Functional Dysphonia During Mental Imagery: Testing the Trait Theory of Voice Disorders

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Purpose: Previous research has proposed that persons with functional dysphonia (FD) present with temperamental traits that predispose them to their voice disorder. We investigated this theory in a controlled experiment and compared them with social anxiety (SA) and healthy control (HC) groups.
Method: Twelve participants with FD, 19 participants with SA, and 23 HC participants were studied before, during, and after mental imagery of positive, neutral, and aversive scripts in a within-subject reversal paradigm with multiple experimental conditions using psychometric, self-report, and psychophysiological measures.
Results: In psychometric tests, those with FD demonstrated increased fear in social situations but not increased avoidance. On measures of mood, all groups responded with predicted increases in pleasant mood for positive scripts and unpleasant mood for aversive scripts; on vocal effort ratings, those with FD reported greater effort for all scripts following imagery. Under experimentally controlled conditions, the SA and HC groups demonstrated predicted activation of EMG measures of mood, whereas the FD group demonstrated overall reduced activation of EMG measures.
Conclusion: Results may suggest that those with FD respond to emotional stimuli with reduced behavioral expression, compared with SA and HC groups, consistent with the temperamental trait of behavioral constraint.

KEY WORDS: emotion, voice disorders, psychophysiology

Functional dysphonia (FD) is a voice disorder in the absence of anatomical, mucosal, and peripheral neurological abnormalities (Roy, 2003; Sama, Carding, Price, Kelly, & Wilson, 2001). It is manifested as a behavioral disruption of normal voice production and is often associated with increased and unnecessary muscular tension during phonation (Kaufman & Blalock, 1982; Morrison & Rammage, 1993; Roy, 2003; Sama et al., 2001). Historical descriptions and accounts of FD have assumed a psychological etiology (Aronson, Peterson, & Litin, 1966; Matas, 1991), and its many names have reflected either a muscular or psychological etiology: primary muscle tension dysphonia (Verdolini, Rosen, & Branski, 2006), tension-fatigue syndrome (c.f. Roy, 2003), hyperfunctional dysphonia (Goldman, Hargrave, Hillman, Holmberg, & Gress, 1996), muscle misuse dysphonia (Morrison & Rammage, 1993), habitual hyperkinetic dysphonia (Arnold, 1962), ventricular dysphonia (Aronson et al., 1966), nonorganic habitual dysphonia (Demmink-Geertman & Dejonckere, 2002), habituated hoarseness (Kaufman & Blalock 1982), psychogenic dysphonia (Elias, Raven, Butcher, & Litllejohns, 1989; Gerritsma, 1991; Schalen & Andersson, 1992), conversion dysphonia (Matas, 1991), hysterical aphonia (cf. Roy, 2003), and phononeurosis

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(Milutinovic, 1991). Although the clinical presentation of FD is well researched (Behrman, 2005; Kaufman & Blalock, 1982; Leonard & Kendall, 1999; Morrison & Rammage, 1993; Sama et al., 2001; Stager, Bielamowicz, Regnell, Gupta, & Barkmeier, 2000; Lawrence, 1987, cited in Sama et al., 2001), the underlying etiology of this increased muscular tension and assumed psychological disruption remains under investigation (Gerritsma, 1991; Goldman et al., 1996; House & Andrews, 1988; Kinzl, Biebl, & Rauchegger, 1988; Schalen, Andersson, & Eliasson, 1992; White, Ian, & Wilson, 1997).

In a series of related studies, Roy and Bless found that those with FD presented with personality or temperamental traits that may predispose them to acquiring this voice disorder (Roy & Bless, 2000; Roy, Bless, & Heisey, 2000a, 2000b; Roy, McGrory, Tasko, Bless, Heisey, & Ford, 1997). They employed a battery of psychometric tests to investigate temperamental trait differences among those with different voice disorders and showed that those with behaviorally acquired voice disorders, namely vocal fold nodules and FD, presented with differences in temperamental traits compared to those with neurologically acquired voice disorders and clinic controls. Additionally, Roy and colleagues (2000a, 2000b) found no evidence that these trait differences were a result of the dysphonia because, in their studies, levels of anxiety, depression, and well-being were not related in any way to levels of voice impairment or length of time suffering from dysphonia. They proposed the trait theory of voice disorders, wherein temperamental traits presented vulnerability in acquiring certain voice disorders (Roy & Bless, 2000).

In the FD population, Roy and colleagues (2000a, 2000b) discovered that those with FD presented differences in temperamental traits associated with emotional processing; specifically, those with FD presented with higher levels in the constructs of neuroticism or negative emotionality (N/NE), decreased levels in extroversion or positive emotionality (E/PE), and higher levels in behavioral constraint (CON). N/NE is the temperamental trait associated with increases in stress reactivity, alienation, aggression, and anxiety; E/PE is a trait associated with well-being, social potency, social closeness, and achievement; and CON is the degree to which an individual expresses or acts upon their temperamental traits (Patrick, Curtin & Tellegen, 2002; Tellegen, & Waller, in press). For example, an individual high in N/NE and high in CON might have more subjective experiences of stress, anxiety, or alienation than another individual, but they tend not to overtly express or act upon those emotions.

We aimed to test the trait theory of voice disorders for those with FD by experimentally manipulating their emotions and comparing them with two control populations: those with social anxiety (SA) and healthy controls (HC). SA served as a control population because of their presumed similar temperamental traits to those with FD (Gerritsma, 1991; White, et al., 1997).

According to the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.; American Psychiatric Association, 1994), *social anxiety (SA)* is the fear of social situations and negative evaluation from others. More specifically, SA is a fear of embarrassment and humiliation, despite the knowledge that this fear is irrational, which leads to avoidance of situations that require interaction and communication with others (Cuthbert, 2002). However, those with SA do not present with voice disorders and would therefore serve as an appropriate control for temperament. SA has been extensively researched, and in this study, we employed well-established methodologies used to study temperamental traits and physiologic activity in those with SA (Cook, Melamed, Cuthbert, McNeil, & Lang, 1988; Cuthbert, 2002; McNeil, Vrana, Melamed, Cuthbert, & Lang, 1993).

