

Measuring Improvement in Teachers with Voice Complaints Using the Inability to Produce Soft Voice (IPSV): Preliminary Data

Jennifer L. Spielman¹, Eric J. Hunter², Angela E. Halpern¹, and Ingo R. Titze²

¹ National Center for Voice and Speech-Denver
An Affiliate of the University of Colorado, Denver, CO 80204, USA,

² National Center for Voice and Speech-Denver
The University of Utah, Salt Lake City, UT, USA

We assessed the Inability to Produce Soft Voice (IPSV) for tracking vocal improvement in teachers with general voice complaints, during and after voice therapy. Eleven grade school teachers received direct voice therapy (“Vocal Fold Adduction Training”, VFAT) or Voice Amplification (VA) over six weeks, and rated their ability to produce soft phonation using the IPSV before, during, and after treatment. Baseline ratings were also collected during a two-week period prior to VFAT and VA. Teachers were actively teaching during all phases of the study. Pre- to post-therapy IPSV changes were calculated, and compared to Voice Handicap Index (VHI) scores and acoustic voice measures. IPSV ratings decreased throughout therapy for the VFAT but not the VA group. Decreases were significant and correlated somewhat with VHI improvements. IPSV ratings during the baseline period were stable and showed no learning effect. Acoustic measures did not change significantly. The IPSV appears to sensitively track improvement in teachers with general voice complaints during a period of voice therapy, with no evidence of learning effect. Future research should replicate these findings with larger subject and control groups. The IPSV should also be tested for usefulness in tracking response to other voice treatments. Updates to this memo can be downloaded at <http://www.ncvs.org/ncvs/library/tech>.

Keywords: vocal fatigue, subjective ratings, vocal therapy, vocal training, vocal fold swelling, soft voice, voice break, vocal effort, vocal loading.

1. Introduction

A growing body of literature continues to support the finding that teachers around the world are at risk for developing voice disorders (de Jong et al., 2006; Fortes et al., 2007; Kovess-Masfety et al., 2006; Munier & Kinsella, 2008; Roy et al., 2004b; Sliwinska-Przygocka et al., 2006; Smolander & Huttanen, 2006; Thibeault et al., 2004; Williams, 2003). Prevalence estimates of the problem range widely depending on the method used to gather the information (Mattiske et al., 1998; Williams, 2003; Yiu, 2002), but the impact of voice disorders among teachers has been well documented in reports of lost workdays (Roy et al., 2004a; Sapir et al., 1993; Smith et al., 1997; Smolander &

Huttanen, 2006), short- and long-term reductions in teaching load (Smith et al., 1998), and an estimated annual cost (medication, clinic visits, substitute teachers, etc.) to the U.S. economy of \$2.5 billion (Verdolini & Ramig, 2001). Voice disorders may also negatively affect areas of a teacher's life outside of school (Ma & Yiu, 2001; Smith et al., 1996) and can ultimately force a change in career (Mattiske et al., 1998).

Voice disorders among teachers may be commonplace enough to be considered an “occupational hazard” (Morton & Watson, 1998), yet etiology remains under investigation. Individual studies have highlighted the effects on the voice of the amount and intensity of voicing (Thibeault et al., 2004), distribution of voicing and silence periods throughout the day (Titze et al., 2007), comparison of at-work and not-at-work voicing patterns (Hunter and Titze, 2010), physical and psychological stressors (Kooijman et al., 2006), body posture (Kooijman et al., 2005), and family history of voice disorders (Roy et al., 2004b). Reviews of the literature reflect on the multi-factorial nature (Mattiske et al., 1998; Vilkman, 2004) and the gender differences of the problem (Hunter et al., 2011). To date, it remains unclear which factors play the largest role in the development of voice complaints and disorders among teachers.

Recently, increased attention has been placed on preventing teaching voice problems. Such programs are intended to increase awareness and reduce the likelihood of developing a disorder. They are supported by limited evidence demonstrating that teachers who have had vocal training appear to complain of fewer voice symptoms than those who have not (Bistrizki & Frank, 1981; Ilomäki et al., 2005). But prevention of a problem is challenging when the exact causes are unknown, and this is reflected in the variety of approaches recommended for maximizing vocal health in teachers. Some programs have focused on education and vocal hygiene (Chan, 1994), while others aim at direct modification of voice behaviors (Duffy & Hazlett, 2004). A third category includes both direct and indirect training approaches (Amir et al., 2005). Program lengths and intensity vary widely, ranging from one to two days (Bovo et al., 2007; Lehto et al., 2003) to a course of six to eight weeks (Amir et al., 2005; Pasa et al., 2007). Some researchers have proposed integrating voice training for professional voice users into a general educational curriculum, spanning more than a year (Timmermans et al., 2004), and some advocate for the use of portable amplification devices to reduce vocal loading (Jonsdottir et al., 2001).

Preventive treatment studies report at least some benefit to vocal health, and research continues to evaluate the effects of different therapeutic approaches on both at-risk and disordered teaching voices (Chen et al., 2007; Gillivan-Murphy et al., 2006; McCabe and Titze, 2002; Niebudek-Bogusz et al., 2008; Roy et al. 2001, 2002, 2003). However, no one program or approach has emerged as a proven effective training for teachers in the prevention of voice problems, either through vocal hygiene education or direct voice building, or a combination. There remains insufficient evidence to support the recommendation of any preventive voice therapy program despite the acknowledgement that they are probably useful (Cochrane Review; Ruotsalainen et al., 2007).

