Voicing Periods in a Primary School Teacher

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Abstract

Teachers form a large group of professional voice users and are thought to be at risk for voice problems than the general population. Primary school teachers report the common need to shout or raise the voice to make children heard. In a complete working day, the excessive vibration of vocal fold tissues due to loud or prolonged vocalization has been assumed to contribute to voice problems. There are relatively few studies focused on measuring the amount of voicing performed by speakers over time. Hence, the present study quantified the amount of voice use on a single workday and measured the changes, if any, in the acoustic parameters of voice [mean fundamental frequency (F0), standard deviation of fundamental frequency (SD F0), and mean jitter]. A primary school teacher of 32 years of age having twelve years of teaching experience participated in the study. The voice samples were recorded in a class room setting, the natural working environment of the teacher, with a portable, lightweight digital audio tape (DAT) recorder. The entire workday speech/voice sample (throughout the working hours) was recorded. Also, prolongation of vowel /a/ was recorded at four times of interval in the day - before the first class, after the first class, after lunch and after the last class. The external noise was removed by using CoolEdit software. The voicing (pitch) periods were measured using PRAAT software. Dr. Speech software was used to analyze F0, SD F0, and jitter at four different intervals of time. The voicing percentage was found to be around 31.46 % (i.e., 1 hour 49 minutes 48 seconds). F0, SD F0 and jitter increased from the first to the last recording. The results of the study throw light on vocal usage and its effect on voice by a primary school teacher who work with children on a entire workday.

Key words: Phonation, Jitter, Accumulation, Vocal fatigue

Voice is defined as the laryngeal modulation of the pulmonary air stream which is then modified by the configuration of the vocal tract (Brackett, 1971). The term 'professional voice user' is applied to individuals whose professional role and employment are dependent on effective and efficient use of voice. Kaufman (1998) classified lecturerers, teachers as level II professional voice users. Teaching is one of the most vocally demanding occupations. In classrooms teachers need to speak frequently and often loudly in the presence of background noise, risking occupational damages to their voices. Loud speaking, increase of pitch and straining of voice may lead to vocal fatigue that eventually causes damage to vocal fold tissue. As many as 50% to 80% of teachers experience and have experienced voice problems according to several questionnaire studies (Pekkarinen, Himberg & Pentti, 1992; Gotaas & Starr, 1993).

The vocal loading in teachers has been quantified thoroughly and systematically in the recent past. Voice accumulation and voice dosimetry devices have been developed for monitoring voice use at work (Buekers, Bierens, Kingma & Marres, 1995; Airo, Olkinuora & Sala, 2000; Cheyne, Hanson, Genereux, Stevens & Hillman, 2003). Measures called 'Vocal Dose' have been proposed for quantifying voice usage (Svec, Titze & Popolo, (2003). The three vocal doses identified so far are the time dose, the cycle dose and the distance dose. The time dose is equal to the voicing time and measures the total time the vocal folds are vibrating. The cycle dose measures the total number of cycles accomplished by the vocal folds (in the unit of thousands). The distance dose measures the total distance traveled by the vocal folds on their oscillatory trajectory. The simplest vocal dose is time dose, often called the voicing time, which accumulates the total time the vocal folds vibrate during speech. Rantala & Vilkman (1998) reported that the F0 time is a bigger risk factor for vocal fatigue.

Voice accumulation times and the voicing percentages relative to total time at work have been found to be higher in teachers than in other

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professions. Masuda, Ikeda, Manako and Komiyama (1993) measured a voicing percentage of 21% for teachers in an 8 hours workday, compared to 7% for office workers. Sala, Airo, Olkinuora, Simberg, Strom, Laine, Pentti & Suonpaa (2001) reported that the average speaking time of day care teachers was 40% of the time at work, compared to 28% for nurses. In these studies, the primary focus was on the accumulated phonation time, also referred to as 'vocal load'.

Analyses of teachers' voices, recorded over the course of a working day have been carried out in order to detect changes in voice quality and parameters such as the fundamental frequency and sound pressure level (Rantala, Paavola, Korkko & Vilkman, 1998). There are relatively few studies on voice changes induced by vocal loading. In addition, most studies have used short loading times, the shortest being 15-20 minutes (Stone & Sharf, 1973; Linville, 1995) and the longest from 45 minutes to 2 hours (Neils & Yairi, 1987; Gelfer, Andrews & Schmidt, 1996). These studies have reported contradictory results. The most common result was an increase in fundamental frequency after loading (Gelfer, Andrews & Schmidt, 1991; Stemple, Stanley & Lee, 1995). Studies have also explored the relationship of voice loading versus jitter and standard deviation of fundamental frequency (SD of F0). The jitter values have reportedly increased (Gelfer, Andrews & Schmidt, 1991), decreased (Stemple, Stanley & Lee, 1995) or shown no essential change (Verstraete, Forrez, Mertens & Debruyne, 1993) after loading. Rantala, Vilkman & Bloigu (2002) reported increased SD F0 after vocal loading.

