Efficacy of a Computer-Assisted Voice Treatment Protocol

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A voice treatment protocol using a computer-assisted biofeedback device for hyperfunctional voice disorders was evaluated in two adults. The specific components of the treatment were assessed using a single-subject interaction design. The overall contribution of relaxation to the treatment package was also evaluated. The treatment package was effective in improving the voice, as demonstrated by elimination of the vocal nodules, subjective data (ratings of the voice by subjects and naive listeners), and objective data (changes in fundamental frequency, maximum phonation time, perturbation factor percentages, breathing errors, and slow rise in volume). It appeared that the effect of the combined relaxation and traditional voice protocol was cumulative in nature, and addition of the relaxation component was no more effective than the protocol without the relaxation component.

Voice treatment programs have numerous components, including vocal hygiene, identification and elimination of abuses, reduction of laryngeal hyperfunction, respiratory training, easy onset of phonation, and relaxation. Some clinicians spend a great deal of time on the reduction of laryngeal hyperfunction, others on the elimination of abuses, and still others on relaxation procedures. It is important to determine which components of voice treatment make the greatest contribution to the overall efficacy of treatment for particular clients. In the treatment of voice disorders, few studies report on the efficacy of treatment in a systematic fashion. In 1985 Perkins, reporting on the state of the art for the assessment and treatment of voice disorders, reviewed more than 170 articles in the area of voice. He indicated that only two case studies were found on the effectiveness of treatments for hyperfunctional voice disorders. Johnson (1985) reported on a vocal abuse reduction program and provided data for its effectiveness. Although reviews of voice treatments are contained in textbooks (Aronson, 1990; Boone & McFarlane, 1988; Greene & Mathieson, 1989; Stemple, 1984), few studies have addressed the clinical efficacy of these commonly reported treatments.

Hyperfunctional voice disorders are often accompanied by excessive muscular tension in the laryngeal area. Muscular tension dysphonia has been associated with vocal abuse, changes in fundamental frequency, changes in perturbation factors, environmental stress, and palpable tension in the laryngeal area (Aronson, 1990; Morrison, Nichol, & Rammage, 1986; Stemple, 1984).

The beneficial effects of respiration training on phonation have been reported (Greene & Mathieson, 1989; Hixon, 1987; Proctor, 1980; Wilder, 1983). Many clinicians believe that respiration training should be a minimal part of the overall package for hyperfunctional voice disorders because relaxed breathing patterns are all that are needed to return the voice to normal (Aronson, 1990; Boone & McFarlane, 1988; Greene & Mathieson, 1989; Stemple, 1984). However, these authors also concede that it is necessary to employ respiration training in clients who demonstrate abnormal or tense breathing patterns. Stemple (1984) provided specific suggestions for clients who continue to talk on residual air (i.e., expiratory reserve volume). Boone (1988) provided a detailed four-point program for helping the client develop better expiration control. Respiration differences are usually viewed as secondary compensations for excessive glottal resistance, but can still be identified as complementary targets for clients who need this type of assistance.

Maximum phonation time has been reported to provide "information about the control of respiratory function, glottal efficiency, and laryngeal control" (Colton & Casper, 1991, p. 199). Although Stone (1983) reported problems with reliability over time for maximum phonation time, Bless and Hirano (1982) have reported that three trials were adequate for reliable measurements when clients were given proper training and instructions. Case (1984) indicated that "the ability to sustain phonation to a maximum duration is clinically relevant information as part of the voice disorder evaluation" (p. 88). A number of

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authors have reported that maximum phonation time provides some measure of overall respiratory and glottal efficiency (Aronson, 1990; Greene & Mathieson, 1989; Stemple, 1984).

Relaxation training and exercises have been recommended for general and specific body stress (Berstein & Borkovec, 1973; Boone & McFarlane, 1988). Authors have also reported on the effects of electromyographic feedback as an effective adjunct to voice treatment programs (Stemple, Weiler, Whitehead, & Komray, 1980). Many textbooks include relaxation exercises for children and adults with voice problems, so it is important to clarify the role relaxation plays in remediation of clients with voice disorders.

Although these studies have demonstrated that numerous techniques to describe changes in voice function are available, there have been few "systematic" studies employing multiple-baseline, single-subject designs that allow clinicians to chart the success of particular aspects of treatment sessions. Clinical studies are needed to determine the effectiveness of the treatment, and which particular components of a treatment package prove most effective in helping clients regain their voices. In clinical research it is important to be able to "dismantle" currently used treatment approaches to determine which of the specific components are contributing most to overall effectiveness. Hegde (1987) emphasized that single-subject research designs are eminently practical in clinical settings because they permit the assessment of treatment effects with individual clients who seek clinical services. The purpose of interaction designs in single-subject research is to evaluate the additive or interactive components of a treatment program. When two or more treatment components contribute to the effectiveness of a total program, interaction designs can help isolate the independent and interactive components of the treatment (Hegde, 1987; Kazdin, 1982; McReynolds & Kearns, 1983). The obvious advantage to these designs is that clinicians can begin to spend more time on the most effective components of treatment. The need for studies validating new and used clinical treatments remains a priority in the area of voice disorders.

This study was designed to answer two questions:

1. What is the effectiveness of a voice treatment program using vocal education, abuse reduction, computer-assisted easy onset of volume and breathing information, and transfer activities?

2. What is the overall contribution of relaxation training in such a voice treatment program?

Method

Subjects and Setting

Two self-referred, adult women with vocal nodules served as participants.