We propose that the main reason it has been difficult to assess the merits of preventive voice training is that a measure has not yet been established that successfully evaluates functional improvement in mildly dysphonic or non-dysphonic voices. The methods used to date—including questionnaires, voice handicap scales, and acoustic analyses—all present challenges to interpretation, as described below. In addition, these methods do not necessarily estimate “voice-

related working ability” (Vilkman, 2004), which has been proposed as a standard by which to measure the effectiveness of training programs designed to promote vocal endurance. What follows is a brief discussion of current approaches, followed by a description of a new index of soft phonation (the Inability to Produce Soft Voice, or IPSV) that we believe may help track changes in voices exposed to heavy use.

Questionnaires, Perceptual Scales, Acoustic Measures

Teachers often complain of voice symptoms that come and go throughout the day, or interfere with teaching during the week but then improve over the weekend. One common and reasonable approach to researching the effects of training programs is to ask teachers to describe the frequency and severity of voice symptoms before and after training (e.g. Lehto et al., 2003; Pasa et al., 2007). However, in learning to make such judgments, post-treatment results—whether positive or negative—may be affected by changes in awareness, in addition to any therapy-related differences in behavior or function. Moreover, there is debate about whether speakers can accurately and reliably monitor and report on their own voices (Karnell et al., 2007). Bastian, Keider, and Verdolini-Marston (1990), for example, found that 26 singers who presented themselves for evaluation at a voice clinic estimated the duration of their symptoms very differently before and after discussion with a clinician, suggesting that even trained voice users may lack awareness regarding what constitutes a worsening voice.

Many studies have employed the Voice Handicap Index (VHI) (e.g., Bovo et al., 2007; Duffy & Hazlett, 2004; Timmermans et al., 2004), a reliable and valid 30-question self-rating form that gathers information about the functional, physiological, and social impact of a voice disorder (Jacobson et al., 1997; Webb et al., 2007). While recent evidence suggests that this and some other standardized self-rating tools reliably assess changes following voice therapy in dysphonic voices (Steen et al., 2008), it may not be sensitive enough to detect improvement in individuals whose main complaint is “vocal fatigue”. The VHI specifically requires a minimum decrease of 18 points to indicate significant change, and may demonstrate a “floor” effect among individuals without frank dysphonia if the initial rating does not provide enough room for improvement (i.e., the pre-treatment rating is less than 18).

Most studies combine questionnaire and listener-perception outcomes with instrumental or acoustic voice measures (e.g., Amir et al., 2005; Bovo et al., 2007; Chan, 1994; Duffy & Hazlett, 2004; Pasa et al., 2007; Timmermans et al., 2004), providing objective information to support self- and clinician ratings. However, studies attempting to correlate voice complaints with objective acoustic measures often remain inconclusive. Lehto et al. (2006) recorded a group of telephone customer advisors four times during a working day and asked them to report on their voice symptoms at the same time. They found that while F_0 increased significantly during the course of the day, there was no correlation between the acoustic measures (F_0 , SPL, and alpha ratio) with the 11 self-reported symptoms. Similarly, Laukkanen et al. (2008) found no significant correlation between reported symptoms of vocal fatigue and acoustic measures (SPL, F_0 , alpha ratio, jitter and shimmer) for a group of female teachers recorded before and after a “vocally loading” working day. Like Lehto et al. (2006), these authors did find a statistically significant increase in F_0 at the end of the working day, as well as increases in some other acoustic variables. In light of such findings, these studies and others (e.g. Jonsdottir et al., 2002) have suggested that observed increases in F_0 and SPL may actually reflect “adequate adaptation to vocal loading” in some individuals, and not vocal

degradation, potentially explaining why individual speakers have been found to exhibit different patterns of change after a vocally loading task or a working day (Laukkanen & Kankare, 2006; Niebudek-Bogusz et al., 2007; Rantala et al., 1998).

Vocal Fatigue in Teachers, and the Inability to Produce Soft Voice (IPSV)

In summary, many of the measures chosen to examine voice improvement in teachers receiving treatment have shown limited consistency across studies, making it difficult to assess the usefulness of therapy. Moreover, as implied in the above discussion, symptoms described by teachers often fall under a general complaint of “vocal fatigue”, a widely-used term without a formal definition (Solomon, 2008; Welham & Maclagan, 2003). Vocal fatigue has been described in terms of production, as a voice “weakened” through prolonged use (Bach et al., 2008), self-perception, as an increase in the sense of phonatory effort following prolonged use (Solomon 2008), or a combination of increased effort combined with phonatory degradation (McCabe & Titze, 2002). While strong arguments exist for defining vocal fatigue in terms of effort (Solomon, 2008), we have chosen to focus on the physiological effects of excessive use and adopt the definition used by Welham and Maclagan (2003): “negative vocal adaptation that occurs as a consequence of prolonged voice use” (p. 22). Exactly how this negative adaptation is related to the host of signs and symptoms often associated with fatigue—such as hoarseness, discomfort, and instability (see Holmberg et al., 2007)—or to long-term vocal pathology, remains unclear. However, the definition suggests a clear cause (prolonged voice use) and a general effect on the voice (negative adaptation).

Negative vocal adaptation in this context may pertain to either lamina propria material fatigue or laryngeal muscle fatigue, or some combination. Although it is not yet clear which of these systems is the greater driving force behind the experience of vocal fatigue, it has been demonstrated that prolonged vocal fold vibration causes damage to the lamina propria (Gray & Titze, 1998), while the intrinsic muscles of the larynx appear more resistant to fatigue (Cooper & Rice, 1990). Titze (1999) has also suggested that brief rest periods from phonation may benefit the laryngeal muscles to a greater extent than vocal fold tissue, which requires more time for recovery. Eventually, prolonged voice use may cause a chronic problem when tissue recovery requires more rest time than is available. Because teachers are often subjected to vocal demands after school or on weekends (rehearsals, coaching, debate team), those in need of more time for repair may not be getting sufficient voice rest to start the school week with a recovered mechanism. Eventually there may be a threshold below which recovery of tissue is no longer complete, muscular compensation to produce a stronger or more consistent voice may become entrained, and a chronic condition has developed (Boucher et al., 2006; Branski et al., 2006; McCabe & Titze, 2002). It is just such a chronic condition that preventive voice training programs hope to avert.