Voice loading investigations have been usually conducted in laboratory settings (Gelfer, Andrews & Schmidt, 1991; Stemple, Stanley & Lee, 1995). Only a very few trails have been arranged in a work environments (Ohlsson, 1988; Novak, Dlouha, Capkova & Vohradnik, 1991). Subsequently, questions about the generalisability of the results to real-life situations remain unresolved. Field studies involve many practical and technical problems, which probably explain the small number of these investigations. No studies are reported on Indian primary school teachers. The primary schools in India have more background noise and sometimes there are no partitions between classes. Also, it can be assumed that primary school teachers in India have more voice loading factors. They handle more number of subjects/classes than their western counter part and spend extra time in teaching academically poor students, participating in extra-curricular aspects like training the students for sports, drama, dance and conducting parents meetings. In this context, the present study quantified the amount of cumulative vocal fold vibration on a single workday of a primary school teacher and documented the effect of prolonged teaching on voice parameters (F0, SD of F0 and jitter).

Method

Subject: A normal 32 year old adult female who has been working as a primary school teacher for 12 years participated voluntarily in the study. She teaches Kannada, Environmental science and Mathematics to second and third grade children. The average number of students in each class was about 30. She did not have any speech, language, hearing or voice problems at the time of the study. The subject was explained about the study and instructed to teach in a normal workday manner. Written consent was taken for her participation.

Phoniatric examination: A stroboscopic evaluation was done before the voice recording which indicated that the regularity of vocal fold (VF) vibration, amplitude of VF vibration, quality of mucosal wave and glottic closure were normal.

Instruments used: A portable, light-weight digital audio tape (DAT) recorder was used. The recorder has in-built electret condenser microphone and weight of the devise is about 54 grams. PRAAT and Dr. Speech software were used to extract voicing periods and other voice measures such as F0, SD F0 and jitter.

Recording procedures and samples

(a) Classroom speech: The recording of voice samples was done on a normal workday (Monday) after a relaxed week end. The DAT recorder was worn around the neck of the subject. The distance between microphone and mouth was 10-12 cm. As the recorder was tiny, it allowed the teacher to move, walk freely in the classroom. An entire workday speech/voice was audio recorded from first to last class. The subject was asked to maintain a logsheet where the she made a note about the vocal activities through-out the day. It also included the time at which the voice activities took place; for e.g. 9.45-10.30 am taught Kannada to II standard. Figure 1 shows the subject wearing the DAT recorder.

(b) Sustained phonation: The subject was instructed to phonate vowel /a/ for 7-8 seconds at four different time intervals – (1) before first class, (b) after first class, (3) after lunch and (d) after last class. Both oral and written instructions for using the tape recorder and

performing the tasks were given to the subject in advance.

Figure1: Subject wearing the digital audio tape recorder.

Analyses: The recorded six hours voice/speech sample was transferred onto the computer memory. The external noise was removed by using CoolEdit software. The entire day speech/voice sample was truncated into ten minute tokens and a total of 36 ten minutes tokens were made. Each of the ten minute samples was viewed as waveform on PRAAT software and the voicing periods were extracted. In addition, the voicing periods or F0 time was calculated for classroom teaching/at work, and not at classroom teaching/not at work. Inclusion of voicing duration not at classroom teaching definitely resulted in the entire vocal load in the school circumstances. Voice activities at leisure time, lunch time with colleagues and advicing students/guiding parents-personally are some of voice usage that comes under not at classroom teaching. Dr. Speech software (Tiger Electronics) was used to analyze jitter, F0 and SD of F0 of the sustained vowel /a/ at four time intervals. Figure 2 illustrates extraction of voicing periods.

