A METHOD FOR THE FIELD EXAMINATION AND FOLLOW-UP OF VOICE THERAPY IN PROFESSIONAL VOICE USERS WITH VOCAL FATIGUE

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ABSTRACT

Speech data of ten female teachers was collected from their first and last lessons of a working day by means of a portable DAT-recorder. The mean fundamental frequency (F0) at the beginning of the first lesson was significantly lower than that of the last one (p=0.059). Although the within-teacher variation of the F0 was very idiosyncratic, trends seen in the changes of pitch during the lessons can be ralated to the symptoms of vocal fatigue.

INTRODUCTION

Most of the studies that have been made about vocal fatigue are either questionnaire surveys or laboratory examinations. In the labs the most common schema has been to let subjects with no history of vocal problems read a standard text at different loudness levels over varied time periods [1-3]. Some studies have used natural work as a vocal load [4, 5]. The results vary in relation to the research paradigm used, some showing a clear trend between loading and fatigue, some not. One of the most extensive examinations of the relationship between vocal load and fatigue is the study by Pekkarinen et al. [3], where the working day of a teacher was simulated. Not all the results can be unambiguously interpreted because of the great interpersonal and intrapersonal variation, but one of the parameters that was most clearly affected by the load was the F0.

Although laboratory studies have many advantages due to the possibility of controlling independent variables, the problem of generalisation remains unsolved. From every day life we all know that the voice is sensitive to different situations, to our own moods, and to our personality, and this has been verified in investigations with acoustic methods [6-10]. Undoubtedly there are features in natural contexts that influence behaviour and voice and that cannot be created in labs. However, the problems of suitable equipment and of analysis methods may in part have hindered the development of field studies. In Sweden two interesting examinations were arranged in working situations: one was carried out with electroglottography [6], the other with a voice accumulator, i.e. a small contact microphone fixed to the anterior neck [7]. Voice pitch, its range and phonation time were the main variables measured in these studies. The results were promising and they showed that of these parameters the F0 can indicate changes in the vocal load.

The aim of the present preliminary study is to improve the objective description of voice in professional voice users by developing a method for use in occupational circumstances.

METHOD

Subjects and Recording Procedure

Ten female teachers, mean age 45 years (range 33 - 53), in the junior grades of a Finnish school (schoolchildren aged 7 - 12) participated voluntarily in the study. The mean time for having been a teacher was 19 years (range 6 - 30). 28-item questionnaires charted both the teachers´ subjective appraisal of their voice problems and the background variables. All the subjects were nonsmokers and no one was undergoing voice therapy at the time of their participation. A phoniatrician examined the larynx of all except two teachers who could not find a suitable time for examination. None of the examined persons had pathology in the larynx except one whose vocal folds did not close fully, which was evaluated, however, to be a normal variation of the female laryngeal function. The questionnaires revealed that teachers experienced widely varying numbers of symptoms of vocal fatigue.

The speech samples of the teachers were collected using a battery-operated portable DAT-recorder (Sony TCD-D3) that permitted the teacher to walk freely in the classroom. The microphone was attached to a head-band and was located to one side of the mouth, 6 - 8 cm from the lips. The teachers recorded their first and last lessons of the same day. The average duration of the lessons was 35 minutes.

Data Analysis

The F0 and sound pressure level (SPL) were measured with a commercially available analogical system (the modular series by F-J Electronics, Inc.) consisting of a pre-amplifier, a F0 meter, an intensity meter and an audio frequency filter. For the F0 analysis the signal was low pass filtered at 330 Hz with the slope of 36 dB/octave and high pass filtered at 70 Hz and amplified. The logarithmic output of the meter was used in all subsequent data processing and analyses. For the calibration in the SPL analysis a sine wave of 200 Hz with the intensity of 80 dB was used. The signal was amplified (Sony PCM-F1) and input into two channels of the intensity meter with different integration times (2.5 ms and 10 ms). The signal of the shorter integration time was used for computing speech and pause times, the longer one for measuring the SPL. Altogether four signals were needed in the analysis.

After measuring the signals they were analysed by a micro-computer (Apple Macintosh Quadra 950) equipped with three extension boards (a National Instruments MIO-16-9L data acquisition board, a DSP2300 signal processor board and a DMA2800 direct memory access board). The digital speech processing functions were provided by software blocks custom-built and implemented to the LabVIEW 2 graphical programming system (National Instruments, Inc) consisting of four programs: calibration (see above), data acquisiton, editing and analysis.

In the data acquisition program the signals were digitized with the sampling rate of 5 kHz to each signal. The maximum duration of one input speech sample was 4 minutes because of the limitations of the computer memory. Samples were taken from the beginning, middle and end of the lesson. The editing program was used to exclude undesirable distorting background noise from the signal. Graphical display of the signal in a scrollable time window (each of the four data channels could be selected) and the monitoring of the sound through headphones permitted the erasure of any unwanted parts. For control purposes it was also possible to measure directly the F0 and the SPL values. The analysis program calculated mean values and standard deviations of the F0, SPL and speech and pause times. The limits employed in this study were 61 - 100 dB for the SPL and 140 - 450 Hz for the F0, values falling outside these limits being ignored. The shortest durations that were identified as speech segments were 70 ms long and as pause segments 250 ms long.

