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VOICE PROBLEMS AND OCCUPATIONAL ENVIRONMENT

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ABSTRACT

Knowledge of environmental causes of voice disorders is scanty and is mainly based on the clinical experience of speech therapists. However, there is evidence in occupational research that factors in the physical environment, such as air pollution and chemical substances, might harmfully influence the mucous membrane of the voice organ. This paper presents the outlines of a study in progress where the aim is to describe voice quality in two groups of shipyard workers working in different environments regarding amount of air pollution and chemical substances. Within this framework a preliminary study is presented indicating that perceptual analysis of voice quality differentiates significantly between organic and non-organic voice disorders. The report on voice problems in shipyard workers will be published later.

1. INTRODUCTION

Voice problems constitute one of the largest groups of disorders at departments of logopedics and phoniatrics. The waiting list for voice therapy is consequently very long and reflects an unsatisfied need for preventive work in the area. Knowledge of the organic and non-organic causes of voice disorders in the environment and behaviour has mostly been gained from clinical experience. Little research has been done in the field of occupational environment and voice behaviour, but the subject has attracted growing interest in recent years.

In Foniatri för medicinare (1973) Fritzell writes (in my English translation) "We do not know how many persons there are who have problems with their voices or how many who have deviating voices without experiencing discomfort... No attempts have been made to define the prevalence of voice deviations in the general

population". Since this was written voice studies have been carried out on teachers (Johansson and Södersten 1977; Eklund, Ludwigsson and Åstrand 1977), which confirm the clinical consensus that persons working in occupations where the voice has to be used frequently, such as teachers, telephone operators and politicians, run the risk of acquiring voice problems. These are also the kinds of professions that are typically found among patients seeking help for non-organic voice disorders at speech therapy clinics. Voice studies on other occupations than those mentioned above have not been reported. Occupations associated with environmental factors that might be expected to influence the voice organ harmfully are those in industrial environments with noise, air pollution and chemical substances.

2. THEORETICAL BACKGROUND

Earlier work on voice occupational environments in industry is scanty. However, results from research on occupational hazards related to the upper respiratory tract and larynx underline the probability of persons working in polluted environments developing laryngeal diseases.

H von Zenk (1968) points out that changes in industrial production and new insights in phoniatrics should result in increased interest in occupational effects on the larynx. He cites results from various studies indicating that lesions in the larynx have been caused by factors in the occupational environment. He classifies the factors into three groups: Mechanical, chemical and physical. Examples of mechanicla factors are dust from asbestos, aluminium, fibre glass and chalk. Chemical factors are water soluble gases, superphosphates, cadmium, vanadin, sulphur, salt solutions and salt compounds. Zenk is of the opinion that these materials cause chronic laryngitis. Examples of physical factors are heat and alternations between dry and humid air. Zenk also points out substances that are carcinogenic to the larynx such as asbestos, chromium and hydrocarbons.

Volney Bulteau (1975) cites Fabricant (1963) who points out that chemicals are the most frequent cause of industrial diseases in the throat. He lists various chemical components that can cause irritations to the mucous membrane in the upper respiratory tract. These can be found in the form of gas, fumes, mist, vapour, dust or smoke. He writes "...fumes from metals and alloys used in welding or burning are capable of producing severe irritation in the postnasal space".

G B Glasenapp (1975) describes a case of cancer of the larynx that developed from chronic laryngitis owing to mechanical and physical conditions in the air at the working place.

G P Moore (1971) lists the same substances as does Frabricant, above, and adds "Considerable impairment to the respiratory and vocal mechanisms of persons in the general population probably occurs from inconspicuous inflammatory substances that exist in occupational or home environments and which exert their influences cumulatively over considerable periods of time. This possibility demonstrates that the speech clinician needs to investigate these potentially irritating factors along with the pattern of vocal use, particularly when the amount and kind of speaking or singing does not support a diagnosis limited to vocal abuse. With suitable mucosal conditions, a mild amount of vocal misuse could cause excessive vocal deviation. The presence of inflammation and associated edema in the vocal folds provides an ideal basis for vocal deterioration". Moore is of the opinion that the irritants described by Fabricant often produce chronic laryngitis.

The quatotions above motivate this forthcoming study.

3. QUESTIONS AND GOAL

The aim of this study is to investigate the vocal behaviour and vocal experience of welders as compared to non-welders.

Questions.

Are there any connections between vocal behaviour and occupational environment?

What methods are optimal in measuring vocal behaviour in this situation?

4. PLAN

4.1 Data collection

4.1.1 Material

The subjects of this study are shipyard workers. Two groups will be studied, one exposed to welding and the other not. All subjects are non-smoking men. Mean noise levels at the working places are known. The size of the sample has not yett been decided.