The ability to easily and reliably measure signs of vocal fatigue, and the recovery from fatigue, is therefore a potentially powerful tool in both the prevention of voice problems in teachers and the measurement of improvement in vocal function for speakers subjected to heavy use. Although to date there is no clear metric of vocal fatigue in non-pathological voices, controlled vocally fatiguing tasks (speaking for prolonged periods, usually at higher than normal intensities) often result in increased phonation threshold pressure (PTP) (Chang & Karnell, 2004; Solomon & DiMattia, 2000; Solomon et al., 2003; Vilkman et al., 1999) and negative or variable changes in glottal closure patterns (Linville, 1995; Solomon & DiMattia, 2000; Stemple et al., 1995). Such changes in PTP and glottal closure can be expected to give rise to an increase in the sense of effort required to

phonate (Chang & Karnell, 2004, Laukkanen et al., 2004; Solomon & DiMattia, 2000), and increased difficulty with soft phonation. Therefore, as voices become fatigued, the ability to produce a soft voice using minimal effort is likely to suffer. This would reasonably reflect changes to laryngeal tissue and/or muscle activation, as discussed above.

The ability to phonate quietly may be instructive even without fatiguing the voice. Orr et al., (2002) found that non-dysphonic teachers in a group considered “at risk” for voice problems differed from a control group of perceptually normal voices partly by their inability to produce soft phonation without creating a large glottal chink. The inability to produce soft, high phonation has been proposed as a means for testing vocal fold swelling (Bastian et al., 1990) and has been correlated with vocal effort and dosage in singers (Carroll et al., 2006). A specific test of the inability to produce soft voice (IPSV) has recently been used by Hunter and Titze (2009) to measure vocal fatigue in teachers. This test requires participants to rate their ability to perform four simple vocal tasks as quietly as possible at a high pitch. Analysis of 86 teachers engaged in self-ratings during and after a two-hour reading task indicates that the IPSV successfully tracked both vocal fatigue and recovery over an 18-hour period.

Since one of the aims of prevention is maximizing vocal health and economy, a self-rating measure such as the IPSV that may be rapidly responsive to underlying physiological indicators of vocal fatigue can theoretically act as a straightforward and sensitive indicator of improving vocal function. This could be especially useful for studying treatment-related change, given the poor correlation between objective acoustic measures and ratings of vocal fatigue, the problems inherent in using voice disorder scales on non-dysphonic voices, and the difficulty determining whether acoustic changes reported following a day of heavy voice use reflect positive or negative adaptations to vocal loading (Laukkanen & Kankare, 2006; Lehto et al., 2006; Rantala et al., 1998; Vilkmann, 2004).

Study Objective

The purpose of this study was to evaluate whether the IPSV would uncover therapy-related changes in two groups of full-time primary and secondary school teachers with no or minimal dysphonia over a six-week treatment period. We also wanted to know whether the IPSV would be sensitive to vocal changes without being susceptible to practice effects. Finally, we examined the IPSV in relation to other standard measures of pre-post treatment change, including the VHI and a variety of acoustic variables. It was hypothesized that the IPSV would vary in relation to treatment, while the self-rating scale and acoustic variables would not show clear patterns of change as a result of therapy.

2. Methods

Subjects

Twelve teachers from the Denver, CO, area were recruited to take part in this study (Table 1). One subject (F094) withdrew from the study before completing therapy, leaving a total of 11 subjects. All subjects were part of an earlier study involving the use of a voice dosimeter to collect speech data during two weeks of teaching (Titze et al., 2007) and signed IRB-approved consent forms to participate in both the dosimetry and treatment arms of the study. At the time of their initial entrance

into the study, subjects filled out a vocal health questionnaire and underwent laryngeal videostroboscopy with a laryngologist to record baseline vocal function. This occurred during the summer months when they were not teaching. Further laryngeal examination was not repeated prior to beginning the treatment phase. The date of stroboscopy ranged from 8 to 27 months prior to starting treatment. Initial stroboscopy revealed a variety of minor abnormalities but no paralysis, significant tissue injuries, or signs of neurological voice problems. Teachers were rated for dysphonia by two highly experienced voice pathologists blind to the study. The voice pathologists rated sustained phonation, 30 seconds of spontaneous speech, and the first two sentences of the Rainbow Passage collected for each subject in a sound-treated booth just prior to therapy. Only one subject was considered by both SLPs to have moderate dysphonia, while the remaining 10 teachers were considered to have mild or no dysphonia. These ratings were not used to assign subjects to a group but only for descriptive purposes.

