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VOICING AND SILENCE PERIODS IN DAILY AND WEEKLY VOCALIZATIONS OF TEACHERS

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Abstract

The National Center for Voice and Speech (NCVS) data bank on voice dosimetry was used to study the distributions of continuous voicing periods and silence periods in 31 teachers over the duration of two weeks. Recordings were made during all awake hours of the day. Voicing periods were grouped into half-decades, ranging from 0.0316 – 0.10 s for the shortest periods of phonation to 31.6 – 100 s for the longest periods of phonation. Silence periods were grouped into similar half-decades, but ranged up to periods of several hours. On average, the teachers had 1800 occurrences of voicing (onset followed by offset) per hour at work and 1200 occurrences per hour while not at work. Voicing occurred 23% of the total time at work, dropping to 13% during off-work hours and 12% on weekends. The greatest accumulation of voicing occurred in the 0.316 – 1.0 s voicing periods, whereas the greatest accumulation of silence occurred in the 3 – 10 s silence periods. The study begins to lay the groundwork for understanding vocal fatigue in terms of repetitive motion and collision of tissue, as well as recovery from such mechanical stress.

Keywords

vocal fatigue; occupational voice use; phonation; vocal vibration dose

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INTRODUCTION

Teaching is one of the most vocally demanding occupations. The vocal load of teachers is beginning to be quantified thoroughly and systematically. Voice accumulation and voice dosimetry devices have been developed for monitoring vocal use at work (Airo et al., 2000; Buekers et al., 1995; Cheyne et al., 2003; Granqvist, 2003; Ohlsson et al., 1989; Popolo et al., in press; Švec et al., 2003; Szabo et al., 2001). 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, et al., 1998; Södersten et al., 2002; Szabo et al., 2003). Voice accumulation times and the voicing percentages relative to total time at work have been found to be higher in teachers than in other professions. Masuda et al.(1993) measured a voicing percentage of 21% for teachers in an eight-hour workday, compared to 7 % for office workers. Sala et al. (2002) found that the average *speaking* time of day care center teachers was 40% of the time at work, compared to 28% for nurses. But this speaking time is not equal to voicing time, given that speech carries many unvoiced segments. Comparing the Masuda et al. results to the Sala et al. results suggests that voicing time is about half of speaking time.

Ten healthy female preschool teachers in daycare centers studied by Södersten et al. (2002) had a voicing percentage of 17% as determined by a voice accumulator. This result is basically in agreement with Masuda et al., considering a somewhat different teacher population. Watanabe et al. (1987) found the voicing percentage of 20 normal adults (not teachers) to be 11%, while that of 30 children was 16%. While the measures were collected over several hours and several days, an exact number of recording hours was not given. Although data sets across the globe are beginning to converge, it appears that there still exists some uncertainty about voicing percentages among teachers and other voice user populations.

If a fundamental frequency of 150 Hz is assumed for a mean between male and female teachers, one hour of voicing time (17% of six hours of teaching) translates to about half a million vocal fold collisions per day. These collisions may be a contributor to one aspect of vocal fatigue, the continual deformation of lamina propria material in the vocal folds (Gotaas and Starr, 1993; Sapir et al., 1993; Smith et al., 1997; Morton and Watson, 1998; Russell et al., 1998; Yiu, 2002; Roy et al., 2004a; Vilkman, 2004; Popolo et al., 2004).

In the above-mentioned studies, the primary focus has been on the accumulated phonation time, also referred to as the vocal load. What is missing is an equal focus on recovery time, or the off-load. One might argue that, on a daily basis, recovery time is simply 24 hours minus the accumulated phonation time. Although such a calculation is correct, it does not consider short-term recovery from moments of silence between speech segments. Also, the largest number of recording days thus far has not been adequate to distinguish weekday loads from weekend loads, nor have the at-work versus the not-at-work differences in the same corpus of teachers been documented. This study is an attempt to fill some of these gaps.

We suspect that vocal fatigue in teachers is attributable to the fact that teachers instruct primarily in a monologue style, which allows little vocal rest in a typical class period. We further suspect that total voice accumulation over a typical workday may not tell the whole story. The *distribution* of rest periods may play an important role. For example, four hours of near-monologue speech may be more injury-prone to vocal fold tissues than eight hours of dialogue with frequent turn-taking. At this point in time, however, it is not known what constitutes a minimum rest period for tissues to experience any degree of recovery. On the one hand, it could be as little as a few seconds to a few minutes if increased blood circulation occurs during voice rest (Švec and Sram, 2001) or if internal tissue fluid re-distribution is a critical factor (Fisher et al., 2001). On the other hand, it could be as much as several days if epithelial cells or extracellular matrix (ECM) products of the vocal fold lamina propria need to be regenerated (Gray, et al., 1987).

Given this current state of uncertainty in the duration of the recovery process, it seems prudent to begin with the simple question of how voicing periods and rest periods are distributed in a typical teacher's workday. We expect that short rest periods are more frequent than long rest periods, but is the relation simply inverse? In continuous speech, is there a rest period of a specific duration that accounts for more accumulated rest time than any other? How are voicing and silence periods distributed during work and after work? How are voicing and silence periods distributed on weekends as compared to workdays?