Subject 1 (S1) was a 22-year-old female who indicated that her voice problem had existed for approximately 4 months, with the onset coinciding with autumn allergy season. She indicated that the problem was "totally out of her control," and that she was at the clinic as part of a self-initiated "total makeover" plan. She felt that her voice had always bothered her and contributed to her low self-esteem and poor social life. She reported that she had smoked one pack of cigarettes a day until 2 months ago, and continued to consume approximately 7 ounces of alcohol a week. She also remarked that she had been treated for one upper respiratory infection about 4 months before the interview. She complained of hoarseness, intermittent dysphonia, and tender laryngeal and neck muscles. She explained she abused her voice at athletic events, oral interpretation, and drama classes. She thought that the problem continued to change, although she noticed a deterioration in voice quality in the past 2 months. She had recently entered a period of stress in her life after a close friend had been in a serious automobile accident and she was the "support group." She was not taking any prescription medications and was in good health. S1 was an active student taking a full academic course load. She spent an average of 20 hours a week working in a bakery. She had never been in voice treatment nor participated in any type of relaxation training.

Medical evaluation revealed bilateral vocal nodules, diagnosed through indirect mirror laryngoscopy.

The voice assessment included a perceptual evaluation, the use of the Visi-Pitch (Kay Elemetrics) to obtain fundamental frequency and perturbation measurements, and the use the Computer-Aided Fluency Establishment Trainer (CAFET; Goebel, 1988a, 1988b) to evaluate breathing and easy onset (slow rise) of volume (Appendix A). Results of the voice assessment revealed a moderate dysphonia characterized by breathy-tense components on the Wilson Voice Profile (Wilson & Rice, 1977). S1 was able to sustain /s/ for 11 sec, /z/ for 10 sec, and /a/ for 8 sec. She demonstrated phonation breaks and pitch breaks while phonating from a low to high /o/ and /i/. She was able to count vigorously to 100 and produced a sharp glottal attack and cough. Musculoskeletal tension testing revealed self-reported minimal pain on palpation and downward movement of the larynx. S1 explained "typical voice usage for a day" as talking with friends, speaking approximately 45 minutes on the telephone socially, and acting as the local counselor and "Dear Abby" for friends. She could not provide a quantitative measure for speaking time, but asserted she "talked all the time." It appeared that she had very little quiet time, and that weekends were more vocally abusive than weekdays because of athletic events, and the fact that her boyfriend was on a number of intramural teams. She rated her present voice as a 7 on a 10-point rating scale, in which 1 was normal for her and 10 was rated as very different from normal. She rated her relaxation as 6 on a scale of 1 (very relaxed) to 7 (very tense).

Results for sustained production of three vowels (averaged over three trials) revealed that her fundamental frequency range was 174 Hz (taken at different times) during 5 days of baseline data collection. Her perturbation factor percentages averaged 1.7% for the same baseline period.

Results from the CAFET were summaries of the number of correctly observed behaviors for 100 trials. The client was able to demonstrate a relaxed breathing curve on CAFET (without breath-holding and fast airflow) for 20 of 100 trials (norm = 86 of 100). The client was able to demonstrate a slow rise of air volume and breathy voice for 10 of 100 trials (norm = 81 of 100).

Subject 2 (S2) was a 20-year-old female who indicated that her voice problem had existed for approximately 8 months, with the onset coinciding with a summer job as a lifeguard. She indicated that she developed complete loss of voice at athletic events and "social mixers" after baseball and football games. She was at the clinic because a number of friends had indicated that her voice sounded different, and continually asked if she were sick. She reported she had an active social life and went out at least 4 nights a week. During this time she was usually in loud, smoke-filled rooms, and consumed approximately 3 or 4 ounces of alcohol per evening. She also remarked that she had been treated for three upper respiratory infections during the past year. She complained of tension, intermittent breathiness, loss of volume, and tender laryngeal and neck muscles. She thought that the problem had been getting better about 1 month before the interview, but felt it was "now worse than ever." She reported that she took the prescription drug Seldane occasionally for allergies, she was not taking any other medications, and was in excellent health. The client was an active student taking a full academic course load. She reported that she was under a lot of stress about graduation because she was on academic probation. She spent an average of 6 hours a week working on the telephone for a magazine-subscription-ordering company. She had been in voice treatment for 1 year in grade school for treatment of vocal nodules, but had never participated in any type of relaxation training.

Medical evaluation revealed bilateral vocal nodules, diagnosed through indirect mirror laryngoscopy.

Voice assessment revealed a moderate dysphonia characterized by breathy-tense components on the Wilson Voice Profile (Wilson & Rice, 1977). S2 was able to sustain /s/ for 15 sec, /z/ for 11 sec, and /a/ for 10 sec. She demonstrated phonation breaks and pitch breaks while phonating from low to high /o/ and /i/. She was able to count vigorously to 100 and produce a sharp glottal attack and cough.

Musculoskeletal tension testing revealed self-reported pain on palpation of the larynx. She explained "typical voice usage for a day" including yelling and shouting, and that "if you're seen, you should be heard." She indicated that she used her speaking voice at least 5 hours a day, most of the time when she was not in classes. She indicated that she also had to clear her throat often because she felt like something was blocking it. It appeared that she had very little quiet time. She rated her present voice as an 8 on a 10-point rating scale for which 1 was normal for her and 10 was rated as very different from normal. She rated her relaxation as 5.5 on a scale of 1 (very relaxed) to 7 (very tense).

The Visi-Pitch revealed that her fundamental frequency range averaged 188 Hz (taken at different times) during 9 days of baseline data collection. Her perturbation factor percentages averaged 1.4% for the same baseline period.

Results from the CAFET were summaries of the number of correctly observed behaviors for 100 trials. She was able to demonstrate a relaxed breathing curve on the CAFET (without breath-holding and fast airflow) for 8 of 100 trials. She was able to demonstrate a slow rise of air volume and breathy voice for 8 of 100 trials.