Treatment

Subjects were randomly assigned to one of two therapy programs upon entry into the study. One group received direct vocal training designed to strengthen the voice and improve vocal fold closure (Vocal Fold Adduction Training, VFAT) and a second group was provided with personal Voice Amplification systems (VA) to use during teaching. The two contrasting approaches were chosen in order to compare the effects on soft phonation of a treatment (VFAT) that was intended to

Table 1: Subject characteristics

Subject	Group	Age	Grade	Fatigue complaints	SLP ratings	Voice training	GERD	Hrs sleep	% voicing
F025	VA	24	9-12	yes	None	yes	no	7	18.5
F064	VA	45	K-5	yes	None-Mild	no	yes	7	17.1
F066	VA	27	4	no	None-Mild	no	yes	7	11.9
F080	VA	29	K-5	yes	None	yes	no	7.5	13.3
F094	VA	43	9-12	no	None	yes	yes	5	16.8
M006	VA	35	6-8	no	None-Mild	no	yes	5	No data
<i>mean</i>		33.8 (8.7)		50%		50%	67%	6.4 (1.1)	15.5 (2.8)
F009	VFAT	43	K-8 PE	no	Mild	yes	yes	8	19.3
F073	VFAT	50	6-8	yes	Mod	yes	yes	6.5	20.1
F081	VFAT	53	K	no	None-Mild	yes	yes	5.5	16.5
F101	VFAT	44	9-12	yes	None-Mod	no	no	7	16.8
M042	VFAT	25	6	yes	None	no	unknown	6.5	18.9
M045	VFAT	29	9-12	yes	None	yes	yes	7.5	17.7
<i>mean</i>		40.7 (11.3)		67%		67%	80%	6.8 (0.9)	18.2 (1.4)

Notes: GERD diagnosed on exam by laryngologist. Percent voicing reflects voicing time during the work day, collected by *dosimetry*

directly change glottal efficiency (i.e., less glottal leakage) to a treatment(VA) which may decrease amplitude of vocal fold vibration but make no direct modifications to adduction. While both therapies had the potential to improve performance on the IPSV over time, it was anticipated that the group receiving direct voice therapy would be more likely to improve IPSV scores, since soft phonation without phonatory breaks relies in part on complete glottic closure. However, it was also anticipated that for some teachers (those with a tendency to use a pressed voice by hyper-adducting), the VFAT might not provide a benefit.

Subjects in the VA group were trained once in the use of a portable, wearable personal amplifier (LightSpeed, Model PA-3) and instructed to wear their amplifiers for six weeks while teaching. These subjects did not attend therapy sessions during this amplification period, but were contacted periodically by an investigator to answer questions or discuss concerns. Subjects receiving direct voice therapy (VFAT) attended 45-minute individual therapy sessions once a week for six weeks with a trained voice pathologist. In brief, VFAT uses gentle vocal fry, or a gentle “creak” sound, to loosely adduct the vocal folds, with reduced airflow and subglottal pressure, before transitioning into complete glottal closure (Nix et al., 2005). Vocal fry was used to initiate phonation throughout all levels of treatment, increasing in complexity over the six weeks (including vowels, sung scales, words, and phrases), until fry was eventually reduced and then eliminated in favor of a gentle, but complete, modal onset. The characteristics of fry, including decreased airflow and subglottal pressure (Blomgren et al., 1998) and increased thyroarytenoid activity relative to other intrinsic laryngeal muscles (McGlone & Schipp, 1971), were considered ideal for facilitating the transition to a healthy glottal adduction for phonation. As fry phonation is often associated with a reduction of the glottal chink, it was thought to be especially appropriate for addressing the characteristic increase in glottal opening with louder phonation reported for the less “robust” teaching voice (Orr et al., 2002). VFAT was provided by two certified speech-language pathologists (SLPs) specialized in voice therapy. Each subject was assigned only one therapist. Therapy was administered using standardized protocols designed by the treating SLPs. Participants receiving VFAT were required to practice a brief set of exercises three times a day for homework. Participants in both groups were required to complete three daily self-assessments of their ability to produce soft phonation (IPSV), as described below.

Data Collection

Inability to Produce Soft Voice (IPSV). All subjects were asked to rate their inability to produce soft voice (IPSV) three times each day throughout the six weeks of treatment or amplifier use. Subjects were instructed to produce the following four tasks as quietly as possible at a high pitch: 1) sustain a quiet, steady /i/; 2) glide from a low pitch to a high pitch on /i/; 3) repeat a staccato /i-i-i-i-i/; and 4) sing the first two phrases of “Happy Birthday.” They were then asked to rate their ability to perform these tasks on a 1-10 scale (1: able to perform all tasks without trouble, to 10: unable to perform any of the tasks) and were provided with a set of criteria to help them with their ratings (see Appendix). Subjects were asked to rate themselves in the morning before their first class, in the afternoon after their last class, and at night before bed. Subjects were also asked to rate their vocal effort and discomfort associated with typical speech, but only the IPSV ratings will be presented here. Finally, they were asked to report on what they were doing immediately before the rating, what time they did their rating, and what time they completed their homework exercises. Before and after therapy, the IPSV was collected twice in a sound-treated booth as part

of acoustic data collection. These same IPSV tasks were also collected from these subjects well before the start of therapy, as a part of the voice dosimetry arm of the study. Dosimetry occurred during a two-week period of teaching, and subjects rated their voices every two hours each day for the two weeks (see below). These data will be used in the present study as baseline IPSV ratings.

Perceptual and acoustic data. All subjects completed a comprehensive Vocal Health Questionnaire (adapted with permission from Sapir et al., 1996) and the Voice Handicap Index (VHI) prior to therapy, as well as a VHI after therapy. Acoustic data were collected in a sound-treated booth before and after the six-week VFAT or VA period, using an omnidirectional lavalier microphone (Countryman Isomax B3P4FF05L) secured to a head mount and positioned out of the air stream at approximately 8 cm from the lips, calibrated with a Class I Sound Level Meter (B&K Model 2238) at 30 cm to allow for sound pressure level (SPL) analysis. Data were sampled at a rate of 48 kHz and collected directly to a PC using a high-quality microphone pre-amp and A-D converter. Subjects were asked to sustain “ah” for as long as possible, as part of a larger protocol. Three sustained phonations were collected at the beginning of the 30-minute protocol, and three more were collected at the end. Data were not collected by either of the treating therapists.