METHODS

Field Recordings

The National Center for Voice and Speech data bank on teachers was used as the primary resource. For this data bank, which is still growing, voice recordings are captured daily with the NCVS Voice Dosimeter (Figure 1a) as described previously (Švec et al., 2003; Popolo et al., 2005). The long-range goal is to recruit 80 teachers and engage each of them in 14 consecutive days of recording. The dosimeter's transducer (an accelerometer) is attached to the teacher's neck, at the sternal notch, using a special medical adhesive (Mastisol®, Ferndale Laboratories); additionally, adhesive tape is used to secure the transducer for an entire day, as shown in Figure 1b. The dosimeter can record about up to 24 hours of real-time processed data (with the help of a external battery) before needing to be recharged, enough time for a normal day of speaking. The dosimeter captures raw acceleration data at a sampling frequency of 11,025 Hz and processes the data in 30 ms intervals. Calculations of voicing decisions, skin acceleration level (which is converted to an estimate of sound pressure level, Švec et al., 2005), fundamental frequency, and voice duration are then stored every 30 ms. Figure 2 shows an example of a dosimeter recording for a test utterances we ask the teacher to give several times a day. These utterances include a sustained pitch and a pitch glide. The test utterances are performed softly and with a high fundamental frequency to test both the equipment and to elicit statements about vocal fatigue, although vocal fatigue is not discussed in detail in this paper. In Figure 2, silence is followed by sustained phonation at 550 Hz, followed by an upward pitch glide, followed by five repeated syllables / *hi* / at 600 Hz, followed by a portion of the "Happy Birthday" song, followed by silence, and finally by counting "one, two, three." These recordings offer a rich data stream to study short term, intermediate term, and long term voicing periods and recovery periods from vibrational exposure. Specifically, the lowest trace in Figure 2 is a unit step function for voicing periods (value $k_v = 1.0$) and silence periods (value $k_v = 0$). For any teacher who has completed the two-week dosimetry study, there are on the order of 100,000 data records per hour, 1.4 million records per day, or 20 million records over an entire 14-day period.

Subjects used for the current study

To date, a complete data set has been gathered on 31 teachers. The teachers (all from public schools in six Denver metropolitan area school districts) consisted of 26 females and 5 males (the U.S. teacher population is about 20% male). Of these subjects, 23% reported having some sort of voice or speech training. Two of the subjects (both physical education instructors) use an amplification system sometime during the work day; a third teacher (not a physical education instructor) uses an amplification system every day. In a study on vocal intensity, these subjects would have been excluded, but since we are reporting only voice duration results here, the amplification is of little or no consequence. The subject breakdown by teaching grade was 68% K-6th grade, 23% Junior High (7-9th grade), and 14% High School (10-12th grade). Subject breakdown by topic was 45% general education instruction, 23% physical education instruction, 18% music/theater instruction, and 14% other (library instruction, special education, etc.). It will be shown that the results from this moderate-size corpus are statistically significant to draw preliminary conclusions about vocalization of teachers in general, but not specific teacher subclasses.

RESULTS

Consider k_v to be the unit step function for voicing described earlier. Mathematically, it has a value 1.0 when there is voicing and 0.0 when there is no voicing. Let voicing duration (also referred to as voicing period) or silence duration (silence period) be the independent variable, constructed in logarithmic bins ranging from 0.0316 – 0.10 s for the shortest bin duration to 3160 – 10,000 s for the longest bin duration. Let *occurrence* of a given duration be the dependent variable, and *accumulation* within the duration be a derived variable. Figure 3a shows an occurrence histogram and Figure 3b an accumulation histogram from all 31 subjects. Black and white striped bars are for voicing periods and solid gray bars are for silence periods. Collectively, the data in Figure 3 represents 5175 hours of recording over 412 days, (average of 13.3±1.4 days per subject, 9.5 ±1.2 weekdays, 3.8±0.6 weekend days). An average of 12.5 hours per day was recorded per subject, but it was not uncommon for a subject to wear the dosimeter for more than 18 hours a day; the average of 12.5 hours per day includes some short recording days, attributed to equipment failure or the subjects' choice not to wear the dosimeter. Over the span of a week, the daily vocal activity varied widely, as will be explained later. In Figure 3, the vertical bar height represents occurrences per hour (part a) and the derived accumulation per hour (part b). The per hour normalization was necessary to do comparisons because recording durations differed for each day. The variables are plotted logarithmically on the vertical axis. Along the horizontal axis is the duration of bins in s, with the beginning and end of each bin labeled at the tic marks. Across the top is the bin number, labeled 1 through 11 for ease of discussion. Error bars indicate standard deviations across subjects.

Each bin in the histograms contains a half decade of logarithmic time. Thus, bin 1 contains all occurrences that are 0.0316 – 0.10 s long (voicing and silence periods below and up to the phonemic segmental level in speech). Bin 2 contains all occurrences that are 0.1 – 0.316 s long (voicing and silence periods roughly at the phonemic and syllabic level). Bin 3 contains all occurrences that are 0.316 – 1.0 s long (vowels and silence periods roughly at the word and phrase boundary level). Bin 4 contains all occurrences that are 1.0 – 3.16 s long (all-voiced sentences and voicing pauses between sentences). It is tempting to relate these durations to exact speech rhythms and pauses (Boomer and Dittman, 1962); Jaffe and Feldstein, 1970), but the division into half-decades is more systematic and computer-manageable at this point.

Bin 5 contains all occurrences that are 3.16 – 10 s long (sustained phonations, as in singing, and pauses between sentences, as perhaps waiting for a response from a student). Bin 6 contains all occurrences that are 10 – 31.6 s long (rare exceptionally long phonations and silences typical of frequent turn-taking in a dialogue). Bin 7 contains all occurrences that are 31.6 – 100 s long (no voicing periods, but silences that are part of less frequent turn-taking in dialogue). Bin 8 contains all occurrences that are 100 – 316 s long (typical of a break in class to allow students to ponder or do an in-class assignment). Bin 9 contains all occurrences that are 316 – 1000 s long (typical of between-class silent preparations for the next class). Bin 10 contains all occurrences that are 1,000 – 3162 s long (typical of full class periods of silence). Finally, bin 11 contains all occurrences that are 3162 – 10,000 s long, several hours of continuous silence.