The training sessions were conducted in individual treatment rooms at a speech and hearing clinic. The room contained a rectangular table and blackboard and was equipped with a large one-way mirror and an Apple IIe computer.

Dependent Variables: Measurements, Instruments

Nine dependent variables were used to determine the effectiveness of treatment. These included the number of vocal abuses and misuses, changes in fundamental frequency, perturbation measurements, breathing changes, slow rise of air volume, maximum phonation of duration, relaxation ratings, self-ratings of voice quality, and naive judges' ratings of overall vocal quality. Specifically:

1. Vocal abuses and misuses were discussed and then identified in the treatment room. The number of abuses was recorded in treatment by the client and clinician. The client was also required to monitor these behaviors outside the treatment room.

2 & 3. Fundamental frequency and perturbation measurements were obtained from the Visi-Pitch (Kay Elemetrics). The microphone for the Visi-Pitch was positioned approximately 1 inch from the lips. The signal was routed to the Visi-Pitch model 6087 DS by an Apple II computer. Data from the computer screen and hard copy from a printer attached to the computer were used to obtain the fundamental frequency and perturbation information. Results were obtained for sustained production of three vowels, averaged over three trials. Perturbation factor percentages were obtained from the Visi-Pitch print-out.

4 & 5. The Computer-Aided Fluency Establishment Trainer (CAFET; Goebel, 1988a, 1988b) was used to evaluate breathing and easy onset of air volume (slow rise of volume). CAFET consists of a respiratory sensor, pressure transducer, clip-type microphone, and printed circuit board, and plugs into a compatible microcomputer. The respiratory sensor is an expandable rubber tube worn around the client's thorax at the level of the diaphragm. A pressure transducer converts the air pressure to an electrical signal. The battery-dependent microphone is worn around the neck or clipped to the collar of the client's clothing. The software provides colored computer graphics for visual feedback and functions in real time. According to Goebel, CAFET provides feedback on measurements of maximum and minimum changes in the expandable rubber tube, breath-holding, rate of airflow, increases in air volume, air volume changes, and the number of pauses in the phonatory flow. The CAFET program allows the clinician to change the onset, air volume, and timing parameters to suit the needs of the client. Sometimes in clinical situations clients have a difficult time following the clinician's demonstrations of h + vowel, yawn-sigh, and use of easy onset of air volume and initiation of phonation.

CAFET afforded a visual display for each subject to correct her efforts with feedback from both the clinician and the computer. Percentages were calculated for 100 trials for each target behavior. A more detailed description of the CAFET can be found in Appendix A.

6. Maximum phonation time measurements were obtained by having each subject take three deep breaths and phonate /a/ for as long as she could. Subjects were provided with a 15-sec model of sustained /a/ by the author. A stopwatch was used to measure the maximum phonation time.

7. Relaxation ratings consisted of the subjects recording their subjective relaxation state on a scale from 1 (very relaxed) to 7 (very tense). Subjects were provided with a work sheet to complete their daily relaxation levels in between treatment sessions.

8 & 9. Social validation measures were obtained by having (a) each subject rate her own voice improvement, and (b) 20 naive listeners rate improvement in the overall quality of the voice from baseline and follow-up sessions. Audiotapes of the subjects' pre- and post-treatment voice samples were obtained. The tape consisted of four productions of the stimuli from the "Rainbow Passage" (one pre- and one post-treatment for each subject), and 12 productions of the vowel "a" (three pre- and three post-treatment for each subject). The stimuli were randomly placed on a master tape and played for the naive listeners. The listeners were instructed to rate the overall voice quality of the subjects on a 1 (normal) to 7 (disordered, abnormal) scale.

Treatment Design

A single-subject interaction design with multiple baseline across subjects was used in this study. When two or more treatment components are effective in a total treatment program, interaction designs can help isolate the independent and interactive components of the treatment (Hegde, 1987; Kazdin, 1982; McReynolds & Kearns, 1983). In a multiple-baseline design across subjects, the treatment is administered to S1 after a stabilized baseline has been observed. During this time, S2 is held in continued baseline. The design shows the effectiveness of the treatment as long as the subject's observed behavior does not change during baseline sessions. The staggered baseline helps to prove that the observed changes are attributable to the treatment, not some other extraneous factors. Baseline data were stabilized after five sessions for S1, at which time treatment was begun. Treatment for S2 began after nine baseline sessions.

The study design included four phases: (A) baseline; (B) voice treatment protocol; (B+C) voice treatment protocol and relaxation, and follow-up. The overall voice treatment protocol (phase B) included education, abuse reduction, breathing and easy onset of volume elements, and transfer activities (Goals 1, 2, 3, 4, 5, & 6; Appendix B). The overall voice treatment protocol with a relaxation component (phase B+C) included education, abuse reduction, breathing, easy onset, transfer activities, *and* relaxation training (Goals 1, 2, 3, 4, 5, 6, & 7; Appendix B).

The clinical treatment included phase A, phase B, phase B+C, phase B, phase B+C, with follow-up. The changes in the dependent measures observed during the *introduction* and *withdrawal* of the relaxation component could show the relative importance of relaxation in the overall treatment package. The subjects' subjective impressions of voice improvement and 20 naive listeners' impressions of pre- and post-treatment recordings were obtained as social validation measures (Kazdin, 1982) to indicate the extent to which the changes could be determined to be significant.

TABLE 1. The intervention procedures implemented with both subjects.

