ACOUSTICS OF HOARSENESS

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1. Introduction

Hoarseness is a symptom of laryngeal pathology. An acoustic analysis of the voice may provide the first accurate information about the pathologic changes in the larynx or voice disorders. The word 'hoarseness' includes several kinds of vocal abnormality. It is assumed that normal voice results from normal vibration of the vocal folds and hoarseness is the result of some sort of abnormal vibrations. Normal phonation requires complete approximation, adequate tension and regular vibrations. If any of these requisites are disturbed for any reason, resultant condition could be hoarseness. Approximation, tension and vibrations could be disturbed by growth in the vocal folds, by paralysis, by thickening of the cords etc. In hoarseness the production of voice is disturbed because the vibratory behaviour of the cords are altered. The vibratory irregularities will be reflected in the acoustic analyses of such voice.

2. Review of Earlier Research

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

Moore (1962, 1968), *Moore* and *Thomson* (1965) have filmed the vocal cord vibrations of normal and hoarse individuals. In normals the vibratory pattern is characterised by three phases. (1) opening (2) closing of the vocal cords and (3) closed, during which the air flow is interrupted and subglottal pressure increases. He has discussed that in abnormal cases the vocal cord movement vary in atleast five ways.

Yanagihara (1967 a, 1967 b) conducted the spectrographic analysis of hoarse voice and categorized four degrees of hoarseness ranging from slight hoarseness Type I to severe hoarseness Type IV. He has observed the major acoustic factors relating to hoarseness as noise components in the main formant regions of vowels and loss of harmonic components.

Iwata and *Vonleden* (1970) have analysed the hoarse and normal voice taking contour spectrograms and have recommended spectrographic analysis as an objective measure for the acoustic quality as well as degree of hoarseness.

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

3. Aim

In this paper an attempt is made to analyse the acoustic characteristics of various pathological laryngeal vibrations with an emphasis on the noise components.

4. Subjects

15 Adults, 7 males and 8 females with various laryngeal pathologies were selected for this study. All the subjects were examined by otolaryngologists and the pathological nature of the larynx was specified. All the subjects were examined in the speech clinic by speech pathologists and were assessed as having hoarse voice.

5. Recording and Analysis

The subjects were asked to phonate three vowels /a/, /i/ and /u/ for a period of one second approximately at their comfortable level with no restriction imposed on pitch or loudness. Their utterances were recorded in a sound treated room on a tape using OKI-300 tape recorder. Broad and Narrow band spectrograms of these samples were taken using Kay Electric Sonagraph 6061-B under constant conditions.

6. Results and Discussions

When a narrow band filter setting is used in the analysis of vowels, transverse striations corresponding to fundamental frequency and harmonics are portrayed. In a normal voice there may not be any notable additional sound components in the space between each transverse striation. In contrast to this spectrograms of hoarse voice provide abnormal findings consisting of harmonic changes and noise components.

6.1 *Fundamental Frequency:* The fundamental frequency of the males with hoarse voice varied from 120 Hz to 208 Hz. The fundamental frequency of the females with hoarse voice varied from 210 Hz to 290 Hz. A comparison for fundamental frequency with normal adult males and females showed that patients with hoarse voice tend **to** have a moderate high pitch. The statistical analysis of the results were not carried out because of the limited number of subjects involved in **this** present study.

6.2 *Noise Component:* Of the 15 cases analysed, in two cases there was no noise present in the main formant regions of the three vowels but all showed loss of high frequency harmonic components, a characteristic acoustic property **of hoarse voice (Breathy voice). In** the other cases noise was very predominant in

the low vowel /a/ in the F_x and F_a regions. In the case of /i/ the noise component mainly occurred in the F_2 region. While in 7 cases normal harmonic structure was present in the F_2 region, it was replaced by noise in cases which could be labelled as severe hoarseness. Of the three vowels, the high back vowel /u/ was least affected. But it was also noted that in very severe hoarse voice all the main formant structures of the three vowels was replaced by noise component.

7. Conclusion

Change in the harmonic structure and replacement of harmonic structure by noise component in the main formant regions are the acoustic characteristics of hoarse voice. The presence of noise component was more predominant in low vowel /a/ than in other vowels.

8. Recommendations

(a) Spectrographic analysis of hoarse voice is recommended as an objective way of measuring the severity of hoarseness.

(b) To establish the correlation between the acoustic hoarseness and perceived hoarseness.

(c) To find the change in the fundamental frequency and the noise change in post therapy voice samples.

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