Bin 1 deserves some special discussion. Any period (voicing or silence) less than 0.1 s is sampled by less than three consecutive data points, given that 30 ms was the sampling period of the processed data. Because it requires at least two data points to determine the shortest on-off sequence, considerable "sampling noise" may have contaminated bin 1 data. The temptation was to eliminate bin 1, but there is as yet no strong justification for it. Because the durations are so short, the overall voice accumulations were not significantly affected by bin 1. Hence we kept it in the distribution. However, we did not include bin 1 in the final totals and averages.

In bins 2 and 3, voicing occurrences are slightly greater than silence occurrences. These occurrences pertain to the voiced-unvoiced characteristics of a spoken language, in this case American English. Unvoiced consonants and short gaps between words occur almost as often as vowels and voiced consonants in continuous speech, as reported by Löfqvist and Mandersson, (1987). In a reading monologue, these authors found that the voicing percentage is about 50%, with the silences being divided into unvoiced segments (15%) and boundary pauses (35%). By adding up bins 1 through 3, a total of 2500 occurrences of these segmental durations per hour are derived from Figure 3a. In other words, the vocal folds adducted and abducted almost once per second throughout the day.

For bins 4 and higher, the order-of-magnitude differences between voicing periods and silence periods diverge sharply. Continuous voicing is rare for 3 s or more, but silences for 3 s or more are abundant. Silence durations between 3.16 s and 10 s (bin 5) occur about 125 per hour, silences between 10 s and 31.6 s (bin 6) occur on the order of 40 times per hour, silences between 31.6 and 100 s (bin 7) occur on the order of 10 times per hour, silences between 100 s and 316 s (bin 8) occur on the order of 1.5 per hour, and silences above 316 s (more than 5 minutes, bin 9) occur only on the order of once per day (1-2 every 10 hours).

At-Work and Not-At-Work Comparisons

Each subject kept a daily log of their activities, from which the dosimeter data were subdivided into *at-work* and *not-at-work*. The at-work division included all times at school, meetings after classroom teaching, coaching, performances and all other school related extracurricular activities. This resulted in over 2170 total recording hours with an average of 70±15.5 hours per subject. Not-at-work time was any other time the dosimeter was active, including evenings and weekends, resulting in over 3000 total recording hours with an average of 96.8±22.5 hours per subject.

Comparing the occurrences of voicing periods per hour at-work to voicing periods per hour not-at-work (Figure 4a), the histograms show a 30% reduction in occurrences of short periods, from about 3000 occurrences per hour of voicing collectively in bins 1 – 3 at-work to about 2000 occurrences per hour of voicing in the same bins not-at-work. However, as the bin duration gets larger (e.g., bins 5 and 6), not-at-work occurrences of voicing become equal to or overtake the at-work occurrences.

The larger bins could be influenced by the test utterances we ask the teacher to give several times a day (recall Figure 2). These utterances include a sustained pitch and a pitch glide (both 2-4 s in length). The test utterances are performed softly and with a high fundamental frequency to test vocal fatigue. Since the subjects produced six voice tests per day on average, there would be a minimum of 12 phonations per day (or about one per hour) between 2-4 s long (bins 4 and 5). But it is not uncommon for the high pitched, soft sustained phonations to have voice breaks because of vocal fatigue; therefore, a 3 s sustained pitch with a break may appear as two 1.5 s phonations. This would double the occurrences in bin 4 from test utterances (from 12 to 24 per day), but would still not come close to accounting for the 100 occurrences per hour measured in bin 4. Thus, we conclude that teachers must be vocalizing long duration speech or non-speech (e.g., singing, cheering, or shouting) as part of their teaching material, especially for occurrences in bin 5 and higher.

The longer voicing periods in bins 6 and 7 are not typical of normal speech and happen rarely (bin 6, about once every ten hours; bin 7 about every two days). Given that several of the subjects were music and theatre teachers, and that there are instances were long vocalizations may be used in other teaching examples, it is not surprising that there are some instances of long periods. Because of the low occurrence of such voicing durations, however, no statistical differences between at-work and not-at-work in bins 5 – 7 could be determined. By comparison, differences between not-at-work occurrences and at-work occurrences in bins 2 – 4 were different, t(31, single tailed), $p<0.001$.

Consider now the silence occurrences at-work and not-at-work (Figure 4b). The most interesting result is the gradual increase of the not-at-work bin height (relative to the at-work bin height) with higher bins. Not-at-work time favors long silence periods, while at-work time favors short silence periods. At bin 5, the occurrences are nearly equal. Differences between not-at-work occurrences and at-work occurrences were different for all bins, t(31), $p<0.01$. Consider the 1 – 15 minute silence periods (bins 8 and 9), which occur twice as frequently not-at-work as at-work. These silences may be important for teachers in terms of muscle fatigue recovery. There were about 2 of these silences per hour not-at-work, but most of them less than five minutes in length. Occurrences of 5 – 15 minute rest periods (bin 9) occurred only about once every six hours at-work and once every three hours when not-at-work. These long durations could be slightly underestimated, however, due to accelerometry artifacts (e.g., from physical activities such as swallowing or bumping one’s neck). These artifacts, in the form of disruptions of voicing or silence, cannot be eliminated completely from current dosimetry. Our measurements indicate, however, that accelerometry artifacts can account for only about 2% of the detected voicing durations (unpublished).