We tested the trait theory of voice disorders for those with FD using mental imagery (Cook et al., 1988; Lang, 1979; McNeil et al., 1993). We measured emotional reactions in an auditory mental imagery paradigm without using overt speech so that explicit vocalization was not a factor in emotional experience.

Hypotheses

Our first hypothesis states that compared with healthy controls, those with FD will have increased measures of N/NE and increased CON in psychometric measures of temperament. Because Roy and colleagues (2000a, 2000b) suggest that those with FD score higher in N/NE and because past research suggests that those with FD are similar to those with SA (Gerritsma, 1991), our second hypothesis proposes that the FD group will demonstrate *increased* measures of autonomic activation associated with emotion compared with the HC group (Bradley & Lang, 2000) and will demonstrate *similar* autonomic measures of emotion compared to the SA group (Cuthbert, 2002). Finally, our third hypothesis is based on Roy and colleagues' finding that those with FD score higher in CON (Roy et al., 2000b). We expect that those with FD will demonstrate reduced measures of behavioral expression of emotion, compared with the HC group. Furthermore, because it is suggested that those with FD present similarly to those with SA (Gerritsma, 1991), the FD and SA groups should behave similarly in measures of emotional expression (Cook, et al., 1988). Our subhypothesis is that there will be greater decreases in behavioral expression in speech conditions than in nonverbal conditions for those with FD compared with

HC and SA, given their difficulty with voicing and, therefore, with speech.

Method

Three experimental groups were studied before, during, and after a mood-inducing mental imagery procedure. Imagery scripts included positive and aversive scenarios involving either speech or nonverbal communication as well as neutral scenarios that did not involve communication. The experimental design was a within-subject reversal paradigm including multiple experimental conditions, with experimental stimuli counterbalanced within and between participants to avoid order and fatigue effects. All participants were exposed to all stimuli. Comparisons were made among the three groups.

Participants

A power analysis based on data published by Cook and colleagues (1988) indicated that 11 participants per group would be sufficient to yield group differences in psychophysiological measures. Participants in the current study belonged to one of three experimental groups. The FD group included 12 women ranging in age from 18 to 55 years (M = 42.4 years). Inclusion criteria for this group included (a) a diagnosis of FD—specifically, the absence of anatomical, mucosal, or neurological pathology under videostroboscopy, which was confirmed by an otolaryngologist, and (b) absence of SA as judged by a score falling outside the diagnostic criteria for SA on the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987). All participants had received speech-language intervention in the past[1] and were recruited through announcements given to their health care professionals.

The SA group included 19 women ages 18–55 years with a mean age of 27.1 years. Inclusion criteria for this group involved screening using the Social Avoidance and Distress Scale (Watson & Friend, 1969), a 28-item questionnaire measuring the degree of distress one feels in social situations; a positively identifying score on the LSAS (Liebowitz, 1987); and a 24-item questionnaire measuring the degree and type of social anxiety, social avoidance, or both. Participants in the SA group did not exhibit any voice difficulties as perceptually judged during high quiet singing (Bastian, Keidar, & Verdolini-Marston, 1990) by the primary investigator, who is a certified speech-language pathologist (SLP) specializing in voice disorders, nor did they have any history of FD or laryngeal pathology per self-report. Participants were recruited through (a) flyers advertising a study on voice and emotion for people with SA and (b) a general screening for SA administered through the University of Minnesota's Department of Speech-Language-Hearing Sciences.

The HC group included 23 healthy women ages 18–55 years with a mean age of 28.6 years. Inclusion criteria for this group included (a) the absence of any current vocal difficulties as perceptually judged during high quiet singing (Bastian et al., 1990) by the primary investigator, who is a certified SLP specializing in voice disorders, nor a history of FD or laryngeal pathology per self-report, and (b) absence of SA as judged by a score falling outside the diagnostic criteria for SA on the Liebowitz Social Anxiety Scale (Liebowitz, 1987), nor any other psychological ailment such as depression, generalized anxiety disorder, or personality disorder per self-report. Recruitment for this population was accomplished through flyers advertising a study on voice and emotion placed around the University of Minnesota campus.

Age differences between groups were evaluated by performing an analysis of covariance (ANCOVA) of self-report and physiological response measures in which age was included as a covariate along with group membership. Age was also evaluated by age-matching participants in the SA and HC groups to the FD group so that group size was equal (N = 12) and ages were matched. In both analyses, age and group size did not interact significantly or change results in any measure, and therefore, all data were employed in statistical analyses. Pre-experimental administration of the Betts Questionnaire Upon Mental Imagery (Betts, 1909; Sheehan, 1967) established that imagery ability did not differ across groups (p = .05).

Measures

Mood-Inducing Stimuli—Independent Variables

Mood was induced using an imagery paradigm in which scripts were read to participants as they sat with eyes closed. Scripts of familiar common life activities included descriptions of specific activities and physical responses to these activities. The different script categories were balanced for activity content and number of response propositions.

The 20 mood-induction scripts fell within three affective conditions: positive, aversive, and neutral (see Table 1). The eight positive scripts were high in arousal and described positive situations. Four of these scripts involved speech, and four involved nonverbal communication. The eight aversive scripts were likewise high in arousal and described affectively negative situations. Four of these scripts involved speech, and four involved nonverbal communication. The four scripts in the

[1]The principal investigator had been a former therapist for two of the participants in the study. However, the data for these two participants did not differ compared with the data for the other participants with FD.

Table 1. Script assignment for script affect, script communication, and neutral conditions.

		Script affect condition (valence)		
		Aversive	**Positive**	**Neutral**
Script communication condition (speech)	*Nonverbal*	*Public evaluation* A. Standing in front of a group B. Being observed by a group of superiors	*Winning* A. Supporting a performer at a talent contest B. Passing a driver's test	Affect and communication conditions, no neutral condition
		Conflict A. Negative looks from a stranger B. Embarrassed about poor parking	*Nurturing* A. Observing a friend performing at a concert B. Waving at a young relative	
	Speech	*Public evaluation* A. Giving a speech in class B. Introducing a proposal for your boss	*Winning* A. Cheering for a relative at a race B. Congratulating girl scouts for winning a contest	Affect and communication conditions, no neutral condition
		Conflict A. Bad annual review at work B. Conflict with a relative	*Nurturing* A. Talking with loving grandmother B. Talking with a dear friend	
	Neutral	Neutral condition, no aversive condition	Neutral condition, no aversive condition	A. Bank trip B. Folding laundry C. Stop sign D. Setting the table

neutral condition were low in arousal and involved neither speech nor nonverbal communication.