Data analysis

Raw IPSV scores from the 1-10 scale, and rescaled IPSV scores, were both analyzed. Raw (“un-scaled”) data were used when comparing baseline (dosimetry) scores to a larger group of teachers, and when comparing the rates of change in IPSV during dosimetry with voice therapy. Rescaled data were used for statistical analysis of the current data set. Procedures are described below.

IPSV stability. The stability of the IPSV measure was evaluated by examining the series of un-scaled IPSV ratings from the subjects during the earlier dosimetry phase of the study (Titze et al., 2007). During two weeks of dosimetry, subjects wore a portable dosimeter that collected the intensity and frequency of their voice through an accelerometer. The dosimeter also prompted the subjects to rate their IPSV every two hours throughout the day, starting first thing in the morning. On average, subjects participated in 12.8 (2.3) days of dosimetry and rated themselves 6.9 (1.2) times per day, for an average of 88.3 ratings per subject. Change in IPSV rating was evaluated by measuring slope, reflecting the typical change in IPSV per day for the two-week period. The descriptive statistics from these IPSV ratings were also compared to data from a larger set of 52 teachers participating in dosimetry (Hunter & Titze, 2008), to determine whether the subjects in the present study were representative of the group at large.

IPSV in response to treatment. IPSV ratings collected twice during in-booth data recording sessions before and after therapy were used to compare the two groups immediately prior to treatment, and evaluate change after treatment. Because scores were normally distributed within individual subjects in the large group (Hunter & Titze, 2008), but means differed across subjects, data were rescaled within each subject to allow for across-subject comparisons. Specifically, each subject was scaled by subtracting a value of 1 from each raw data point and dividing that by the subject’s highest IPSV rating from the baseline period (dosimetry), such that all values fell into a scale of 0-1. To scale the treatment-period data, the highest rating from dosimetry, not from treatment, was again used as the denominator. This provided a direct relationship to scaled baseline data. Repeated Measures Analysis of Variance (RM-ANOVA) was used to compare groups and measure pre-to-post differences once the data were scaled.

Daily ratings collected throughout treatment were also compared to daily ratings collected during the earlier dosimetry phase by means of slope characteristics. These ratings were rescaled for graphic presentation along with the scaled pre-to-post ratings, but the un-scaled values were used to calculate slope characteristics, since it is clinically more useful to have information about the expected rate of change in IPSV on the 1-10 self-rating scale.

Voice Handicap Index (VHI) and IPSV. The VHI was administered to assess group equality prior to treatment. The differences between post-pre VHI scores and post-pre IPSV ratings were also calculated and the difference scores tested for correlation using the Pearson product-moment correlation coefficient. Scaled IPSV data were used for this analysis.

Acoustic analysis. Six maximum duration sustained “ah” phonations collected in the booth before and after treatment were analyzed for the following: percent jitter (JIT), percent shimmer (SHM), signal-to-noise ratio (SNR), and corrected amplitude differences between the first and second harmonics (H1*-H2*) (Hanson, 1997). For all measures, the stable middle three seconds of each phonation was selected, with a 20-msec window selected in the center of this segment for measurement of H1 and H2 amplitudes. Analysis was performed using TF32 software (Milenkovic, 2001) by a researcher experienced with voice acoustics and blinded to treatment group. Twenty five percent of the acoustic measures were re-analyzed by an additional researcher for reliability. Group comparisons and pre-to-post treatment changes were evaluated using RM-ANOVA.

3. Results

Reliability

Correlation coefficients and standard errors (SE) were calculated for the repeated acoustic analyses. Correlations were as follows: JIT ($r = 0.97$, $SE = 0.05$); SHM ($r = 0.96$; $SE = 0.26$); SNR ($r = 0.99$, $SE = 0.38$); H1 amplitude ($r = .89$, $SE = 2.7$); H2 amplitude ($r = .99$, $SE = 1.3$).

IPSV Stability

Raw IPSV ratings throughout dosimetry appear in Figures 1a and 1b for each subject and group. One subject’s ratings (F081) were removed from the VA group after day eight of dosimetry because she complained of a cold, which caused her ratings to jump from an average of 3.8 to 8.6. Combined slope statistics for the current treated subjects during dosimetry ($N = 11$) compared to a larger group of teachers ($N = 52$) are presented in Table 2. Statistics between the groups are comparable, and indicate that on average subjects gave themselves poorer ratings over time (+0.047 per day for the current group and +0.042 per day for the larger group).