Since there is a general inverse relation between the number of occurrences of a voicing period and its duration (i.e., all shorter occurrences are more frequent than the longer ones), a reasonable question is whether or not the distributions become flat if the total *integrated* time of phonation or rest is plotted for each bin. This is done in the lower part of Figure 4 (c and d). The accumulations of voicing and voice rest offer a different perspective. The distributions are not flat, but unimodal up to bin 10. Again, because bin 11 is poorly sampled due to low occurrence, there is less confidence in the shape of the distribution at high bins. For voicing accumulation, the peak is at bin 3 and the distribution is skewed slightly to the left. The 0.316 – 1.0 s voicing periods in bin 3 (basically strings of vowels and voiced consonants) were responsible for the greatest amount of accumulated voicing. There are 460 s/hour of accumulated voicing in bin 3 at-work and 350 s/hour not-at-work.

For silence accumulation (Figure 4d), we also see a broad unimodal distribution, but the skewing is slightly to the right. The peak of the distribution is at bins 5 – 6. These 3.16 – 31.6 s silence periods in bins 5 and 6, which we deemed typical of dialogue turn-taking, provided the greatest amount of accumulated vocal rest. Note also that bins 9 – 10 are larger than bins 1 – 2 for not-at-work hours, which is not true for the at-work hours. After work, the teachers get more accumulated rest from the long silences than from the short silences.

Workdays and Weekend Comparisons

Of further interest is the comparison between work days and non-work days (i.e., *weekdays* and *weekends*). Figure 5 shows this comparison. If we assume that teacher weekend vocal loads are typical of average non-teacher vocal loads, then these numbers provide the internal control for voicing on the job to normal (non-occupational) voicing. In general, the weekend histograms are similar to the not-at-work weekday histograms (compare all the striped bars in Figure 5 to all the striped bars in Figure 4).Weekday occurrences of voicing and weekday voice accumulations are all higher than their weekend counterparts for bins 1 – 4 (Figures 5a and 5c), but for larger voicing periods (bins 5 – 7) there is a reversal. This may again be attributed to non-speech vocalizations, or poor sampling of the occurrences of these long periods. Aside from this overall lowering of the voicing occurrences and accumulations on weekends, the distributions did not change remarkably.

Changes over a week

Figure 6 shows ensemble averages for voicing occurrences per hour and voicing percentage (of recorded time) over a one week stretch. The two-week data were averaged to get this equivalent one-week result. Voicing occurrences (Figure 6a) were on the order of 1800 per hour at-work and 1200 per hour not-at-work (bin 1 occurrences were not included in these totals and averages). The overall daily average (dark, solid curve) was 17,000 occurrences per work day, computed over an average 12.4 hour recording session (7.5 hours at-work and 5.35 hours not-at-work). If the not-at-work time were extended to 8 hours, there may be as many as 20,000 occurrences of voicing per day for an average teacher. In terms of voicing percentage, Figure 6b shows a mean of 23% at-work and 13% not-at-work. On weekends, voicing percentage drops to 12%. However, this difference between not-at-work and weekend was not statistically significant. The value 12-13% is considered to be the control value for the population at large, assuming that teachers spend their weekends and time away from work the same way as people in other occupations. It is close to the 11% value cited earlier (Watanbe et al., 1987) for a general population of non-teachers.

Details of inter- and intra-subject comparisons, with means and standard deviations, are given in Tables I and II. Table I shows results for occurrences of voicing and silence periods, while Table II shows results for voicing percentage. At-work and not-at-work averages for both the number of occurrences and percent voicing were statistically different ($p<0.001$), whereas not-at-work and weekends were not statistically different.

DISCUSSION AND CONCLUSIONS

In a long-range goal of quantifying the amount of vibration exposure that teachers inflict upon themselves by talking, a first step has been taken to determine the distribution of voicing and silence periods. It was found that teachers vibrate their vocal folds 23% of the time that they teach, as opposed to 12% of the time that they do not teach. The total accumulation of voicing time is then about two hours in an eight-hour workday. This agrees with findings of others, who report the voicing percentages of teachers to be between 15-40 % (Masuda, et al., 1993; Rantala, et al., 1994; Rantala, et al., 2002; Södersten, et al., 2002). But because voicing is not continuous for long periods of time, the distribution of voicing periods and silence periods becomes important. Overall, voicing turns on and off about 20,000 times a day for teachers. This in itself may be a fatigue factor because laryngeal adductor/abductor muscles must execute this switching on and off of the voice. There are many short on-off episodes and a few long ones. Voicing periods and silence periods are about equal in number of occurrences, about 1000 per hour, when their duration is less than a second. This is simply a function of spoken language, reflecting the number of voiced and unvoiced segments in speech. Voicing periods in the 3 – 10 s range are rare, reflecting non-speech vocalizations such as singing or testing of one's voice. Silences in the 3 – 10 s range are abundant, on the order of 100 per hour. These silences, and those in the 10 – 100 s range, are frequent in dialogue. They represent the greatest accumulation of vocal rest during the work day. When teachers are not at work (evenings and weekends), more of the total vocal rest is attributed to longer periods of silence. Sleep time is, of course, the greatest contributor to this. We have not asked the teachers to wear the dosimeter during sleep, but informally, members of our research team have done so. They report no problem in gathering the data, but results are not included here.