Prior to this investigation, we verified the affective properties of these scripts in an independent sample of 25 healthy women by having these participants read each script and rate it on dimensions of pleasantness (valence) and excitement (arousal) using the Self-Assessment Manikin (SAM; Bradley & Lang, 1995). Aversive, neutral, and positive scripts were significantly different from one another in rated valence. Positive scripts exceeded neutral scripts, and both positive and neutral scripts exceeded negative scripts: positive versus aversive, $t(8, 16.06)$, $p < .001$; positive versus neutral, $t(8, 6.61)$, $p < .001$; aversive versus neutral, $t(8, 5.7)$, $p < .001$. In addition, the affective scripts both significantly exceeded the neutral scripts in rated arousal: aversive versus neutral, $t(8, 6.78)$, $p < .001$, and positive versus neutral, $t(8, 5.56)$, $p = .002$, with positive and aversive scripts not differing from each other.

Dependent Measures

All measures were chosen a priori, and in addition to serving as dependent variables in analyses of group differences, some measures also provided manipulation checks that facilitated data interpretation.

Psychometric measures—Personality, psychopathology, and voice handicap. A battery of psychometric tests was administered prior to the experimental session, including (a) the Multidimensional Personality Questionnaire–Brief Form (MPQ-bf; Patrick et al., 2002), a 155-item personality inventory that measures temperament-related traits and dispositions to behaviorally express these traits; (b) the State-Trait Anxiety Inventory (STAI; Spielberger, Gorusch, Lushene, Vagg, & Jacobs, 1983), a 40-question self-report measure of the degree of transient anxiety associated with current mood (state anxiety) and of more enduring tendencies to experience anxiety across situations (trait anxiety); (c) the Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961; Beck & Steer, 1993), a 21-item measure of the degree of depression in an individual; (d) the Voice Handicap Index (VHI; Jacobson et al., 1997), a 30-question measure describing the type and degree of impairment that an individual may experience as a result of a voice disorder; and (e) the LSAS (Liebowitz, 1987), a 24-item scale designed to differentiate between social anxiety and performance anxiety. These measures served to confirm group membership and replicate research by Roy and colleagues (2000a, 2000b).

Self-report measures of mood and affect. The second set of measures was a manipulation check that served to confirm mood induction following the mental imagery task and also assessed perceptions of vocal effort as a function of mood. These measures included self-report evaluations of levels of affective valence (pleasantness) and arousal (excitement) prompted by the various imagery scripts and were assessed along 9-point Likert scales using the SAM rating protocol. To measure the perceived vocal effort following mood induction, participants were asked to read a script-related sentence aloud and to rate their vocal effort using the Borg CR-10 (Borg, 1982), a 10-point category ratio scale.

Physiological and behavioral measures. The third set of measures—physiological and behavioral responses during the mental imagery task—assessed participant reactions to mood induction. These measures included tonic levels of electromyography (EMG) of the zygomaticus major muscle, known to reflect positive mood (Bradley & Lang, 2000); tonic levels of EMG of the corrugator muscle, known to reflect negative mood (Bradley & Lang, 2000); and EMG of the submental complex (digastric, geniohyoid, mylohyoid, and platysma muscles) and the thryohyoid muscles to index tonic shifts in submental and neck musculature (Ding, Larson, Logemann, & Rademaker, 2002). In addition, electrocardiography (ECG) measured heart rate (HR), an autonomic measure of arousal and affect (Bradley & Lang, 2000). Table 2 displays a list of the dependent measures used during each phase of the experiment.

Procedures

After signing informed consent, each participant completed the battery of psychometric tests. Then, EMG electrodes (Med Associates, St. Albans, VT) were placed on the left zygomaticus major muscle and left corrugator muscle according to procedures described by Fridlund and Cacioppo (1986), in the submental region and in the midlateral thyrohyoid space (cf. Ding et al., 2002). Electrocardiogram electrodes (Med Associates, St. Albans, VT) were placed on the right and left forearms to measure heart rate. Both EMG and ECG electrodes were 0.25 Ag-AgCl and were filled with electrolyte paste. Correct placement of all electrodes was verified by visual inspection of amplitude changes in voltage during tasks used to elicit specific muscle activity.

Table 2. List of dependent measures within each experimental phase.

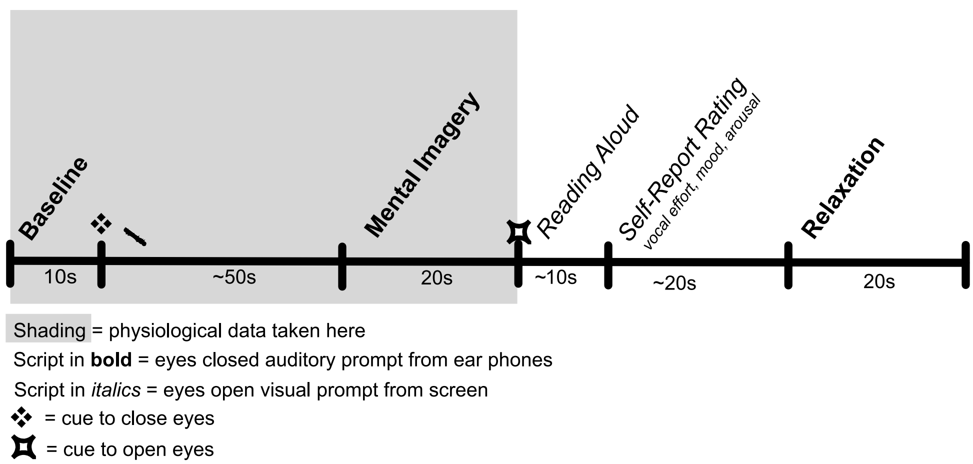
Variable	Measure
Recruitment screening	Social Avoidance and Distress scale
Pre-experimental measures	Questionnaire Upon Mental Imagery Multidimensional Personality Questionnaire State-Trait Anxiety Inventory Beck Depression Inventory Liebowitz Social Anxiety Scale Voice Handicap Index
Assessment during imagery	Electromyography of corrugator Electromyography of zygomaticus major Electromyography of thyrohyoid Electromyography of submental area Electrocardiography for heart rate
Post-mood-induction measures	Borg CR-10 measure of vocal effort Self-Assessment Manikin rating of valence Self-Assessment Manikin rating of arousal