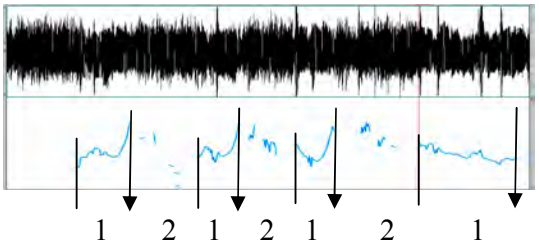

Figure 2: Voicing periods of teacher's utterances (1) and students' repetitions (2).

Results and Discussion

Voicing periods: The total time of the recorded sample was 5 hours 48 minutes i.e., about 20,880 secs. It was found that the voicing time (active vocal fold vibration time) was 6568.94 secs. Teacher's vocal folds were vibrating a cumulative average of 31.46% (voicing percentage) of her time at work (about 1 hour 49 minutes, 48 seconds).

	Voicing periods (seconds)	Percentage of voicing (%)
At classroom teaching	5479.99	83.42
Not at classroom teaching	1088.95	16.57
Total	6568.94	99.99

Table 1: F0 time and percentage of voicing at classroom and not at classroom teaching.

Table 1 shows the cumulative vocal fold vibration time (F0 time) and percentage of voicing at classroom teaching and not at classroom teaching. Further, the results indicated that the teacher's vocal folds were vibrating a cumulative average of 83.42% at classroom teaching (about 1 hour 31 minutes, 33 seconds), and a cumulative average of 16.57% not at classroom teaching (about 18 minutes 14 seconds). Figure 3 shows the total voicing durations on a single working day of 5 hours 48 minutes.

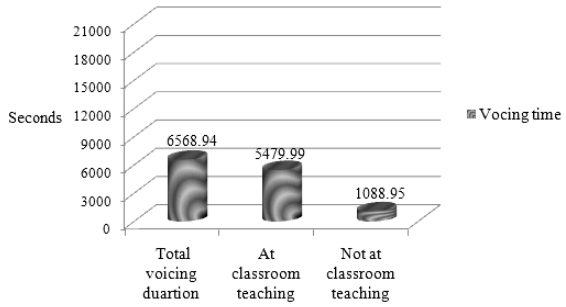

Figure 3: Total voicing time (out of 20880 seconds).

The results of this study are in agreement with Masuda et al. (1993) who reported that the voicing percentage was 21 % in an eight hours workday, considering a somewhat different teacher population. The obtained voicing duration of 1 hour 49 minutes is in consonance with the result of Titze, Hunter & Svec (2007) who found in their teachers the voicing duration was about 1 hour 50 minutes for 8 hours of working day. The comparison indicates that the teacher in this study used her voice more excessively, vigorously within shorter period of nearly 6 hours. The teacher used her vocal folds about 83 % of her time at classroom teaching and only about 16 % of her time for non-teaching purpose. It indicates that the voice usage was at maximum in classroom situation where the teacher prolonged, raised her voice loudly for a long period in presence of background noise to make every student heard. This excessive continuous voicing may be a fatiguing factor for the vocal folds because of repetitive motion and collision of tissue. As these

results were obtained from a single primary school teacher, one should be cautious enough in generalizing the results.

Effects of prolonged teaching on F0, SD of F0 and jitter: The results showed that some voice features changed during the course of a workday. The most obvious change was in fundamental frequency (F0), which increased towards the end of the day. Figure 4 depicts the changes of F0 at four different intervals of time across the working day. The F0 increased around 7.24 Hz between the first and last recording. The obtained result is in agreement with the results of Rantala, Vilkman and Bloigu (2002) who reported that the F0 increased about 9.7 Hz between the first and last lesson.

Figure 4: Fundamental frequency (F0) at different interval of time.

Two explanations for the F0 rise have been offered in the literature. According to Stemple, Stanley & Lee (1995), increased F0 is a consequence of weakness of the thyroarytenoid muscle. When the muscular layer of thyroarytenoid muscle slackens, the cover and transition layers of the vocal folds stiffens. This leads to an increase of the rate of vibrations in the vocal folds and hence a rise of the F0. Vilkman, Lauri, Alku, Sala, & Sihvo (1999) have suggested another explanation. The increased F0 was caused by the speaker's compensatory reactions to alterations in their voice. When compensating for the physiological changes, which could be alterations in the mucosa, the speaker increases the frequency of vocal fold vibration and the glottal adductory forces. This increased constriction influenced the F0 indirectly. It increases the subglottal pressure, which adds tension to the vocal folds and, consequently raised the F0.