4.1.2 Methods

The informants will be interviewed individually, using questionnaires that highlight voice problems and vocal use.
The questionnaire that will be used has been refined several times and will now be tested in its sixth version.

Voice recordings will be made in a soundproof room with a two-channel tape recorder (Revox A77). The airborn signal will be recorded on one channel from a microphone mounted on a spectacle frame worn by the subject. The other channel will record the signal from a contact microphone attached to the neck, below the cricoid cartilage. The subjects will be asked to read aloud a standardized text and thereafter to produce a vowel, [ɑ:], three times. The subject will be instructed to prolong the vowel maximally in each trial. Before the vowels are recorded I will demonstrate this task to the subject.

4.2 Data work

The replies to the questionnaires will be evaluated with regard to voice problems and vocal use.

Auditory analysis of the voice recordings will be carried out by a group of logopeds. The voice diagnosis scheme that will be used is similar to the one used by Hammarberg et.al. (1981) for their study of waveform perturbations in patients with voice disorders. The scheme will be presented later in this paper in the section dealing with the auditory analysis of organic and non-organic voice disturbances.

The harmonic-to-noise ratio will be quantified with the aid of sound spectrograms of the vowels (Yumoto, Gould and Baer, 1982).

The waveforms of parts of the contact microphone signal will be analysed. Many investigators have studied the cycle-to-cycle variations in the speech waveform and the results indicate that these variations occur more frequently in organically caused voice disturbances than in others (Iwata and Leden, 1970; Lieberman, 1963; Askenfelt and Hammarberg, 1981).

The fundamental frequency distributions will be analysed. It is known from clinical experience and from the research literature that voice disorders caused by mass lesions of the vocal folds result in restricted fundamental frequency distribution (Hecker and Kreul, 1970; Kitzing, 1979).

Maximum phonation time will be measured on the longest of the three vowel productions. A decrease in maximum phonation time is expected in cases where the glottal closure is incomplete (Neiman and Edeson, 1981; Hirano, 1981). The vital capacity of the lungs will be known for all of the informants.

In order to answer the main questions that this study addresses the data will be mutually correlated. The data on the subjects that are exposed to welding will be compared to the data on the subjects that are not.

5. AUDITORY ANALYSIS OF VOICE QUALITY IN ORGANIC AND NON-ORGANIC VOICE DISORDERS

5.1 The aim of this study is to test whether the voice diagnosis scheme proposed for the study on welders can differentiate between

a) Hoarse voices and non-hoarse voices
b) Organic voice disorders and non-organic voice disorders

5.2 Material

A sample of voices previously diagnosed as to organic or non-organic disorders was selected from the tape archives of the Department of Logopedics and Phoniatrics in Gothenburg. The recordings were checked to make sure that the voices chosen for this study really were representative of their diagnosis, i.e. that no one voice would sound too good or too bad compared with the average voice of that diagnosis. Fifteen voices were selected. The diagnoses were chronic laryngitis (5), paralysis of the recurrent nerve (3), vocal nodules (3) and phonasthenia (4). The examples of the last diagnosis come from patients with healthy vocal folds. All the other patients had pathological changes of their vocal folds. The organically caused voice deviations were all recorded before voice therapy.

5.3. Method

The recordings were copied twice, onto two separate tapes. The voice productions were ordered randomly, differently on each tape. The listener group consisted of speech therapists and students of speech therapy. They were all unaware of the fact that the two tapes were composed of the same voices. The number of listeners available for the first tape was 13 and for the second tape 11. Each tape was listened to on a separate

occasion with an interval of at least fourteen days between them. When judging the first tape the listeners rated the degree of hoarseness for every voice on a 4-point scale. When judging the second tape the listeners rated their impression of voice quality on a 4-point scale. The voice quality terms rated on every voice were those in daily use in the phoniatric clinic: tense, lax, creaky, hard glottal attacks, breathy, rough, gratings, intermittent aphonia and diplophonia. It is assumed in clinical experience that hoarseness corresponds best to the terms breathy, gratings, rough and intermittent aphonia.

5.4 Results and discussion

Mean scale degrees (MSD) and standard deviations (SD) were computed for voice productions made by the patients with organic voice disorders (ORG) and compared to the voice productions made by the patients with non-organic voice disorders (NON-ORG). The results are presented in Table 1. ORG stands for voice productions from the patients with chronic laryngitis, paralysis of the recurrent nerve and vocal nodules, NON-ORG stands for voice productions from the patients with phonasthenia. MSD and SD for every voice quality term are listed. The listeners' interreliability was significant for W =.728 at the .001 level (tested with Kendall's Coefficient of Concordance).