Each participant underwent specific instructions to vividly imagine that she was involved in the situation described in the script to maximize compliance with the imagery task (Lang, 1979). Stimuli were delivered via E-Prime software running on an IBM-compatible computer. Auditory stimuli (scripts) were delivered binaurally through Etymotics headphones (Model ER-4S, Elk Grove Village, IL). Visual stimuli (sentences and self-report measures) were delivered via computer monitor. Following training and prior to each script, participants listened to a 20-s relaxation script that focused on breathing and were given an additional 10 s prior to auditory stimuli (scripts) that served as a baseline. Following baseline, participants listened to scripts and actively imagined involving themselves in the scene for 20 s after the script ended. A tone alerted the participant at the end of the imagery to look at the computer screen and read the displayed sentence aloud. They were given 10 s to read each sentence. The participant completed the Borg CR-10 vocal effort rating, the SAM valence, and the SAM arousal ratings prompted by the computer. After presentation of all 20 scripts, the electrodes were removed. The total experiment (completing questionnaires, electrode hook-up, and imagery) took approximately 2 hr. See Figure 1 for a timeline of the procedures.

Instrumentation and Data Reduction

Physiological data were recorded and digitized at a rate of 2000 Hz on a second IBM-compatible computer using a 32-channel Neuroscan SynAmps amplifier (Charlotte, NC) with Neuroscan Acquire software. Physiological activity was examined during the last 20 s of script delivery, during the 20 s of imagery, and during the 10-s baseline period (see Figure 1). Data during mood induction were referenced to the 20-s pre-script baseline period. EMG signals were filtered using a 500-Hz low-pass filter, epoched in successive 5-s bins, and re-referenced using MATLAB. EMG activity was measured by computing the median activity level during the last 20 s of script presentation and the 20 s of imagery (40 s total) and then subtracting from the median activity level during the 10-s baseline. HR was estimated from intervals between

Figure 1. Procedure timeline.



successive ECG R waves and was converted to mean values in beats per min for the script presentation, imagery, and baseline periods. Shorter segments of EMG and HR activity were analyzed but did not contribute additional information; therefore, they were not further analyzed.

Analysis

Psychometric measures of personality, psychopathology, and voice handicap. For each pre-imagery psychometric measure, a one-way analysis of variance (ANOVA) was performed to compare group means. Tukey's honestly significant difference (HSD; $\alpha = .05$) post hoc analyses were performed to clarify significant group effects. All statistical tests were Bonferroni corrected.

Self-report measures of mood and affect. Post-imagery ratings on the SAM valence, arousal, and Borg CR-10 scales were examined using two separate three-way repeated measures ANOVAs for script affect and script communication—for script affect: a 3 × 3 Group (FD, HC, SA) × Script Affect (positive, neutral, aversive) ANOVA; for script communication: a 3 × 3 Group (FD, HC, SA) × Script Communication (nonverbal communication, neutral, speech) ANOVA. Separate analyses were necessary for the script affect and script communication conditions because the same neutral scripts served as a comparison condition for both. Post hoc analyses (Tukey's HSD; $\alpha = .05$) were used to clarify omnibus effects.

Physiological measures. Each physiological dependent measure gathered during imagery was examined using two separate three-way repeated measures ANOVAs for script affect and script communication—for script affect: a 3 × 3 Group (FD, HC, SA) × Script Affect (positive, neutral, aversive) ANOVA; for script communication: a 3 × 3 Group (FD, HC, SA) × Script Communication (nonverbal communication, neutral, speech) ANOVA. Separate analyses were necessary for each condition because the same neutral scripts were used in both comparisons. Post hoc analyses (Tukey's HSD; $\alpha = .05$) were used to clarify omnibus effects. All statistical tests were Bonferroni corrected.

Contrasts. Univariate contrasts were used to describe group differences within the main effects. The advantage of this analysis is that variances from all three groups were represented in individual group analysis, thereby strengthening the level of significance. The linear contrast in the Group × Script Affect repeated measures ANOVA compared aversive to positive conditions to reveal valence effects. The quadratic contrast compared the combined aversive and positive conditions with the neutral condition to determine arousal affects. For the Group × Script Communication repeated measures ANOVA, the linear contrast compared speech with nonverbal communication conditions and displayed affects of voicing. The quadratic contrast compared the combined communications conditions to the neutral conditions effect and revealed communication effects.

Results

Psychometric Measures—Personality, Psychopathology, and Voice Handicap (Pre-Mood Induction)

Differences between groups on the psychometric measures (see Table 3) were apparent for seven subscales of the MPQ-bf as well as for the STAI, BDI, LSAS, and VHI. On the MPQ-bf, the SA group differed from the other

Table 3. Mean scores and *SD*s on pre-experimental psychometric measures for each experimental group.

