequency over time in each voice sample was also noted.

Subjective Analysis

Three Master Degree students of Speech Pathology were requested to rate the 11 voice samples using a 6 point scale. O being=normal, l=Mild, 2 Mild-Moderate, 3=Moderate, 4=Moderately Severe, 5=Severe.

Five samples were rated as 0. 1 sample was rated as 2 and 2 sample as 3, and the remaining 3 as 1. When 2 of the judges agreed upon a particular rating then it was considered as rating of that particular voice sample.

The inspection of the spectrograms revealed:

Sample 1 (Male—Age 32 years)

(Judges rating—2)

(a) Irregular Vertical Striations. (Indicating a periodic vibrations of the vocal cords).

(b) No noise components.

(c) Frequency (Fo) varied from 135 Hz to 147 Hz.

(</) Average amplitude varied beyond 6 dB.

Sample 2 (Female—22 years)—Vocal Nodules (Judges rating—1)

(a) Irregular Vertical Striations;

(b) No noise and harmonic components;

(e) Fo—varied from 161—240;

(d) Average amplitude—varied beyond 6 dB.

Sample—3 (Male—22 years—Chronic Laryngitis Rating—3)

(a) Irregular Vertical Striations;

(b) Noise components in the higher frequency range even- in 6 KHz range;

(c) Fo—remained constant at 130 Hz;

(d) Average amplitude—variations beyond 6 dB.

Sample 4 (Male—32 years, vocal nodules, Rating—1)

(a) Regular Vertical Striations (indicating a periodic vibration of vocal cords).

{b) No noise components;

(c) Fo—remained constant at 90 Hz;

(d) Average amplitude did not show variation beyond 6 dB.

Sample—5 (Male 45 years—Chronic Laryngitis, Rating—3).

(a) Irregular Veitical Striations;
(b) No noise components;
(c) Fo—varied from 137-143;
(d) Average amplitude varied beyond 6 dB.

Samples—6-9 (Males, normals, Rating—0)

(a) Regular Vertical Striations;
(b) No noise components;
(c) Fo—did not vary;
(d) Average amplitude did not vary beyond 6 dB.

Sample 10 (Male—32, Vocal nodules) Phonating at optimum frequency—120 Hz—Rating—1.

(a) Regular Vertical Striations;
(b) No noise components;
(c) Fo—maintained constant;
(d) Average amplitude within 6 dB

Sample—11 (Female'—vocal nodules maintaining optimum frequency at 240 Hz, Rating—0).

(a) Regular Vertical Striations;
(b) No noise components;
(c) Fo—maintained constant at 240 Hz;
(d) Average amplitude did not vary beyond 6 dB.

Thus the analysis of spectrographs of hoarseness and normal, indicate that presence of operiodic vibration of V.C. presence of noise components, variations in Fo and amplitude as contributing to the hoarseness of voice. The results of the present study are similar to the reports made by Yanagihara (1967a, 1967b) Liberman (1963) Iwata and Van Ledan (1970).

Further it is also indicated that at optimum frequency there will be less hoarseness. This is in support of earlier reports by Shantha (1973).

Thus it can be concluded that the acoustic analysis indicates, irregular vertical striations, presence of noise components in the higher frequency range,variations in fundamental frequency and amplitude as related to hoarseness. In other words these acoustic parameters indicate the aperiodic vibrations of vocal

cords, incomplete closure of glottis and irregular variation in vibratory pattern of vocal cords. Therefore it can be stated that all these factors may be contributing to the severity of hoarseness.

It is recommended that the spectrographic and other acoustic measurements may be used for objective classification of hoarseness and other quality disorders.

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