Design Phase	Sessions	Intervention (Goals found in Appendix B)
Baseline Phase A	5 sessions for S1; 9 sessions for S2	Data collected on dependent variables
Treatment Phase B	Session 1	Data collected on dependent variables; Goals 1, 2, & 3
	Sessions 2 & 3	Data collected on dependent variables; Goals 1, 2, 3, 4, & 5 15 minutes for review of Goals 1, 2, 3, & 4; 30 minutes for CAFET training Goal 5
Treatment Phase B+C	Sessions 4, 5, & 6	Data collected on dependent variables; Goals 1, 2, 3, 4, 5, & 6 15 minutes for review of Goals 1, 2, 3, & 4; 15 minutes for CAFET training Goal 5 15 minutes for relaxation training Goal 6
Treatment Phase B	Sessions 7, 8, & 9	Data collected on dependent variables; Goals 1, 2, 3, 4, 5, 6, & 7 15 minutes for review of Goals 1, 2, 3, & 4; 30 minutes for CAFET training Goals 5 & 7
Treatment Phase B+C	Sessions 10, 11, & 12	Data collected on dependent variables; Goals 1, 2, 3, 4, 5, & 6 15 minutes for review of Goals 1, 2, 3, & 4; 15 minutes for CAFET training Goal 5 & 7 15 minutes for relaxation training Goal 6
Follow-up	Sessions 1, 2, & 3	Data collected on dependent variables

Selection of Treatment

The treatment selected for these subjects was based on the goal of restoring normal voice. This approach incorporates vocal re-education about abuses and misuses, computer-assisted respiratory training, easy onset of volume, and relaxation training. The treatment included seven components: (a) review of anatomy and physiology of laryngeal musculature, with normal and pathologic vocal folds voice production and education; (b) identification of misuses and abuses of the voice; (c) establishment of a monitoring program for abuse and misuse reduction; (d) transfer of the "new voice" to daily living activities; (e) establishment of correct respiratory and supportive breathing habits using CAFET; (f) establishment of easy onset of air volume using CAFET; and (g) relaxation training (Goals 1–7; Appendix B).

Treatment Program

The 5 (S1) or 9 (S2) baseline sessions, 12 treatment sessions, and 3 follow-up sessions (1, 2, and 3 months after the termination of voice treatment) made up the intervention protocol. Table 1 describes the intervention session by session.

Results

Effectiveness of Treatment

Both subjects were again evaluated medically after the third follow-up visit, and diagnosed through indirect mirror laryngoscopy as having normal vocal folds (no nodules). S1 was reported to have minor irritation of the folds. Results of the voice evaluation revealed a normal-sounding voice quality for both clients on the Wilson Voice Profile (Wilson & Rice, 1977).

Changes in the dependent variables were examined in the order in which they were presented in the previous section. Specifically:

1. The number of abuses and misuses identified and charted by S1 during the first session totaled 33; only 2 abuses were identified at the follow-up sessions. For S2, the numbers of correctly identified abuses and misuses were 45 for the first session and only 3 for the final follow-up sessions. These numbers indicated an awareness and significant reduction in the vocal abuses and misuses for both subjects.

2. As is evident in Figure 1, increases in fundamental frequency were observed for S1 (170 Hz to 210 Hz) and S2 (190 Hz to 224 Hz). It should be noted that there was some

FIGURE 1. Fundamental frequency for S1 and S2 measured in cycles per second on the Visi-Pitch for baseline, treatment, and follow-up sessions.

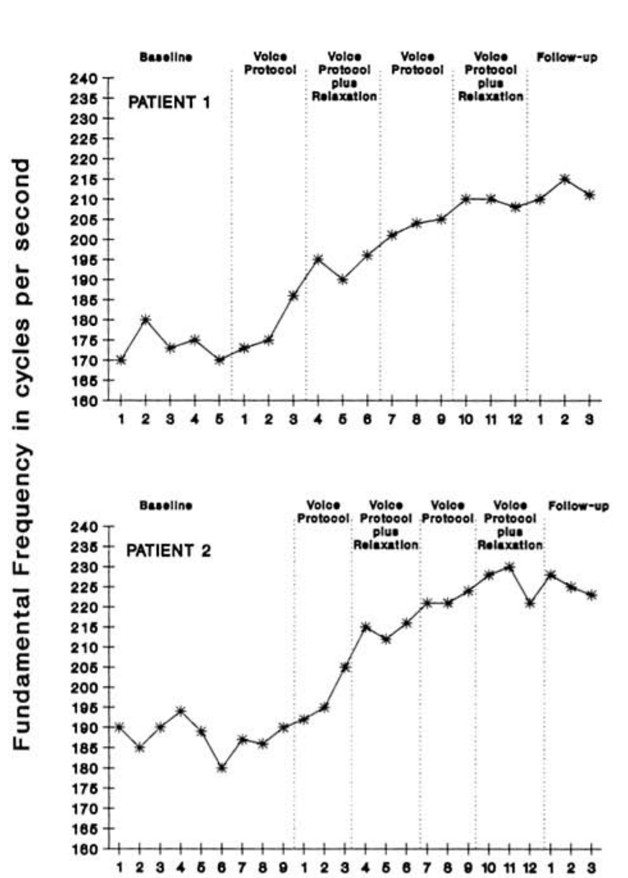
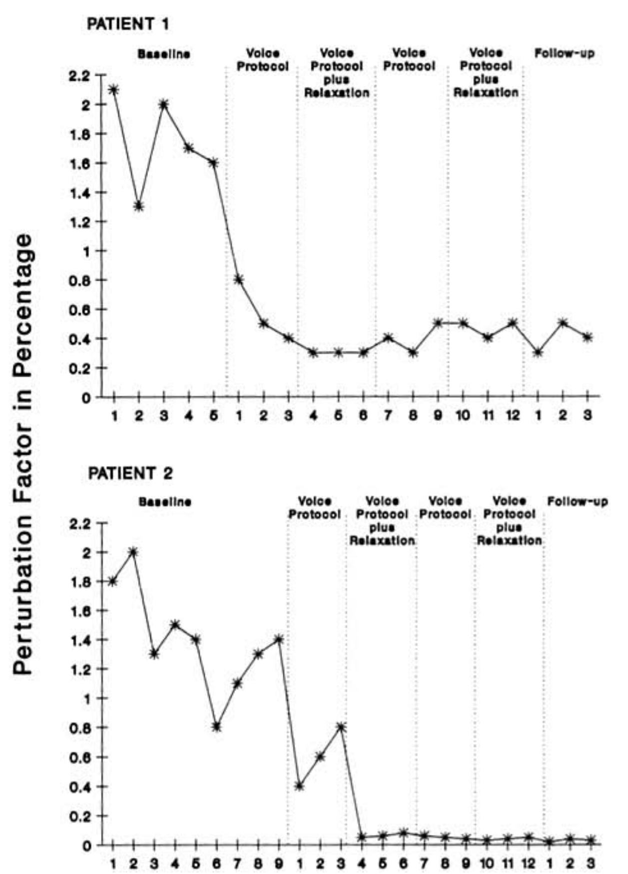