Spielman, et al.: IPSV rating in teachers

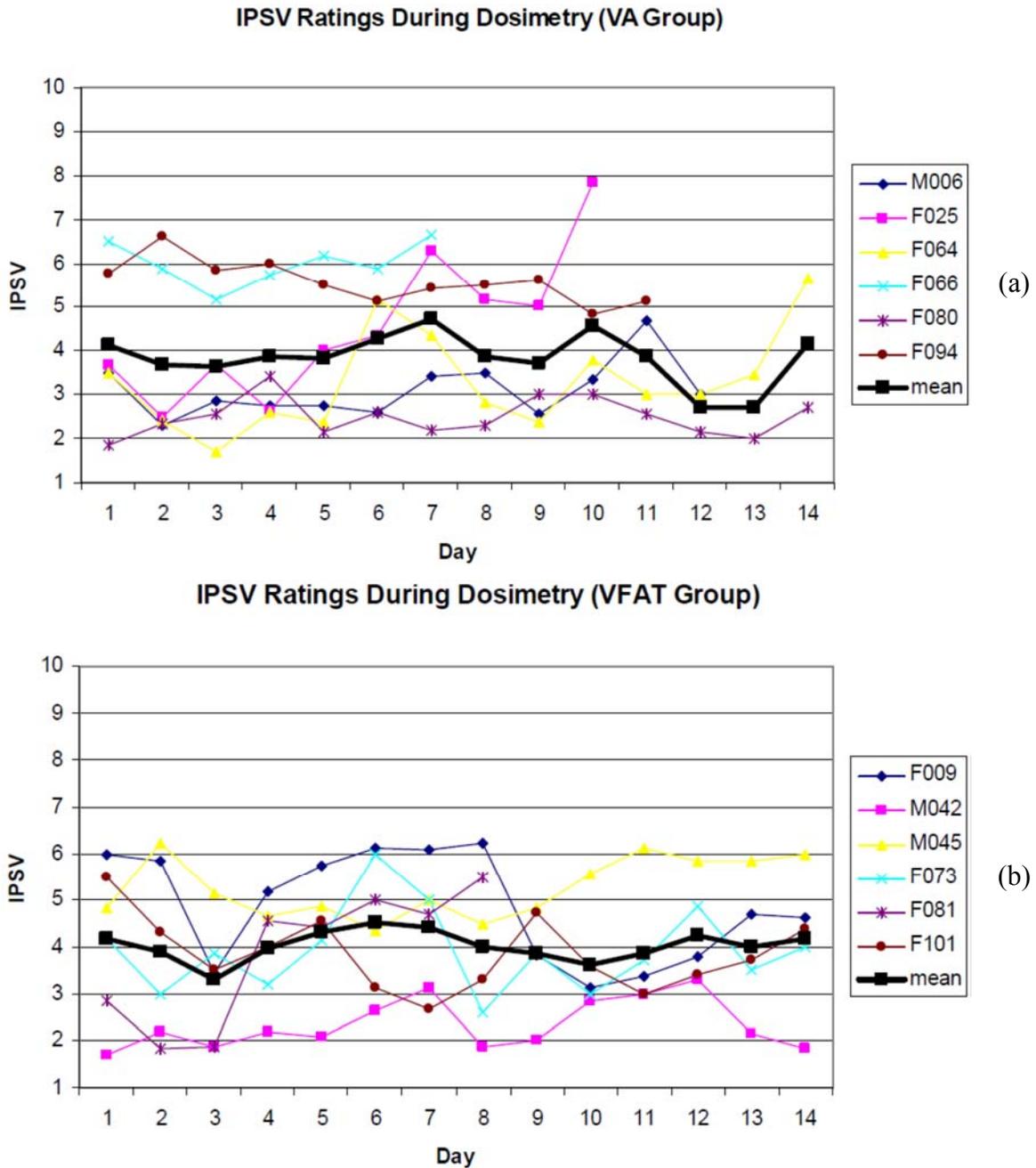


Figure 1. (a) Un-scaled IPSV ratings for the VA group during dosimetry. The bold line reflects the overall group mean. (b) : Un-scaled IPSV ratings for the VFAT group during dosimetry. The bold line reflects the overall group mean.

Table 2: Slope statistics comparing the current treatment group to the larger group of teachers undergoing dosimetry. Slope reflects the change in IPSV score per day for a 2-week period. Un-scaled data were used for comparison.

	Combined Current Group data (VA + VFAT)	Large Group Data (Hunter & Titze, 2008)
Slope statistics	(N = 11)	(N = 52)
mean	0.0466	0.0419
variance	0.0237	0.0279
sd	0.1539	0.1671
median	0.0440	0.002
Q1	-0.0292	-0.0646
Q3	0.0728	0.0793
skewness	1.8106	1.3333
kurtosis	4.8300	5.1952

Pre-Post IPSV

Pre- and post-IPSV scores (scaled) collected in the sound-treated booth are presented in Table 3. Subject M094 was excluded from these data, as she did not complete the therapy portion of the study. There were no significant differences in pre-treatment IPSV scores between the two groups. Following treatment, IPSV scores for both groups declined (VA = -0.11; VFAT = -.51). ANOVA indicated main effects for group ($p = 0.019$) and treatment ($p = 0.015$), with a trend toward group x treatment interaction ($p = 0.10$). Further testing (paired two-tailed t tests) indicated that the decline in IPSV for the VFAT group was significant ($p < 0.02$) while the change in IPSV for the VA group was not ($p = 0.55$).

Table 3: Scaled individual and group mean (sd) IPSV ratings pre and post-therapy for VA and VFAT groups.

Subject	Group	IPSV pre	IPSV post	Post-Pre Difference	Significance (paired t-test)
M006	VA	1.4	0.74	-0.66	
F025	VA	0.32	0.64	0.32	
F064	VA	0.80	0.89	0.09	
F066	VA	0.75	0.60	-0.15	
F080	VA	0.74	0.59	-0.15	
	Mean (sd)	0.80 (.38)	0.69 (.13)	-0.11 (.36)	n.s.
F009	VFAT	0.24	0.24	0.0	
M042	VFAT	0.76	0.15	-0.61	
M045	VFAT	0.56	0.24	-0.32	
F073	VFAT	0.50	0.08	-0.42	
F081	VFAT	0.64	0.00	-0.64	
F101	VFAT	1.27	0.18	-1.09	
	Mean (sd)	0.66 (.35)	0.15 (0.09)	-0.51 (.37)	p = .019

Figure 2 displays scaled IPSV ratings collected before, throughout, and after therapy, illustrating a gradual, consistent decline in ratings for the direct therapy group (VFAT) and the relative stability of the measurement in the VA group. Ratings on day one as well as the average of week one are displayed for comparison, since day one ratings were considerably lower for both groups on the first day of treatment when compared to pre-treatment values.