A next step is to determine which of these rest periods has any profound effect on vocal fatigue recovery. The NCVS Dosimeter is designed to query the subject occasionally for perceptual cues of vocal fatigue; while a discussion of fatigue was beyond the scope of this paper, when addressed, fatigue will be analyzed statistically on the basis of the distributed occurrences of voicing and silences. Looking ahead to this in-depth discussion in the fugure, if fatigue is related to re-distribution of fluids in the vibrating portion of the tissue (Fisher et al., 2001), perhaps a rest period of a few seconds will produce some recovery. If blood circulation has been disturbed by tissue vibration, perhaps a few minutes of rest will produce recovery (Švec and Sram, 2001). If muscles have been fatigued in the voice onset-offset gestures, perhaps a fraction of an hour to several hours will produce recovery (Skof and Strojnik, 2006; Augstsson et al., 2006; Albert et al., 2006). Future work will answer these questions at two levels of investigation. First, prescribed levels of vocal duty ratio (e.g., 30% on, 70% off) will be elicited from volunteer vocalists over several hours. Autoperception of vocal fatigue will be tracked (Scherer et al., 1987). Second, using the results from the current paper, *in vitro* studies on engineered vocal fold tissue in a bioreactor (Titze et al., 2004) will be conducted to determine gene expression and corresponding indication of tissue repair due to vibration over specified periods of time. From this gene expression analysis, specific proteins will be identified that may play a role in tissue recovery.

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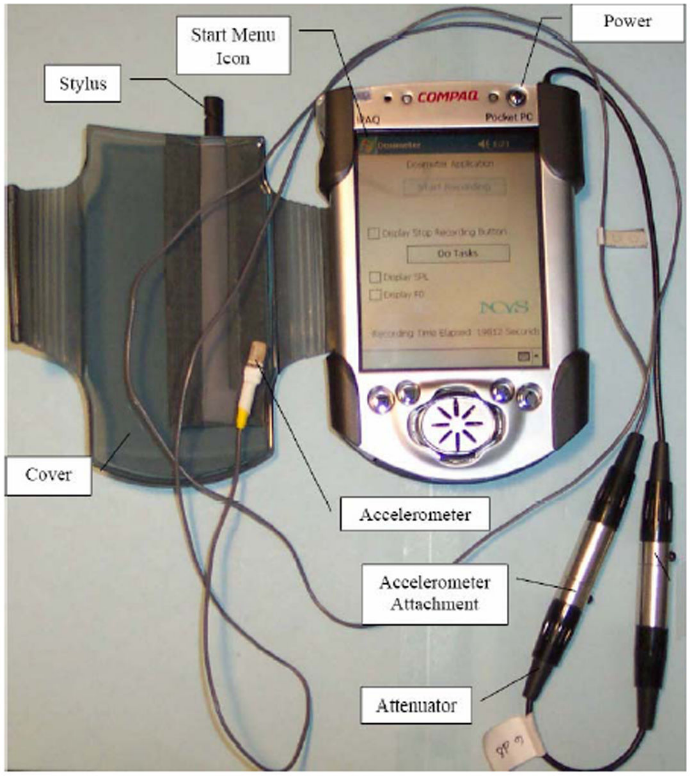
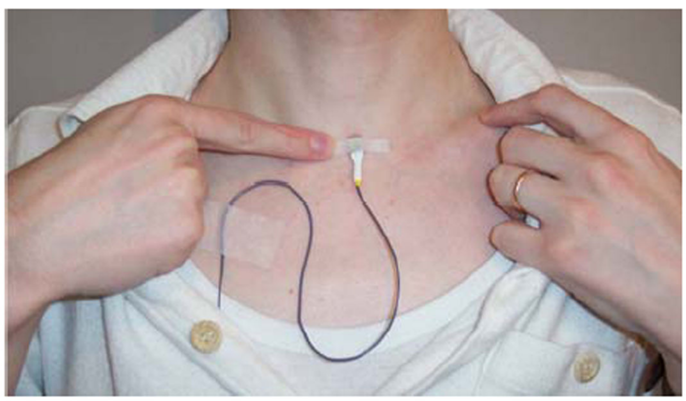


(a)



(b)

Figure 1.

(a) The NCVS Voice Dosimeter, consisting of a modified Pocket PC with an accelerometer as the transducer. (b) The accelerometer is attached using hypo-allergenic medical adhesive and medical tape, attached to the sternal notch. The cabling runs underneath the clothing and the dosimeter is worn in a fanny pack.

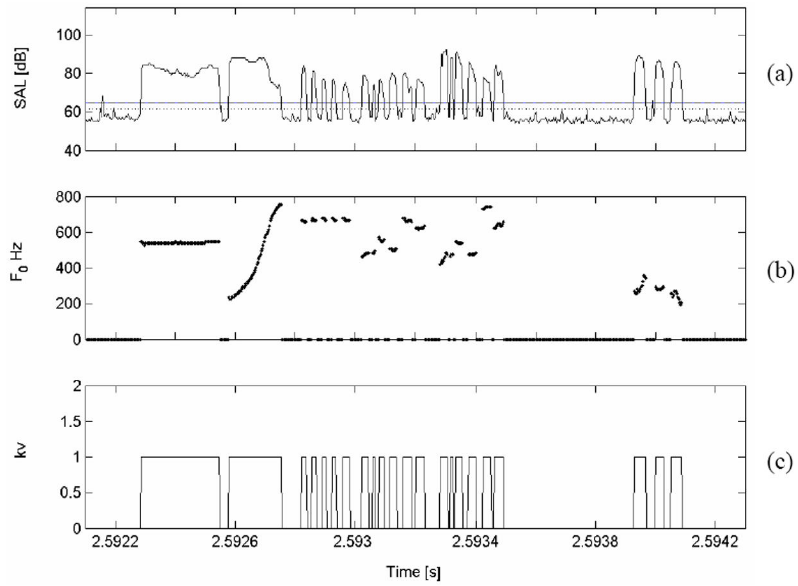


Figure 2.