Measure	FD		HC		SA	
	M	*SD*	*M*	*SD*	*M*	*SD*
Questionnaire Upon Mental Imagery	158.25	33.32	161.5	26.81	143.35	29.49
Multidimensional Personality Questionnaire (MPQ)						
MPQ Superfactor 1—Positive Emotionality[b,c]	54.92	9.40	60.65	9.30	44.45	9.40
MPQ subscale—Well-Being[b,c]	54.65	6.49	54.65	8.21	42.80	8.02
MPQ subscale—Social Closeness[b,c]	53.58	8.52	58.30	7.36	42.00	10.15
MPQ subscale—Social Potency[b,c]	52.83	7.08	58.30	7.28	48.75	9.08
MPQ subscale—Achievement	51.42	7.77	54.78	8.40	51.30	7.19
MPQ Superfactor 2—Negative Emotionality[b,c]	47.67	7.15	44.74	7.55	56.15	9.48
MPQ subscale—Stress Reactivity[c]	49.83	8.83	44.22	7.16	56.35	8.75
MPQ subscale—Alienation[b,c]	50.50	6.25	49.04	6.85	58.30	9.52
MPQ subscale—Aggression	44.50	7.43	44.87	7.56	50.00	8.41
MPQ Superfactor 3—Behavioral Constraint	49.67	11.37	45.58	9.74	46.55	9.76
MPQ subscale—Control	54.00	9.82	51.74	11.13	52.60	9.93
MPQ subscale—Harm Avoidance	51.33	9.20	47.13	7.70	48.40	9.68
MPQ subscale—Traditionalism	42.42	12.99	41.83	9.31	42.00	11.17
MPQ—Absorption	55.83	10.36	57.87	10.50	54.00	9.75
State-Trait Anxiety Inventory (STAI)—Total[b,c]	74.17	16.57	64.57	14.20	89.65	17.97
STAI—State subscale[b,c]	34.33	10.13	29.43	8.37	42.60	9.74
STAI—Trait subscale[b,c]	39.83	7.44	35.13	6.35	47.05	9.74
Beck Depression Inventory[b,c]	5.83	5.78	4.09	3.83	13.35	9.92
Liebowitz Social Anxiety Scale (LSAS)—Total[a,b,c]	39.17[a,c]	15.63	24.52	14.67	75.45	20.89
LSAS—Fear subscale[a,b,c]	21.75	10.18	11.74	8.09	41.50	9.48
LSAS—Avoidance subscale[b,c]	17.42	7.67	12.26	7.94	35.74	12.68
Voice Handicap Index (VHI)—Total[a,b,c]	78.67	16.65	38.43	5.07	53.80	13.90
VHI—Functional Scale[a,b,c]	24.17	2.12	14.04	4.89	18.65	4.21
VHI—Physical Scale[a,b,c]	28.33	6.58	13.26	2.63	18.75	4.54
VHI—Emotional Scale[a,b,c]	23.17	7.33	11.13	1.45	16.40	6.53

Note. [a]Functional dysphonia (FD) group significantly different from healthy control (HC) group, $p < .05$; [b]FD group significantly different from social anxiety (SA) group, $p < .05$; [c]HC group significantly different from SA group, $p < .05$.

two groups on six of the seven subscales. The SA group scored lower on positive emotionality (E/PE), well-being, social closeness, and social potency, and scored higher on negative emotionality (N/NE) and alienation. In addition, the SA group scored significantly higher than the HC group on stress reactivity but did not differ significantly from the FD group.

On the STAI, the SA group also scored significantly higher than both the FD and HC groups on the State and Trait subscales. On the BDI, the SA group also scored significantly higher than both the FD and HC groups. The FD and HC groups did not differ significantly from one another on any of the scales of the STAI or the BDI.

All three groups differed significantly from one another in overall scores on the LSAS. The SA group demonstrated the highest score, which exceeded the total score cutoff of 60 for a positive identification of a generalized social anxiety disorder (Mennin et al., 2002). In addition, the FD group's mean score exceeded the cutoff of 30 for a specific social phobia (Mennin et al., 2002). The HC group's mean score was below the cutoff for identification of any form of social anxiety. On the Fear and Avoidance subscales of the LSAS, the SA group's scores were significantly higher than those for the other two groups. In addition, the FD group demonstrated an elevated Fear (but not Avoidance) score compared with the HC group. Thus, on the LSAS, the FD group demonstrated a specific social fear but no concomitant avoidance secondary to this fear, whereas the SA group showed both fear and avoidance in social situations.

Table 3 shows that all three groups also differed significantly from one another on the total VHI score and on its three subscales. The FD group had the highest total score and subscale scores, followed by the SA group.

Self-Report Measures of Mood and Affect (Post-Mood Induction)

Script affect condition. Across groups, participants rated aversive scripts as more unpleasant and positive scripts as more pleasant than neutral scripts, $F(2, 50) = 102.32, p < .001, \eta^2 = .804$, univariate quadratic contrast, $F(1, 51) = 23.47, p < .001, \eta^2 = .315$ (see Figure 2, Graph A). In post hoc analysis, the SA group responded with less positive mood after imagery across all script types than did the other groups, and this difference was significant in comparison with the HC group.

All three groups rated aversive and positive scripts as significantly more arousing than neutral scripts, $F(2, 50) = 49.2, p < .001, \eta^2 = .663$, univariate quadratic contrast, $F(1, 51) = 97.85, p < .001, \eta^2 = .656$ (see Figure 2, Graph B). There was no Group × Valence interaction, nor any significant differences between groups for any script type.

On the Borg CR-10, shown in Graph C of Figure 2, all groups rated vocal output following aversive scripts as significantly more effortful than output following either neutral scripts or positive scripts, $F(2, 50) = 15.97, p < .001, \eta^2 = .390$, univariate quadratic contrast, $F(1, 51) = 11.01, p = .002, \eta^2 = .197$. In post hoc analysis of all three script types, vocal output was more effortful for participants with FD than for HC participants. Table 4 shows numeric means and standard deviations for the graphs in Figure 2.

Script communication condition. Participants rated both nonverbal communication and speech scripts as significantly more aversive than neutral scripts, univariate quadratic, $F(2, 50) = 11.76, p < .001, \eta^2 = .320$, univariate quadratic contrast, $F(1, 51) = 23.47, p < .001, \eta^2 = .315$ (see Figure 3, Graph B). Post hoc tests revealed that the SA group responded with significantly greater negative ratings for all scripts compared with the HC group.

All groups rated nonverbal and speech scripts as significantly more arousing than neutral scripts, univariate quadratic, $F(2, 50) = 54.53, p < .001, \eta^2 = .686$, univariate quadratic contrast, $F(1, 51) = 97.09, p < .001, \eta^2 = .656$. There was no significant Group × Script Communication interaction (shown in Graph B of Figure 3).