Table 1 shows significantly higher scores on the the vocal terms breathy, gratings and rough for the organic voice disorders. The differences between the samples on intermittent aphonia and diplophonia are also large but not quite significant. These are all terms used in the every-day clinical language to describe "organic hoarseness". The topmost terms tense and lax in the table (and also on the diagnosis sheet) express, regardless of the causes, the function of the vocal folds, which could explain the non-significant difference between these small samples. The terms creaky and hard glottal attacks have scores that differ only marginally between the two samples. This is probably due to the small samples. The masking effect of roughness and gratings on these qualities in the organic voice disorders should result in higher scores for the non-organic voice disorders. The high scores on breathiness, diplophonia and intermittent aphonia in the voice disorders with organic

Table 1. Statistical comparison of summated diagnoses of the nine voice quality terms for 11 subjects with organic voice disorders (ORG) and 4 subjects with non-organic voice disorders (NON-ORG). Significance tested with Mann - Whitney U Test.

Vocal quality term	ORG MSD_o	SD	NON-ORG MSD_n	SD	Diff. $MSD_o - MSD_n$	Level of signif. .01	.05
Tense	1.34	.67	1.02	.45	.32	NS	NS
Lax	.68	.69	.38	.24	.30	NS	NS
Creaky	.89	.58	.88	.49	.01	NS	NS
Hard glott. attacks	.68	.30	.73	.26	-.05	NS	NS
Breathy	1.50	1.07	.54	.22	.53		x
Gratings	.73	.62	.17	.11	.45	x	
Rough	1.12	.77	.15	.11	.97	x	
Interm. aphonia	.53	.67	.08	.06	.45	NS	NS
Diplophonia	.45	.64	.04	.05	.41	NS	NS

causes are inconsistent with hard glottal attacks and creaky voice, and should therefore also contribute to high scores for the non-organic voice disorders. To test if these assumptions were correct a sample of voice productions recorded from 24 subjects with phonasthenia, rated according to the same diagnosis scheme as previously described, were compared statistically regarding MSD scores with the scores of the organic voice disorders in this material. The listeners were four speech therapists with good rating interreliability (W = .706 significant at the .001 level tested with Kendall's Coefficient of Concordance). This comparison indicates that the MSD of scores on creakiness for the non-organic voice disorders in the larger sample was significantly higher than the scores for voice productions made by the patients with pathological changes of the vocal folds (at the

Table 2. Statistical comparison of summated diagnoses on nine voice quality terms for 5 patients with chronic laryngitis and 4 patients with phonasthenia. Significance tested with Mann - Whitney U Test (p = probability that there is no difference in distribution of judgements for the two samples).

Vocal quality term	Chronic laryng. MSD_{cl}	Phonastenia MSD_{fo}	Diff. MSD_{cl} - MSD_{fo}	p. (1-tailed)	Level of signif. .01	.05
Tense	1.53	1.02	.51	.452	NS	NS
Lax	.69	.38	.31	.206	NS	NS
Creaky	.82	.88	-.06	.452	NS	NS
Hard glott.attacks	.74	.73	.01	.452	NS	NS
Breathy	1.74	.54	1.20	.016	NS	x
Gratings	.48	.17	.31	.056	NS	NS
Rough	1.27	.15	1.12	.008	x	
Interm.aphonia	.65	.08	.57	.143	NS	NS
Diplophonia	.39	.04	.35	.095	NS	NS

.005 level tested with the Mann-Whitney U Test). The scores on hard glottal attacks were also higher but not significant above the .5 level. The vocal terms tense and lax were both scored significantly higher for organic voice disorders in this comparison (tense: p = .0446, lax: p = .0091). The earlier differences on all other vocal quality terms were accentuated in this later comparison. In view of these results, the voice diagnosis scheme used in this study is found to be acceptable as an instrument differentiating between organic and non-organic voice disorders.

Referring to section 2, there are findings indicating that persons working in polluted environments run a risk of acquiring chronic laryngitis. The voice productions in this material made by the patients with chronic laryngitis are therefore of special interest. The scores on the voices with this diagnosis were therefore compared separately to the scores on the non-organic voice disorders. This comparison is presented in Table 2.