A dosimeter recording: (a) skin acceleration level (SAL) in dB, (b) voicing fundamental frequency, (c) and voice/no-voice switch k_v (1 for voice, 0 for no voice).

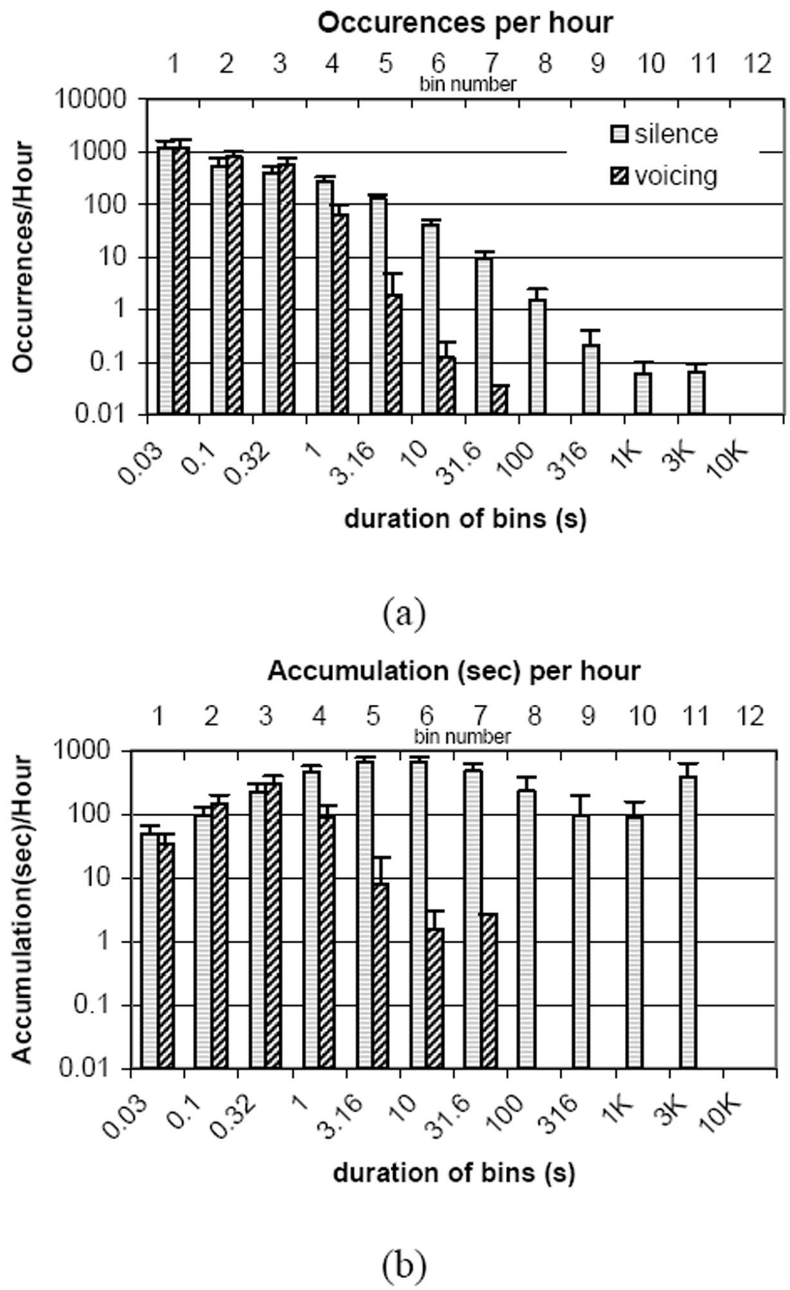


Figure 3.
Ensemble averages (31 teachers) of histograms for (a) voice and silence occurrences per hour for specific durations in logarithmic bins, and (b) voice and silence accumulations in seconds per hour for these same occurrences, over the same bin distribution.

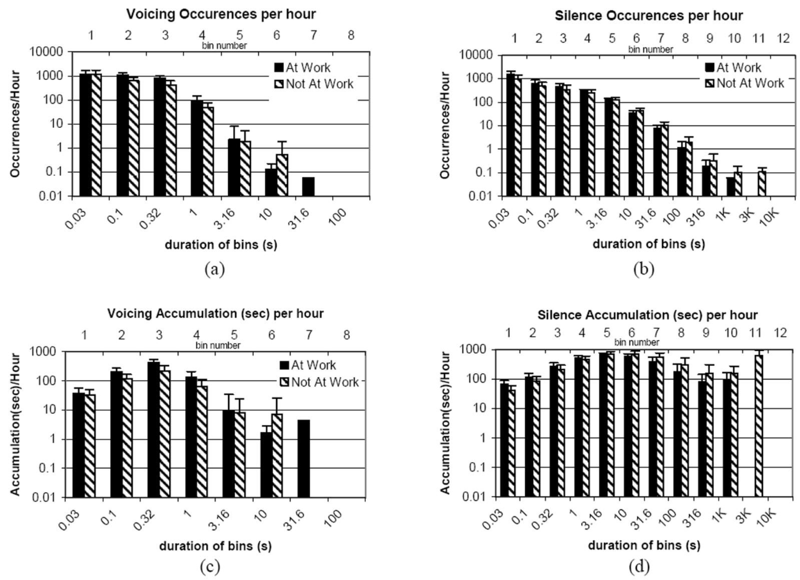


Figure 4.

Ensemble averages (31 teachers) comparing at-work and not-at-work histograms of (a) voice occurrences per hour, (b) silence occurrences per hour, (c) voice accumulation in seconds per hour, and (d) silence accumulation in seconds per hour.