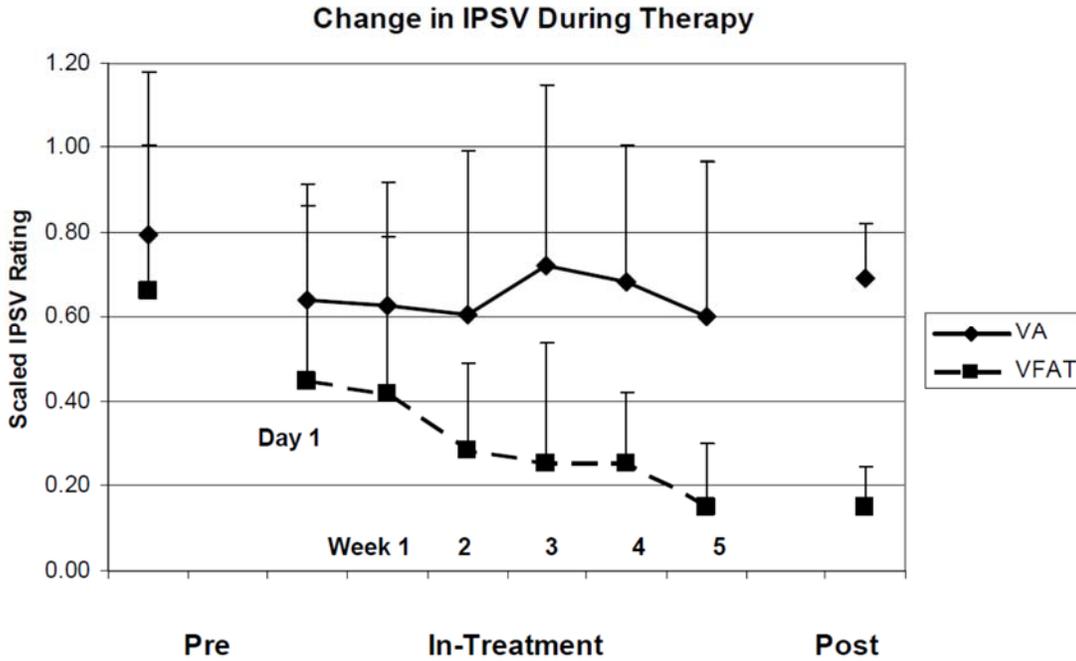


Figure 2: Mean IPSV before (pre), during, and after (post) therapy for each group, scaled.

IPSV and Voice Handicap Index (VHI)

There were no significant differences in mean (sd) pre-treatment VHI scores between the two groups (VA = 21.7 (12.5); VFAT = 20.6 (13)). Post-treatment VHI scores were available for all five VA subjects and four of six VFAT subjects. Individual increases or decreases in VHI and IPSV for each subject revealed a significant although weak correlation ($r = 0.66$) between these two self-ratings ($t = 2.35, p = 0.05$). However, large changes in the IPSV did not always predict large VHI changes (Table 4).

Table 4: Pearson product-moment correlation coefficient for scaled IPSV and VHI post-pre difference scores for subjects completing both ratings. High scores indicate greater perception of voice difficulty for both measures. Correlation = 0.66, $p=0.05$

Subject	Group	VHI post-pre diff	IPSV post-pre diff
F025	VA	36	0.32
M006	VA	0	-0.66
F064	VA	4	0.09
F066	VA	1	-0.15
F080	VA	-4	-0.15
F009	VFAT	-4	0.00
M042	VFAT	-16	-0.61
M045	VFAT	-6	-0.32
F081	VFAT	1	-0.64

Acoustic Measures

Means and standard deviations for JIT, SHM, SNR, and H1*-H2* are presented in Table 5. Pre-treatment measures between groups were not significantly different prior to therapy. Post-treatment measures were not significantly different from pre-treatment measures in either group, although JIT and SHM both decreased slightly, and SNR increased slightly, for the VFAT group.

Table 5: Pre/Post means (sd) for acoustic variables for each group. All differences are non-significant.

Group	Jitter (%)		Shimmer (%)		SNR (dB)		H1*-H2* (dB)	
	pre	post	Pre	post	pre	post	pre	post
VA	0.342 (.14)	0.373 (.14)	2.26 (1.14)	2.43 (.67)	24.1 (5.9)	23.0 (4.1)	5.9 (3.4)	5.8 (4.6)
VFAT	0.357 (.15)	0.287 (.10)	1.93 (.51)	1.82 (.57)	23.3 (1.9)	23.9 (2.2)	6.5 (1.7)	7.7 (3.9)

4. Discussion

This study evaluated the use of the IPSV—a brief set of tasks which measures a speaker’s ability to produce a soft, high, minimally effortful voice—as a way of tracking improvement in at-risk voices of teachers without significant dysphonia. Findings indicate that the IPSV improved over time for the subjects receiving direct voice treatment, suggesting that it may be responsive to underlying voice changes resulting from therapy. While it was anticipated that the group using amplification might also decrease IPSV scores as a result of potentially reduced vocal loading during the teaching day, this did not appear to be the case for most of these subjects.

Self-rating measures of phonatory ability are not new to the literature, and there is precedent for their use in assessing voice changes during therapy. Phonation time, sense of effort level, and self-perception of vocal loudness have all been used to help clients track their own voice improvements throughout therapy (e.g., Vocal Function Exercises, Stemple, 2005; LSVT®, Ramig et al., 1994). The IPSV is unique in its independence from the training program itself. It is designed to isolate and track changes in vocal fold tissue by focusing on the kinds of tasks that would be quickly affected by vocal fold swelling secondary to overuse without sufficient recovery time.