FIGURE 2. Percentages of perturbation factor for S1 and S2 measured by the Visi-Pitch for baseline, treatment, and follow-up sessions.



degree of variability in the initial baseline sessions for both subjects. However, the follow-up data suggest that both subjects never approached baseline behavior. Significant changes at follow-up negated the relatively small fluctuations in variability at baseline.

3. Figure 2 revealed that, for S1, perturbation factor percentages decreased from an average of 1.7% for the five baseline sessions to 0.4% for the follow-up sessions. For S2, perturbation factor percentages decreased from an average of 1.4% for the nine baseline sessions to 0.1% for the follow-up sessions.

4. Results of the CAFET were summaries of the number of correctly observed behaviors for 100 trials. S1 was able to demonstrate a relaxed breathing curve on CAFET (without breath-holding and fast airflow) with 16% accuracy during the baseline sessions. Figure 3 showed improvement with training at a level of 84% accuracy at follow-up. S2 was able to demonstrate a relaxed breathing curve on CAFET (without breath-holding and fast airflow) with 8% accuracy during baseline sessions. With training, she achieved an 86% accuracy level at follow-up.

5. Inspection of Figure 4 showed a dramatic increase in S1's ability to demonstrate a slow rise of air volume. Her 10% accuracy level during baseline was compared with her 87% accuracy at follow-up. Similarly, S2 showed a systematic increase in the productions of easy onset of air volume from a baseline average of 8% accuracy to a follow-up session average of 92% accuracy.

6. Inspection of Figure 5 revealed that maximum phonation time increased from 8 seconds to 18 seconds for S1 and from 10 seconds to 23 seconds for S2.

7. Figure 6 revealed that both subjects perceived themselves as having high levels of tension and stress at the baseline sessions (S1 = rating of 6; S2 = rating of 5.5). The overall treatment package appeared to reduce these tension levels in both subjects for the average of the three follow-up visits (S1 = 2.5; S2 = 2.7).

8. Social validation from the subjects about their voices suggested that both subjects perceived positive changes in their voices from the initiation of treatment. Subjects rated their voices as 1 (normal for them) on a 1–10 scale at the last follow-up session.

9. Results of the analyses of the 1–7 point (normal to not-normal voice) scale ratings for the 20 naive listeners were calculated. The naive listeners' pre- and post-treatment group mean ratings for the second sentence of the "Rainbow Passage" were obtained for both subjects. For S1, the pretreatment group mean rating was 5.3

FIGURE 3. Percentage of error-free breath groups for S1 and S2 measured by CAFET for baseline, treatment, and follow-up sessions.

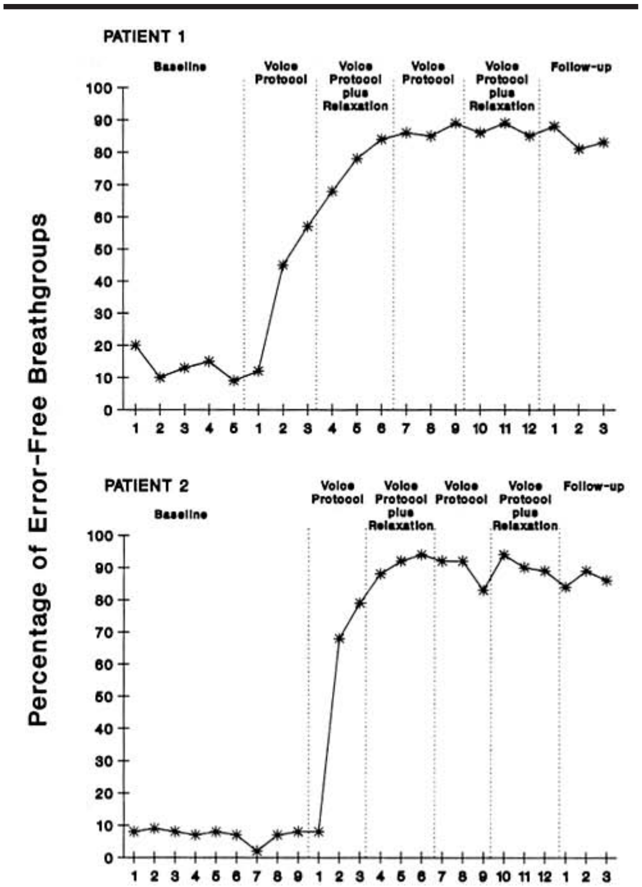
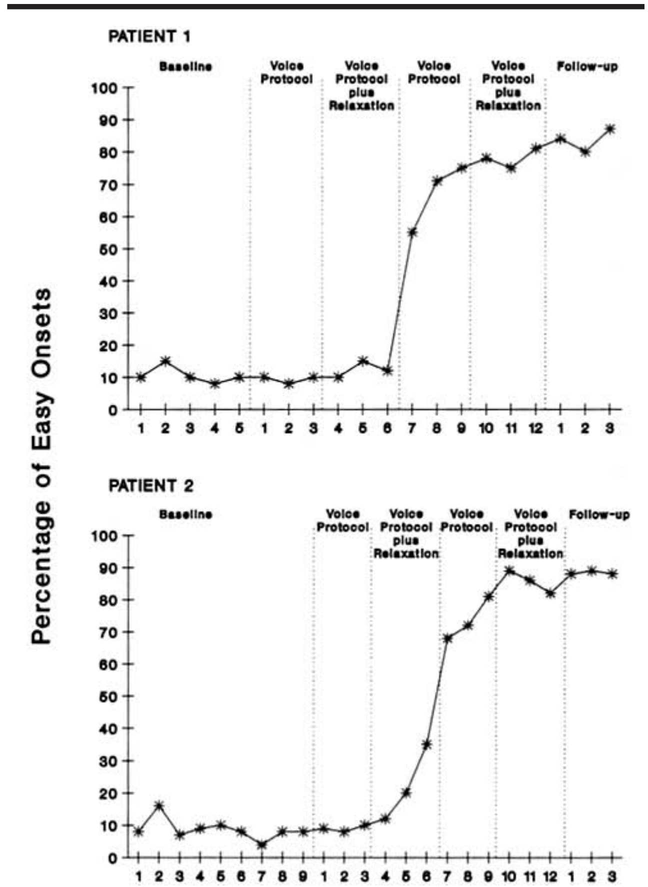