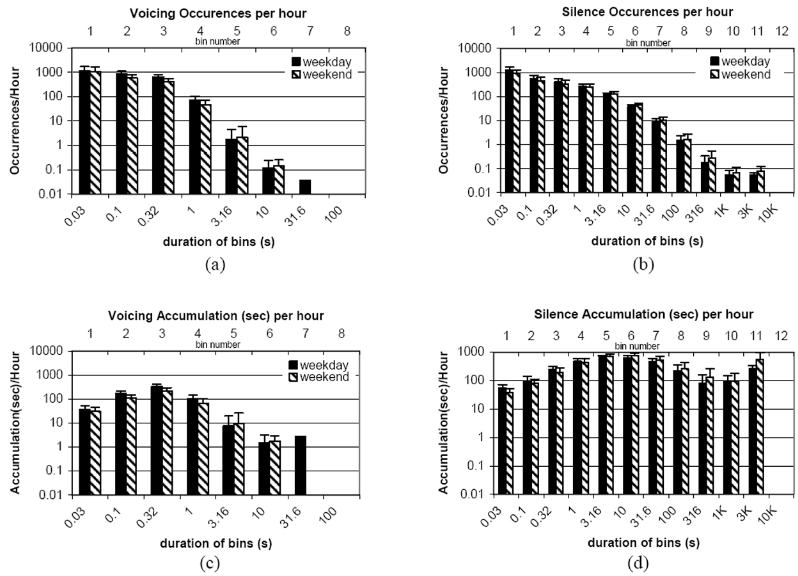
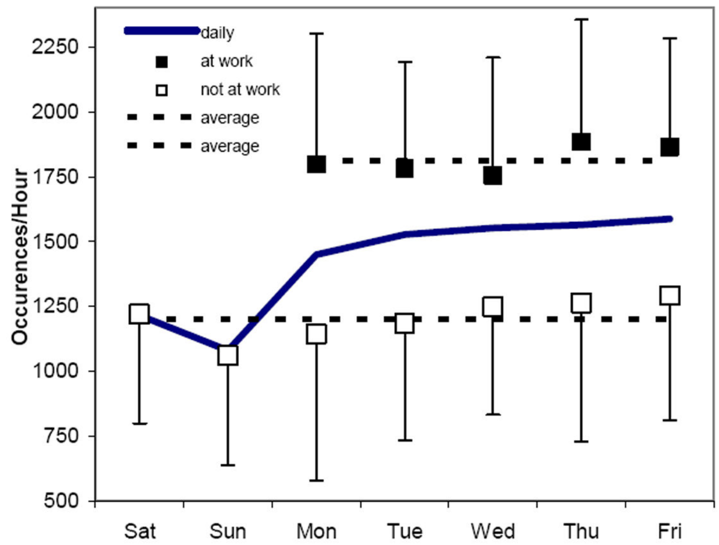
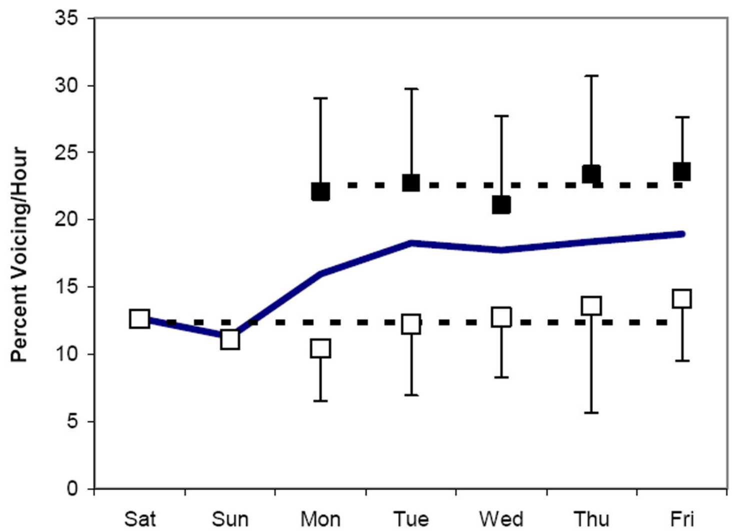


Figure 5.

Ensemble averages (31 teachers) comparing weekday and weekend histograms of (a) voice occurrences per hour, (b) silence occurrences per hour, (c) voice accumulation in seconds per hour, and (d) silence Accumulation in seconds per hour.



(a)



(b)

Figure 6.

Ensemble averages (31 teachers) of (a) voicing occurrences per hour and (b) voicing percentage per hour over a period of a week. A two-week stretch was averaged into an equivalent one week stretch.

Table I.

The results of each subject are presented in terms of vocal occurrences per hour of recording (# occurrences), the number of hours of recording, and number of days the subject participated. Results are displayed in terms of the weekday at work average, weekday not at work average and the weekend average. Averages and standard deviations for the overall group were shown. At Work and Not At Work averages were statistically different (p<0.001) where Not At Work and Weekends were statistically similar.