One concern when using a series of repetitive phonation tasks to measure voice changes is a learning effect, such that regular repetition of the tasks creates improvement simply because the speaker becomes better with practice. For the subjects in this study, two weeks of multiple daily self-rating using the IPSV during dosimetry, averaging 6.9 ratings per day, appeared to show no such effect (figures 1a and 1b). The slope of 0.047, representing average daily changes in IPSV over a two-week period for the individuals in the group, indicates that rather than improving over time the IPSV scores actually worsened. This may be due to increased sensitivity and awareness on the part of the speaker, as well as (or instead of) more difficulty producing soft voice.

In addition to an absence of learning effect, there also appears to be an absence of floor effect for the IPSV. Throughout dosimetry, average subject ratings on the 1-10 scale ranged from 1.7 to 7.8,

with a mean value of 3.9 (sd = 0.5). Slightly higher ranges and averages were reported at the beginning of the treatment portion of the study (mean = 4.8, sd = 1.8). In a larger group of 52 speakers who completed 4,619 IPSV ratings during a two-week period, the average IPSV was found to be 3.8 (sd = 2.0) (Hunter & Titze, 2008). It could be argued that the subjects practiced the IPSV for a longer time during the treatment portion of the study (six weeks, compared to two), and therefore had more time to learn the task. However, the more frequent ratings done during the two weeks of dosimetry add up to a comparable number of IPSV events for both time periods.

The lack of a floor effect is a particularly desirable trait for studying non-pathological voices, since many other acoustic and perceptual measures may not be sensitive enough to reveal changes in voice production. The VHI, for example, is often used in treatment studies to demonstrate changes. However, the scale requires an 18-point improvement to reach statistical significance (Jacobson et al., 1997), which is impossible to attain if pre-therapy scores start below that point. In the current study, 45% of the pre-treatment scores fell below 18, and so the VHI was simply used as a way of measuring group equality prior to therapy. Pre-to-post change scores for the VHI were also compared to changes in the IPSV scores, and found to correlate significantly if weakly. The observation that changes in the VHI appear to reflect changes in the IPSV supports the potential usefulness of the IPSV as a tool to measure pre to post treatment change. However, the small group size makes any conclusion difficult to reach.

Although acoustic measures were not expected to change significantly, small group size may have played a role as well. While there were no significant differences in any of these measures following treatment, percent jitter, percent shimmer and signal-to-noise ratio all moved in desirable directions for the VFAT group. It is possible that a larger sample size would have resulted in significant differences in these or other measures, lending some support to the continued use of acoustic measures. Fundamental frequency (F_0) may also have affected these outcomes, as F_0 was not controlled for during the sustained phonation task. While five of eleven participants maintained an average F_0 differing by no more than 10 Hz from pre to post data collection, the other six subjects increased F_0 by 10 Hz or more during post collection (mean = 32.6 Hz, sd = 17.6).

It should also be noted that not all studies have been unsuccessful in demonstrating improvements in healthy voices following therapy. Stemple et al., (1994) reported that a group of female graduate students receiving Vocal Function Exercises (VFE) improved on a number of acoustic, stroboscopic, and aerodynamic measures following training, compared to a no-treatment and a placebo group, even though these students had no voice complaints and were not at risk for developing problems. However, a quick measure designed for at-risk teachers that requires no special equipment to implement remains a valuable and necessary tool for recognizing both positive and negative voice changes.

There are many limitations to the present study, particularly the small group size. These data should be considered preliminary and supplementary to the larger studies of IPSV on vocal fatigue and recovery in teachers (e.g., Hunter & Titze, 2009). The absence of a control group is also a potential concern, although the baseline IPSV data from the same subjects during dosimetry provide a level of control for the measure. While the VA group might have acted as a treated control group, the two groups were not well-balanced in the amount of face-to-face clinical time, and the VA group was given no direct treatment strategies. Future research should seek to eliminate these differences, which might have affected the motivation level of the VA group.

Of more concern is the lack of control over the IPSV itself. These tasks were not well-controlled for pitch or performance: participants were simply asked to produce them at a high pitch as softly as possible. It is possible that as voice difficulties set in and the task became more difficult, speakers automatically lowered their pitch or increased vocal intensity to make the task easier to perform. Future studies are being designed with specific pitch prompts for each individual, as well as weekly performance reviews to make sure subjects are controlling intensity as well as effort levels.

Finally, critics may question the use of a relatively unknown vocal technique (VFAT) for this study, rather than more established programs such as VFE (Stemple, 2005) or the Lessac-Madsen Resonant Voice Therapy (Verdolini-Marston et al., 1995). As explained above, our goal was to initially use a technique that focused on increased glottal adduction. However, research examining the IPSV before and after a resonant voice therapy-type program (SOVT) is currently underway.

5. Conclusion

Findings from this study support the use of a set of soft, high phonation tasks (IPSV) for self-rating voice production in teachers throughout a period of therapy. The IPSV appears to be a viable tool for measuring both positive and negative voice changes and is, therefore, a candidate for alerting teachers to potential voice problems as well as measuring their response to treatment. This study did not set out to compare the effects of two different types of therapy on teachers' voices. However, the observed differences in IPSV response to the direct and indirect therapies are noteworthy and invite further research into these and other therapy programs. The relationship between IPSV and VHI is also promising, and other self-rating scales in addition to the VHI should be tested in relation to the IPSV. Finally, it could be useful to test the IPSV for tracking response to treatment for laryngopharyngeal reflux, recovery from phonosurgery, and response to Botox injection for spasmodic dysphonia.

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Revisions

- 1.0 Eric Hunter: Conversion of original report (March 2012)
- 2.0 Laura Hunter, technical edits, revision of references, clarifications (May 2015)