FIGURE 4. Percentage of slow rise of volume /easy onset for S1 and S2 measured by CAFET for baseline, treatment, and follow-up sessions.



(standard deviation = 1.2); the post-treatment group mean rating was 1.4 (standard deviation = 0.8). For S2, the pretreatment group mean rating was 6.2 (standard deviation = 2.3); the post-treatment group mean rating was 1.5 (standard deviation = 1.1). Group mean ratings pre- and post-treatment for the three vowel prolongations for S1 were 4.2 (standard deviation = 1.5) and 2.1 (standard deviation = 1.2). For S2 the ratings were 5.3 (standard deviation = 1.6) and 1.9 (standard deviation = 1.3). These ratings demonstrated a positive increase in naive listeners' impressions of the subjects' voices and provided further confirmation of the efficacy of the treatment.

Overall, inspection of the figures revealed steady, positive increases in the fundamental frequency, maximum phonation time, use of easy onset of air volume, and relaxed breathing curves for both subjects. It was also easy to see decreases in tension ratings and perturbation percentages for both subjects. These results suggested that the present treatment approach was successful for the reduction of a hyperfunctional voice disorder. Subsequent to working on breathing and easy onset of air volume, high error rates were seen in both subjects. The effectiveness of training in easy onset of air volume could be observed in the changes from session 6 to session 7 (when the first intervention began) for both subjects. It appeared that CAFET, in combination with traditional voice treatment, was an easy and effective way to teach subjects easy onset of air volume.

Contribution of Relaxation Training

The second question of this study examined the overall contribution of relaxation to the total effectiveness of the voice treatment protocol. Inspection of Figures 1–6 revealed that no substantive changes occurred as a result of the addition of the relaxation component. No major shifts in the dependent variables were seen as a result of the relaxation component on Figures 1, 2, 3, 4, and 5. In fact, the only parameter that showed a change was the relaxation rating (Figure 6). This suggested that when the subjects were involved in relaxation and listening to audiotapes, they rated themselves as more relaxed. Although this is a good indicator of the effectiveness of the relaxation technique, it did not change any of the voice parameters. It should also be noted that it did not have a deleterious effect on the dependent variables either. It appeared that relaxation may not have a separate effect on the measures employed in this study.

FIGURE 5. Maximum phonation time measured in seconds for S1 and S2 for baseline, treatment, and follow-up sessions.