	At Work		Not At Work		Weekends		# Days of recording	
Subject	# occurrences	hrs	# occurrences	hrs	# occurrences	hrs	weekday	weekend days
F002	2712.5	71.6	1735.1	94.8	1610.5	52.8	9	5
F009	3207.8	78.9	1732.9	114.4	1838.9	51.0	10	4
F017	3409.5	35.2	2015.2	104.5	1062.5	40.6	9	4
F020	2366.9	53.6	1551.4	64.7	1296	30.4	8	4
F035	2246.8	76.3	1318.8	63.7	1584.2	46.1	8	4
F061	4353.5	64.1	3093.1	104.3	3105	36.7	10	3
F062	1554.3	78.3	1813.8	58.5	1485.4	24.3	10	4
F064	2911.6	75.6	1649.2	90.3	1549.3	36.9	10	3
F069	2568	38.8	1802.4	62.8	1967.4	29.6	5	3
F076	4161.5	63.2	2188.4	95.0	2088	53.5	10	4
F077	2802.7	100.4	2084.6	75.3	2025	45.6	10	4
F081	3890.5	60.4	1560.5	97.9	1432.9	37.2	10	4
F083	3367.6	70.9	1519.3	75.0	1530.7	27.4	8	2
F086	4505.5	83.0	2650.2	124.5	2842.9	52.4	10	4
F089	2052.8	86.8	1420.2	100.4	1732.8	42.4	10	4
F093	3908.3	87.7	3159.7	103.2	3337.4	47.2	10	4
F094	2467.3	91.3	1775.4	50.9	1960.5	52.3	7	4
F095	2919.1	55.9	2407.8	116.1	2340.7	47.7	10	4
F096	3151.6	72.9	2422.9	77.2	2288	45.7	9	5
F097	3015.9	55.6	2422.6	108.4	2160.8	43.2	10	4
F098	3216.4	56.4	2804.5	124.1	2905.6	44.8	10	4
F100	2201	80.9	1308.1	105.4	1736.8	61.8	9	3
F101	3615.1	58.9	2375.2	108.9	1720.9	51.0	10	4
F102	3050	60.7	2845.7	125.2	3083.3	56.4	10	4
F103	2833.6	73.2	2250.2	87.0	2065.1	37.8	10	4
F104	4634.1	63.5	3493.4	126.8	3791.8	51.6	10	4
M042	3572.7	70.8	2770.2	110.2	1909.1	46.5	10	4
M043	2322.9	85.4	1721.6	103.1	1765.7	46.2	10	4
M044	2655.5	68.6	1578	115.6	1548.6	43.1	10	4
M045	3680.4	99.8	2865.4	77.7	3075.9	29.6	11	3
M047	2711.1	54.4	2940.4	136.6	2776.7	54.1	10	4
avg	*3098.9*	*70.1*	*2170.2*	*96.9*	*2116.7*	*44.1*	*9.5*	*3.8*
std	*750.7*	*15.7*	*611.1*	*22.6*	*676.3*	*9.2*	*1.2*	*0.6*

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Table II.

The results of each subject are presented in terms of the percentage voicing per hour of recording (% voicing), the number of hours of recording, and number of days the subject participated. Results are displayed in terms of the weekday at work average, weekday not at work average and the weekend average. Averages and standard deviations for the overall group were shown. At Work and Not At Work averages were statistically different ($p<0.001$) where Not At Work and Weekends were statistically similar.

	At Work		Not At Work		Weekends		# Days of recording	
Subject	**% voicing**	**hrs**	**% voicing**	**hrs**	**% voicing**	**hrs**	**Weekday**	**weekend days**
F002	20.0	71.6	9.9	94.8	8.9	52.8	9	5
F009	27.3	78.9	14.0	114.4	17.1	51.0	10	4
F017	37.5	35.2	14.6	104.5	10.7	40.6	9	4
F020	14.6	53.6	9.1	64.7	7.6	30.4	8	4
F035	20.7	76.3	9.5	63.7	11.7	46.1	8	4
F061	32.1	64.1	18.4	104.3	16.6	36.7	10	3
F062	12.8	78.3	11.9	58.5	7.8	24.3	10	4
F064	26.7	75.6	9.9	90.3	9.5	36.9	10	3
F069	20.9	38.8	13.1	62.8	14.4	29.6	5	3
F076	25.4	63.2	11.2	95.0	11.0	53.5	10	4
F077	18.8	100.4	13.0	75.3	12.8	45.6	10	4
F081	29.3	60.4	8.8	97.9	8.2	37.2	10	4
F083	27.0	70.9	9.2	75.0	10.5	27.4	8	2
F086	20.0	83.0	9.4	124.5	9.9	52.4	10	4
F089	25.6	86.8	12.0	100.4	14.3	42.4	10	4
F093	21.8	87.7	14.6	103.2	16.2	47.2	10	4
F094	20.3	91.3	10.8	50.9	12.9	52.3	7	4
F095	12.9	55.9	11.7	116.1	12.3	47.7	10	4
F096	19.3	72.9	13.8	77.2	12.6	45.7	9	5
F097	25.0	55.6	13.7	108.4	12.6	43.2	10	4
F098	20.9	56.4	14.2	124.1	16.5	44.8	10	4
F100	22.2	80.9	10.0	105.4	14.9	61.8	9	3
F101	27.8	58.9	11.0	108.9	8.1	51.0	10	4
F102	23.6	60.7	15.7	125.2	18.3	56.4	10	4
F103	15.0	73.2	7.6	87.0	6.8	37.8	10	4
F104	26.1	63.5	13.3	126.8	14.4	51.6	10	4
M042	24.2	70.8	14.7	110.2	9.9	46.5	10	4
M043	12.1	85.4	9.9	103.1	8.3	46.2	10	4
M044	20.8	68.6	9.8	115.6	10.0	43.1	10	4
M045	23.1	99.8	11.5	77.7	11.1	29.6	11	3
M047	22.8	54.4	16.9	136.6	15.7	54.1	10	4
avg	22.5	*70.1*	12.0	*96.9*	13.0	*44.1*	*9.5*	*3.8*
std	5.7	*15.7*	2.6	*22.6*	3.2	*9.2*	*1.2*	*0.6*