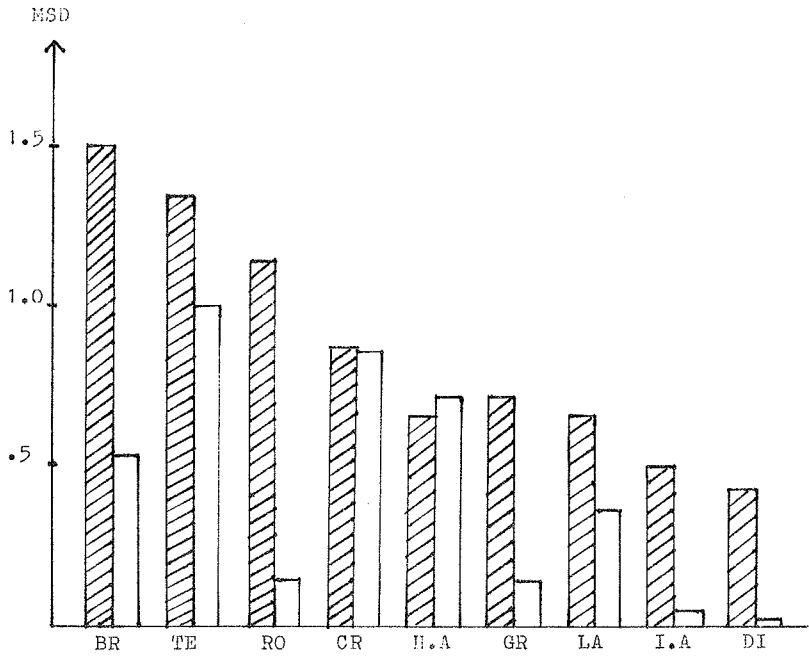

Figure 1. MSD on each of the vocal quality terms for organic voice disorders (marked with lines) and non-organic voice disorders.

Table 2 shows significantly higher scores for voice disorders due to chronic laryngitis on the vocal terms breathy and rough. The score for this diagnosis on gratings is nearly significantly higher than the score for phonasthenia. The scores in Table 2 are in good agreement with the scores in Table 1, and as can be seen the scores on the vocal terms generally associated with organic hoarseness are with one exception higher for chronic laryngitis than for all the organic voice disorders taken together. The exception is the term gratings which probably gets a lower score on chronic laryngitis because of its connection with the diagnosis of vocal nodules. Gratings is described as high-pitched aperiodic noise which is frequently observed in the voices of patients with vocal nodules on their vocal folds.

Mean scalar degrees of the listeners' judgements on the nine vocal quality terms are presented for organic and non-organic voice disorders in Figure 1.

Table 3. Degree of hoarseness (MSD) for the different diagnoses in the two groups of voice disorders.

Diagnosis	Degree of hoarsness (MSD)
Chronic laryngitis	1.93
Paralysis of the recurrent nerve	1.69
Vocal nodules	1.33
Phonastenia	.95

Figure 1 shows the great differences between the two groups of voice disorders with regard to the terms breathy, roughness, gratings, intermittent aphonia and diplophonia. The abbreviations stand for: BR = breathy, TE = tense, RO = rough, CR = creaky, H.A = hard glottal attacks, GR = gratings, LA = Lax, I.A = intermittent aphonia and DI = diplophonia.

To test significance ot using the voice diagnosis scheme as an instrument to detect hoarseness the listener's judgements of degree of hoarseness for organic and non-organic voice disorders were compared. The patients with organic voice disorders are those with chronic laryngitis, paralysis of the recurrent nerve and vocal nodules. The patients with non-organic voice disorders are those with phonasthenia. The mean scalar degrees on hoarseness for the different diagnoses are presented in Table 3.

The difference in degree of hoarseness between organic and non-organic voice disorders was significant at the .25 level (tested with Mann-Whitney U Test). The highest scores of hoarseness were given to the same group of voice disorders that were accorded the highest scores on the vocal quality terms that in general correspond best to organic hoarseness. The voice diagnosis scheme used in this study is therefore suitable as an instrument for detecting hoarseness. The differences in degree of hoarseness between the four groups of diagnoses are presented in Figure 2.

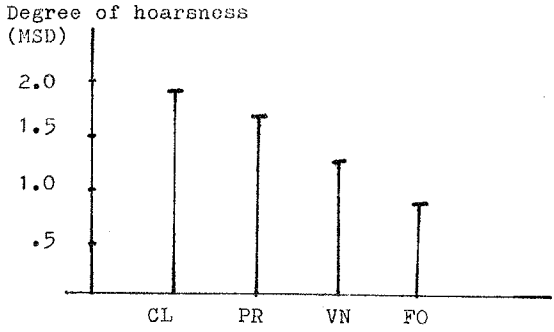

Figure 2. Mean scalar degrees on degree of hoarseness for chronic laryngitis (CL), paralysis of the recurrent nerve (PR), vocal nodules (VN) and phonasthenia (FO).

Figure 2 shows that the greatest difference in hoarseness in this material lies between chronic laryngitis and phonasthenia. This result is in agreement with the high scores for chronic laryngitis on the vocal terms expressing organic hoarseness in Table 2.

5.5 Concluding remarks

The study aimed at testing a voice diagnosis scheme to be used as an instrument for detecting organic hoarseness. The results of the study indicate that the scheme used here is acceptable as such an instrument. There was good agreement among the listeners' ratings and the voice productions with the highest scores on hoarseness were also rated highest on the vocal quality terms usually associated with hoarseness in clinical practice. The organic voice disorders received significantly higher scores on these vocal quality terms than did the non-organic voice disorders.

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