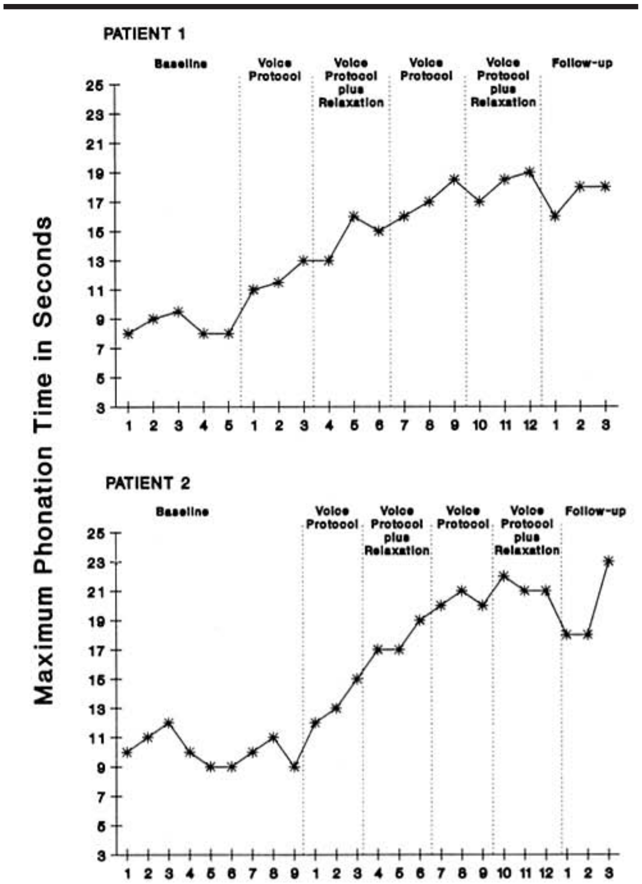
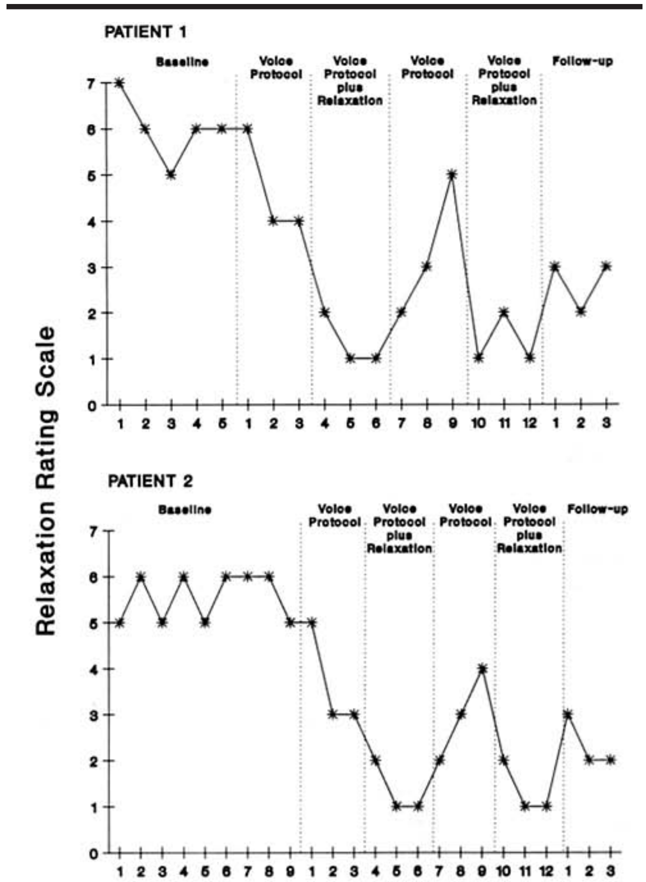


FIGURE 6. Ratings of relaxation by S1 and S2 on a 1 (very relaxed) to 7 (very tense) rating scale for baseline, treatment, and follow-up sessions.



Discussion

The present voice treatment protocol (using both B and B+C phases) appeared to be an effective technique for reduction of hyperfunctional voice disorders in adults. The overall goal of improved voice, elimination of nodules, the ratings of the clients, and the social validations ratings were consistent with this interpretation. It was also important to note that changes in the dependent variables were maintained over a 3-month follow-up period. It appeared that selected aspects of the CAFET program were useful methods of biofeedback in conjunction with more traditional voice treatment approaches. For these subjects, these components of CAFET seemed to be an easy and effective way to teach breathing, increase a gradual rise of air volume, and develop a soft onset (breathy) voice. The present treatment was based on counseling, education, changes in breathing, use of a "soft voice," reduction in laryngeal hyperfunction, and transfer activities. This protocol serves as documentation that voice treatment is a valid and appropriate strategy for reduction of vocal nodules. This specific protocol also suggests that short-term treatment can be very effective with hyperfunctional voice-disordered subjects. The overall goal of the voice protocol was restoration of the voice to near-normal functioning. The fact that the subjects, as well as other naive judges, perceived changes in their voices provided further support for the efficacy of the treatment.

The relaxation component used in this study was not associated with clinically significant improvements in the subjects' voices. This was documented by the design employed in this study. No substantive changes were observed in the dependent variables when the relaxation component was introduced. These results suggested that, although relaxation may serve as an adjunct to the treatment process, there is no evidence that specific general relaxation techniques were necessary. Voice treatment, by its very nature of including re-education and counseling about abuses, may promote general relaxation. It is also possible that relaxation is simply more additive in nature to the overall treatment package. Although the relaxation component had no significant effect on the other dependent measures, it also did not reverse the trends of the results. For subjects with environmental stressors, providing basic relaxation training may alleviate stress and complement the overall treatment package.

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Appendix A

Information About CAFET

The Computer-Aided Fluency Establishment Trainer (CAFET; Goebel, 1988a, 1988b) is a computer-aided biofeedback device that was developed to train and establish fluency for persons who stutter, but also can be used with children and adults with voice disorders, dysarthria, and other speech disorders. CAFET provides a visual image on the computer screen for feedback to help make changes in breathing and easy onset of volume. The image on the computer screen is color-coded and functions in real time. A purple line image is plotted on the computer screen, representing a breathing cycle and following the contour of the movement of the expandable rubber tube placed around the individual's diaphragm. The individual controls the movement curve on the screen by using diaphragmatic breathing, yawn-sigh, or other techniques, coupled with the visual feedback from the computer screen to establish smooth breathing curves. These curves are uninterrupted by quick air pressure changes and rapid volume changes. Goebel indicated that the number of breath groups should be equal to the number of voiced cycles around 20 (normal 18–32 reported by Goebel, 1988a). The client is also encouraged to start voicing with "pre-voice exhalation." This is defined as a general release of air prior to the onset of phonation. Coupled with a measure called slow rise of volume (SRV; also labeled easy onset of volume), the client can be encouraged with visual feedback to create a breathy voice before phonation. The client must extend onset of voicing for 3/10ths of a second, without having her volume rise more than 70% during any 1/10th second. She must also reach full volume within 1.2 seconds. Goebel (1988a) stated that when using the program with vocal nodule clients (it was designed primarily for fluency clients) some of the parameters should be changed. The CAFET program allows the clinician to change the onset, air volume, and timing parameters to suit the needs of the client. Slow rise of air volume and breathy phonation are often goals of voice treatment.