Graph C of Figure 3 shows that all groups rated vocal output following imagery of speech scripts as more effortful than imagery of neutral or nonverbal communication scripts on the Borg CR-10, $F(2, 50) = 6.973, p = .002, \eta^2 = .218$, univariate quadratic contrast, $F(1, 51) = 11.27, p = .001, \eta^2 = .181$. Post hoc tests revealed that the FD group reported greater vocal effort compared with the HC group for both speech and neutral scripts. Table 5 presents numeric means and standard deviations for the data plotted in Figure 3.

Group differences within script type. There were no differences in response with the SAM valence and the

Figure 2. Mean scores for each group for script affect conditions. Graph A displays Self-Assessment Manikin (SAM) valence ratings (9-point Likert scale; 1 = *aversive*, 9 = *positive*). Graph B displays SAM arousal ratings (9-point Likert scale; 1 = *calm*, 9 = *excited*). Graph C displays Borg CR-10 ratings (11-point Likert-type scale; 0 = *no effort*, 10 = *greatest amount of effort*). Each script affect condition included both speech and nonverbal scripts. FD = functional dysphonia; HC = healthy controls; SA = social anxiety.

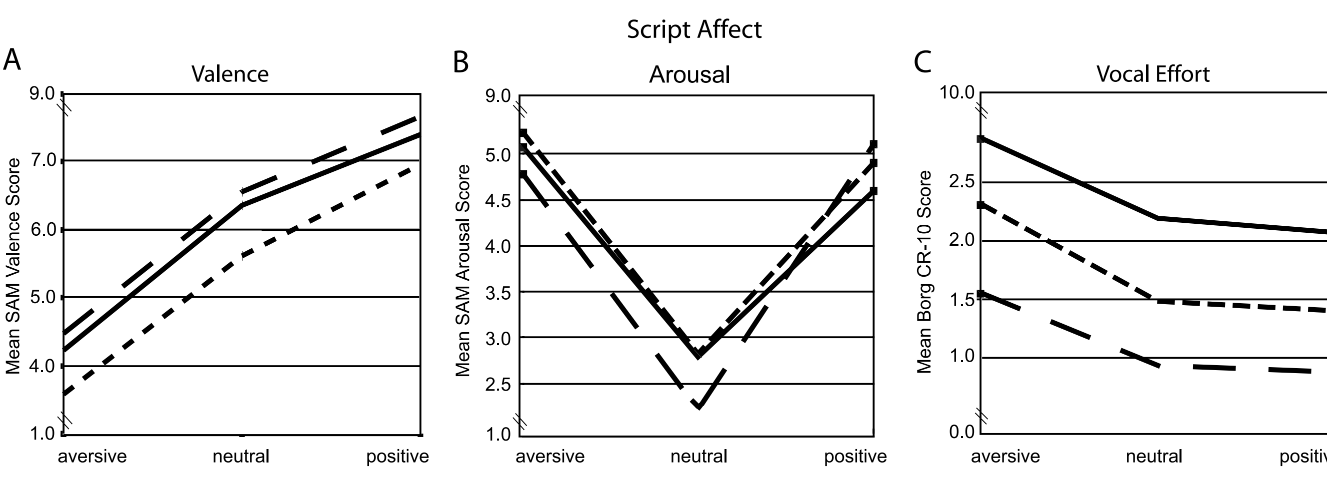


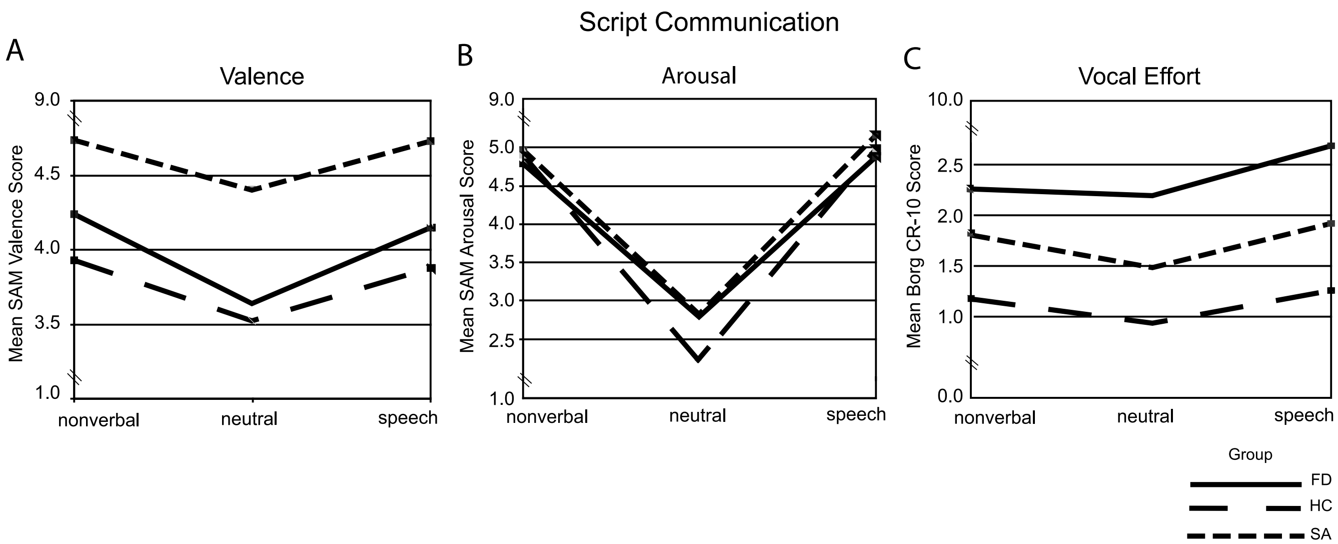
Table 4. Mean scores and *SD*s for post-mood induction self-report ratings for each group for each valence condition.