The standard deviation of fundamental frequency (SD F0) increased from the first recording to the end of the day recording by 1.02. Hammarberg (1986) examined the relationship between voice disorders and SD F0, who found that larger than normal SD F0 accompanied a hyperfunctional, rough or unstable voice. Thus, increased SD F0 may indicate instability of laryngeal function and one possible reason for this could be impaired coordination of VF movements, which is a symptom of fatigue. Also, results are in consonance with the findings of Rantala, Vilkman & Bloigu (2002) who reported increased SD F0 after loading. Figure 5 shows the SD F0 across the working day at four different intervals of time.

The jitter value also increased from starting of the day to end of the day. It was 0.42 % at the first recording (before the first class) and increased to 0.84 % after the last class (figure 6). The same findings was reported by Gelfer, Andrews & Schmidt (1991) and Rantala, Vilkman & Bloigu (2002) who found increased jitter value after vocal loading.

The variables like F0, SD F0 and jitter had peaks and valleys during the course of a teaching day. It was less at the starting of the day and rose after the first class. The reason could be because of vocal warm-up. The duration of the first class was about 45 minutes. Rantala, Vilkman & Bloigu (2002) also observed the same phenomenon where parameters like F0, shimmer and jitter increased after first 4 minutes of teaching sample. Elliot, Sundberg & Gramming (1995) and Vilkman, Lauri, Alku, Sala, Sihvo (1999) reported that vocal warm up is a normal phenomenon that takes place about 10-30 minutes after talking has begun. In vocal warm up, some adaptation of the voice apparatus obviously takes place, and vocal and physical changes follow. However, the physiological backgrounds of the phenomenon as well as its effects are largely unknown. In this study, increase in F0, SD F0 and jitter after the first class may probably caused due to vocal warm-up.

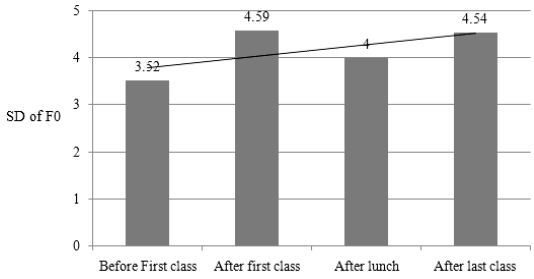

Figure 5: Standard Deviation (SD) of F0 at different interval of time.

The 'trend' followed at four intervals of time for F0, SD F0 and jitter was same and uniform. This can be observed in figures 4, 5 and 6 where it is depicted as 'trend line' in the graphs. There was an increase in F0, SD F0 and jitter after first class, followed by a reduction in these values after lunch. It can be inferred that vocal warm up has taken place after beginning of teaching. Then, the system learned to adjust with the demands of the classroom requirements. This laryngeal

adjustment depends on the classroom situations. Hence there was a reduction in the afternoon. At the end of the day, the phonation sample had higher F0, SD F0 and jitter values compared to the starting of the day. These observations were made on a single workday of a primary school teacher. Larger number of sample is warranted to generalize the results.

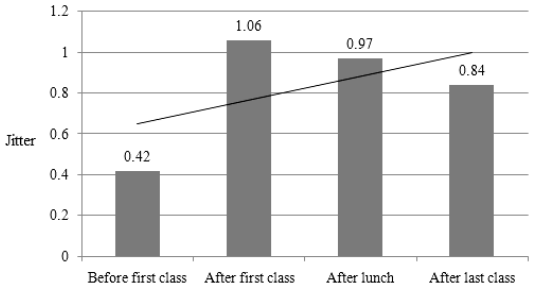

Figure 6: Jitter at different intervals of time.

Conclusions

The present study quantified the cumulative vocal fold vibration of a primary school teacher and measured the effects of prolonged teaching on acoustic parameters F0, SD F0, and jitter. The results indicated 31.46% voicing periods including 83.42% at classroom teaching and 16. 57% not at classroom teaching. Also, the F0, SD F0 and jitter increased from the first to the last recording. The F0 increased was 7.24 Hz between the two recordings i.e., before first class and after last class; SD F0 increased by 1.04 and jitter increased by 0.42%. The F0 rise may be a consequence of the normal physiological adaptation of the vocal apparatus to loading and hence, a sign of healthy voice. These findings indicate that the vocal fold movement may be impaired in coordination which in-turn put in the picture of laryngeal instability due to loading. Hence, these parameters are sensitive enough to document the one working-day related changes on voice. Further investigation on vocal health of teachers and other professional voice users is warranted. Also, the rest periods, its distribution and its effect on vocal fatigue recovery can be determined.

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