For the statistical analysis the Wilcoxon matched-pairs signed-ranks test and the Pearson correlation coefficient were used.

RESULTS AND DISCUSSION

The teachers found the practical arrangements of this study fairly unobtrusive. The tape-recorder was light to wear and easy to use, and recording did not interfere in the normal activities during the lessons. Further details about experiences and solutions to emerged problems are discussed in Rantala et al. [14].

Athough the results did not generally reach a statistically significant level, trends could be found. The overall mean voice pitch used by the teachers was 232 Hz. However, the mean values of F0 for the first and last lessons were different: it was ten hertz higher at the end of the working day (p=0.139). The difference between the beginning of the first lesson and the beginning of the last lesson was significant (p=0.059), Fig. 1. The differences between the beginning of the first lesson and the middle of the last lesson (p=0.16), and between the middle of the first lesson and the middle of the last lesson (p=0.09) were interesting though not significant.

The correlation coefficient between the F0 of the two lessons was significant (r=0.779, p=0.008): the direction of the change of the F0 was

similar, i.e. the voice pitch rose towards the end of the day for most of the teachers.

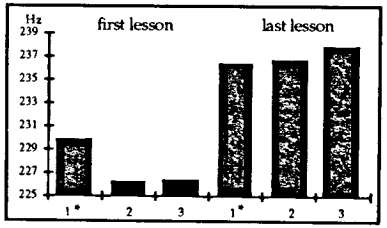

*Figure 1. The mean values of the F0 at different times of the working day in 10 teachers. Sample duration is 4 minutes. 1=beginning, 2=middle, 3=end of the lesson. *=difference significant, p=0.059*

The F0 curves of the teachers were interesting and informative from the clinical point of view. The within-teacher pitch range varied considerably, being quite minimal in some teachers, wide in others. The teachers' mean F0 values for four-minute periods varied during lessons, the lowest value being 180 Hz in one subject and the highest even as high as 293 Hz in another. Both values were considerably over the 95 % confidence interval of the mean F0, which was in this data 215 - 250 Hz. It seems that voice production in the teaching situation has great variation, and is quite different compared to that of sustained vowels produced in peaceful circumstances. Interestingly, in another related project, the mean F0 of the same subjects was found to be 186 Hz as measured from a prolonged /a/ during teaching breaks in the working week [11].

Athough there is great variation, some trends can be seen. The teachers with most difficulties in using their voice had either a high F0 for all of the analysed time in both lessons or their F0 rose towards the end of the working day. The two teachers with only a few symptoms of vocal fatigue displayed the lowest F0 values and the F0 had no sudden or large changes during the day. One teacher who subjectively felt only a few symptoms had the most deviating F0 curve of all. There were large differences in the mean F0 values for the four-minute spans, at most as much as 79 Hz. Figs. 2 a and b present the F0 curves of three teachers with the least symptoms of vocal fatigue, and three teachers with the most obvious .

In a field study there are unavoidably numerous background variables that cannot be controlled and their effects only guessed at. In laboratory settings, on the other hand, time and noise can be exploited as independent variables. In the present study the talking time of the teachers in lessons was almost half of the measured time (42 % in the first and 45 % in the last lesson) and it had no correlation to the F0. When comparing this result to other studies [7, 12] where the speaking time of a work-day has been measured, it is not surprising to find that teachers talk longer than other professions do.

The other variable that could explain the rise in the F0 is the increased loudness of voice because of background noise [13]. The mean values of the SPL of the first and last lessons varied from 78 dB to 81 dB, a correlation existing between the parameters, but not in the two last measured four-minute periods when the F0 was at its highest. This phenomenon probably results more from vocal fatigue than from increased loudness.

Although the results of this preliminary study of field-study methods are promising, they must be considered with caution because of the small sample and the inherent limitations that belong to all field studies. Many background variables (e.g. the noise of the classroom, the teacher's teaching and speaking style, talking time) could not be controlled and regulated systematically. On the other hand some variables are present in all studies of human behaviour (e.g. personality, experienced stress, physical conditon) and they can be controlled neither in field studies nor in laboratory conditions.

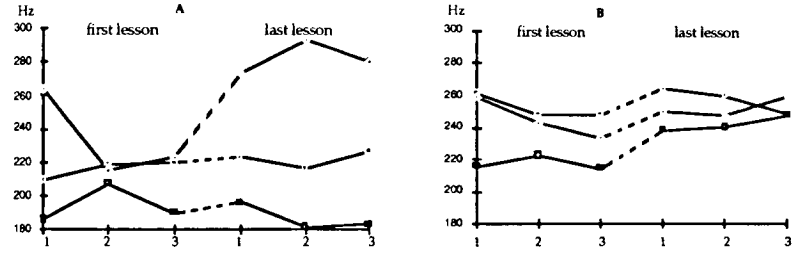

Figure 2. Mean F0 values for six teachers. a) Three teachers with the least symptoms of vocal fatigue. b) three teachers with the most obvious symptoms of vocal fatigue. 1= beginning, 2=middle, 3=end of the lesson.

Further studies are planned in order to increase the number of subjects and hence improve the reliability of the results. It appears that the method is suitable for clinical practise, for specifying diagnoses more closely, focusing the aims of voice therapy and allowing the better following-up of rehabilitation.

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