Variable	FD			HC			SA		
	Aversive *M (SD)*	**Neutral** *M (SD)*	**Positive** *M (SD)*	**Aversive** *M (SD)*	**Neutral** *M (SD)*	**Positive** *M (SD)*	**Aversive** *M (SD)*	**Neutral** *M (SD)*	**Positive** *M (SD)*
SAM Valence	4.20 (1.51)	6.36 (1.22)	7.41 (1.03)	4.47 (1.7)	6.48 (1.29)	7.72[c] (0.92)	3.58 (1.16)	5.60 (0.70)	6.95[a] (1.09)
SAM Arousal	5.07[d] (1.74)	2.79[e,f] (1.20)	4.59[d] (1.98)	4.77[d] (1.49)	2.22[e,f] (1.06)	5.11[d] (1.81)	5.23[d] (1.67)	2.83[e,f] (1.50)	4.90[d] (1.65)
Borg CR-10	2.87[a,d,e] (1.49)	2.19[a,e,f] (1.27)	2.07[a,f] (1.14)	1.55[b,d,e] (1.16)	0.93[b,e,f] (0.81)	0.88[b,d,f] (0.79)	2.31[e] (1.02)	1.48 (1.09)	1.41[d,f] (1.07)

Note. Self-Assessment Manikin (SAM) valence ratings were on a 9-point Likert scale (1 = *aversive*, 9 = *positive*). SAM arousal ratings were on a 9-point Likert scale (1 = *calm*, 9 = *excited*). Borg CR-10 ratings were on an 11-point Likert-type scale (0 = *no effort*, 10 = *greatest amount of effort*).

[a]significantly different from HC; [b]significantly different from FD; [c]significantly different from SA; [d]significantly different from neutral; [e]significantly different from positive; [f]significantly different from aversive.

Figure 3. Mean scores for each group for script communication conditions. Graph A displays SAM valence ratings (9-point Likert scale; 1 = *aversive*, 9 = *positive*). Graph B displays SAM arousal ratings (9-point Likert scale; 1 = *calm*, 9 = *excited*). Graph C displays Borg CR-10 ratings (11-point Likert-type scale; 0 = *no effort*, 10 = *greatest amount of effort*). Each script communication condition included both aversive and positive scripts.



Borg CR-10 in the SA and HC groups between the aversive and positive conditions. However, in post hoc analysis, the FD group rated positive speech scripts as significantly more pleasant than positive nonverbal scripts with the SAM valence (see Figure 4, Graph A). With the Borg CR-10, the FD group rated vocal output following the aversive *speech* scripts as more effortful than the vocal output following the aversive *nonverbal* scripts (see Figure 4, Graph B). On the SAM arousal ratings, all groups rated nonverbal and speech scripts similarly in both aversive and positive conditions.

Physiological and Behavioral Measures (During Imagery Mood Induction)

Script affect condition. All participant groups showed greater EMG activity in the corrugator muscle for aversive scripts compared with neutral and positive scripts, $F(2, 51) = 8.41$, $p = .001$, $\eta^2 = .248$, univariate linear contrast, $F(1, 51) = 9.57$, $p = .003$, $\eta^2 = .155$. In post hoc analysis, the FD group showed less corrugator EMG activation in the aversive condition compared with the neutral and positive conditions. Graph A of Figure 5 separately displays the mean corrugator change from baseline measure by affective condition for each experimental group.

All participant groups showed expected EMG activity for the zygomaticus major muscle. Positive scripts elicited greater activity compared with neutral and aversive scripts, $F(2, 51) = 6.98$, $p = .002$, $\eta^2 = .215$, univariate linear contrast, $F(1, 51) = 9.52$, $p = .001$, $\eta^2 = .184$ (see Figure 5, Graph B).

Participants, in general, demonstrated significantly greater EMG activity in the submental muscles for affective scripts (aversive and positive) as compared with neutral scripts, $F(2, 51) = 4.09$, $p = .023$, $\eta^2 = .138$, univariate quadratic contrast, $F(1, 51) = 7.29$, $p = .009$, $\eta^2 = .123$ (see Figure 5, Graph C). The quadratic contrasts showed significantly greater submental activity in affective versus neutral scripts for the SA groups and showed less submental modulation in affect scripts for the FD group compared to neutral, univariate quadratic contrast, $F(1, 7.289)$, $p = .009$, $\eta^2 = .123$.

Participant groups failed to demonstrate expected EMG activity for the thyrohyoid muscle. Differences in group, script affect, and their interaction for EMG activity did not achieve statistical significance (see Figure 5, Graph D).

Participants demonstrated increased HR for affective scripts than neutral scripts, $F(2, 46) = 4.84$, $p = .012$, $\eta^2 = .174$, univariate quadratic contrast, $F(1, 47) = 6.60$, $p = .013$, $\eta^2 = .123$ (see Figure 5, Graph E). The HC and SA groups demonstrated higher HR relative to baseline during imagery of aversive scripts, whereas the participants with FD showed higher HR relative to baseline during imagery of both aversive and positive scripts: univariate linear contrast, $F(1, 87.48)$, $p = .013$, $\eta^2 = .123$. Refer to Table 6 for numeric values and standard deviations for the graphs in Figure 5.

Script communication condition. Participant groups failed to demonstrate expected EMG activity for the corrugator muscle. Differences in corrugator contraction during speech, neutral, and nonverbal conditions did