Although Goebel's format for using CAFET has a total of 52 steps, its use outside a systematic regimen has yet to be reported in the literature. Therefore, the results from the CAFET were summaries of the number of correctly observed behaviors for 100 trials. Although no normative data are reported on these tasks the way they were used in this study, a normative sample of 50 volunteers without voice disorders was conducted. On the task to produce a relaxed breathing curve on the CAFET, as used in this study, the group mean was 86 correct productions in 100 trials, and a standard deviation of 17.5. On the task to demonstrate easy onset of air volume (slow rise of volume), as used in this study, was 81 of 100 trials, with a standard deviation of 12.8.

Appendix B

Goals, Methods, and Materials of the Voice Protocol

Treatment Goal 1: To demonstrate knowledge about the voice, how it is produced, and laryngeal anatomy and physiology.

Methods: The clinician instructs the client in voice production and terminology of hyperfunctional voice disorders, and reviews the anatomy and physiology of laryngeal musculature.

Materials: Videotapes of fiberoptic and stroboscopic views of normal and pathologic vocal folds, as well as slides and models. Anatomy and physiology education worksheets are used so the client can identify basic structures and understand the proper functioning of the laryngeal mechanism.

Treatment Goal 2: To demonstrate knowledge about vocal abuses and misuses. To correctly identify vocal misuses and abuses in the client's voice production. To increase awareness and self-identification of abuses and misuses. To discuss the impact of vocal abuses and misuses on the vocal mechanism.

Methods: The clinician provides instruction in vocal abuses and misuses and their impact on the vocal mechanism. The clinician and client identify abuses and misuses (i.e., throat clearing, glottal fry, shouting, excessive talking, etc.). Description of the problem in the client's own words, and identification of abuses and misuses from lists generated by the clinician. Discussion of the nature of the voice problem and the necessity of changing behavior. Discussion of basic principles of applied behavioral analyses.

Materials: Educational handouts on voice abuse and misuse, tape recordings of vocal abuse, tape-recorded samples of the client's voice, and worksheets on behavior change.

Treatment Goal 3: To establish a monitoring program for the elimination of vocal abuses and misuses.

Methods: The client is educated in counting abuses and the monitoring program. The client is directed to set up a chart to isolate the behaviors and reduce talking time to at least 50% normal use a day for the first week. The 50% reduction is a negotiated number that the client agrees to reduce talking time. This is used to increase awareness of overuse of the voice. The specific percentage is arbitrary and used merely to increase awareness of abuse and the slight improvement in vocal properties when "Voice Rest and Relaxation (R & R)" is instituted. Strategies for elimination of the abuses are built into the monitoring program, including such activities as: hard swallow, drinking more liquids, less shouting, etc.

Materials: Charts for identification and reduction of vocal abuses and misuses.

Treatment Goal 4: To enable the client to transfer and generalize the activities of the previous goals to daily living situations.

Methods: Several techniques are used to help the client carry her "new voice" over into her own environment. The client is asked to request three friends/significant others to provide "maintenance alerts" for good voice usage. The client is also asked to develop specific strategies for "reminding" or "daily check-ups" on the newly learned strategies for identifying and reducing abuse and misuse of the voice. The client is instructed to perform vocal exercises (gliding up and down on the vowel /i/ and /a/, prolonging several notes for longer durations, and going from very soft to loud on three vowels) three times a day. These vocal exercises are given for their vocal performance value as well as their reminder to monitor the voice value. These transfer activities are also used to practice breathing and easy onset of volume after they have been learned in Goals 5 and 6.

Materials: Videotapes and handouts on the vocal exercises. Review sheets of previous activities and techniques.

Treatment Goal 5: To enable the client to demonstrate correct breathing patterns for speech and non-speech activities.
Methods: To understand the relationship between breathing and good voice, education and training are provided on the CAFET.

The emphasis on ongoing respiration as a continuous event characterized by inspiration and expiration is reinforced by establishing a breathing curve on the computer screen. The client progresses from non-speech activity (quiet breathing) to vowels, syllables, words, short phrases, and conversation to reach the criteria of 90% accuracy in 100 productions.

Materials: The CAFET software, circuit board, respiratory bellows and computer. Handouts from the CAFET program on respiration.

Treatment Goal 6: To enable the client to initiate phonation following inspiration with a breathy, easy, slow rise of volume.

Methods: The client is instructed to fill the volume box on the CAFET computer screen while demonstrating a slow rise of volume. The client is required to produce a step-like increase on the computer screen in the volume box, as well as phonation after the inspiratory phase is completed (or the exhalation phase has been initiated). The CAFET provides two parallel bars for the client to use as guides for the initiation of speaking. The CAFET computer screen is supplemented with the clinician's models of encouragement for adjusting onset of phonation. Productions with slow increase in volume are rewarded.

Materials: The CAFET software, circuit board, respiratory bellows, microphone, and computer. Handouts using h+ words. Also educational handouts explaining yawn-sigh procedures.

Treatment Goal 7: To enable the client to recognize the differences between tense and relaxed muscles states; to acquire knowledge of the benefits of relaxation exercises; and to demonstrate the use of relaxation techniques in the clinic.

Methods: This component of treatment consists of using relaxation techniques from Berstein and Borkovec (1973), which is a shortened form of Jacobson's progressive relaxation method. The client is taught to tense and relax the 16 major muscle groups in a specific sequence. The client is taught the technique and the clinician encourages the client to continue to "sense" a complete state of relaxation. The client is provided a 7-point rating scale to complete. The number 1 on the scale represents no tension—relaxed—and the number 7 on the scale represents tension—not relaxed. The client is instructed to practice the relaxation techniques for 20 minutes each day between treatment sessions.

Materials: A handout explaining relaxation and the 16 major muscle groups. A handout on the benefits of relaxation and its potential relationship to hyperfunctional voice use. A tense/relaxed rating scale. A relaxation tape created by the clinician for relaxing and tensing the major body parts.