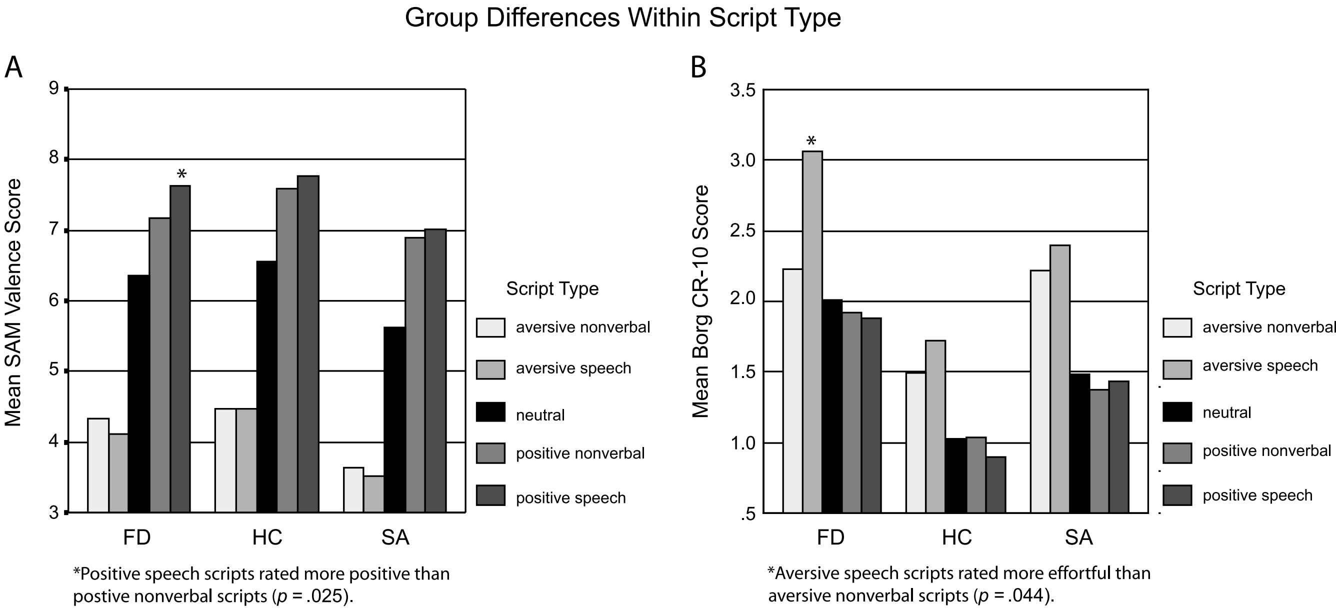
Table 5. Mean scores and *SD*s for post-mood induction self-report ratings for each group for each script communication condition.

	FD			HC			SA		
Self-report rating	**Nonverbal** ***M*** **(*SD*)**	**Neutral** ***M*** **(*SD*)**	**Speech** ***M*** **(*SD*)**	**Nonverbal** ***M*** **(*SD*)**	**Neutral** ***M*** **(*SD*)**	**Speech** ***M*** **(*SD*)**	**Nonverbal** ***M*** **(*SD*)**	**Neutral** ***M*** **(*SD*)**	**Speech** ***M*** **(*SD*)**
SAM Valence	5.76[d] (1.11)	6.36[e,f] (1.22)	5.85[d] (1.10)	6.07[c,d] (1.05)	6.48[c,e,f] (1.29)	6.12[c,d] (0.95)	5.26[a,d] (0.78)	5.60[a,e,f] (0.70)	5.27[a,d] (0.68)
SAM Arousal	4.79[d] (1.69)	2.79[e,f] (1.20)	4.88[d] (1.90)	4.90[d] (1.44)	2.22[e,f] (1.06)	4.98[d] (1.65)	4.98[d] (1.42)	2.89[e,f] (1.50)	5.16[d] (1.68)
Borg CR-10	2.56[d,e] (1.13)	2.19[a,e,f] (1.27)	2.69[a,df] (1.39)	1.17[d,e] (0.98)	0.93[b,e,f] (0.81)	1.26[b,d,f] (0.96)	1.80[d,e] (1.02)	1.48[f] (1.09)	1.92[d,f] (0.91)

Note. SAM valence ratings were on a 9-point Likert scale (1 = *aversive,* 9 = *positive*). SAM arousal ratings were on a 9-point Likert scale (1 = *calm*, 9 = *excited*). Borg CR-10 ratings were on an 11-point Likert-type scale (0 = *no effort*, 10 = *greatest amount of effort*).

[a]significantly different from HC; [b]significantly different from FD; [c]significantly different from SA; [d]significantly different from neutral; [e]significantly different from speech; [f]significantly different from nonverbal.

Figure 4. Ratings for each script type for each group. Graph A displays SAM valence ratings (9-point Likert scale; 1 = *calm*, 9 = *excited*). Graph B displays Borg CR-10 ratings (11-point Likert-type scale; 0 = *no effort*, 10 = *greatest amount of effort*).



not achieve statistical significance for any participant groups.

All participants showed greater EMG activity in the zygomaticus muscle in the communication scripts (speech and nonverbal) than in the neutral scripts, $F(2, 51) = 7.25$, $p = .002$, $\eta^2 = .221$ (see Figure 6, Graph B). Participants also showed greater EMG activity in the zygomaticus muscle for the nonverbal scripts compared with neutral and speech scripts: univariate linear contrast, $F(1, 51) = 6.034$, $p = .017$, $\eta^2 = .104$. They also showed greater EMG activity in the zygomaticus muscle for both nonverbal and speech scripts compared with neutral scripts: univariate quadratic contrast, $F(1, 51) = 7.72$, $p = .000$, $\eta^2 = .221$.

Participants demonstrated increased EMG activity in the submental muscles for communication scripts (nonverbal and speech) compared with neutral scripts, $F(2, 51) = 3.63$, $p < .034$, $\eta^2 = .125$, univariate quadratic contrast, $F(1, 51) = 7.29$, $p = .009$, $\eta^2 = .123$. The SA and HC groups demonstrated different patterns of response compared with the FD group, whereas the SA and HC groups demonstrated greater submental activity for both speech and nonverbal scripts compared with neutral scripts, and the FD group demonstrated less submental activity: Group × Condition interaction of univariate quadratic contrast, $F(1, 52) = 3.271$, $p = .046$, $\eta^2 = .112$ (see Figure 6, Graph C).

Participant groups failed to demonstrate expected EMG activity for the thyrohyoid muscle. Differences in thyrohyoid contraction during speech, neutral, and nonverbal conditions did not achieve statistical significance for any participant groups (see Figure 6, Graph D).

All participants produced greater HR activity for the script communication condition, $F(2, 46) = 3.62$, $p = .035$, $\eta^2 = .136$, univariate quadratic contrast, $F(1, 47) = 7.0$, $p = .011$, $\eta^2 = .130$ (see Figure 5, Graph E). However, there was no significant Group × Script Communication interaction. Refer to Table 7 for numeric values and standard deviations for the graphs in Figure 6.

Conclusion

The purpose of this research was to test the trait theory of voice disorders in persons with FD. Our first hypothesis was that those with FD would have increased measures of N/NE and increased CON compared with healthy controls. On the MPQ-bf, a personality inventory that assesses a broad range of trait dispositions, the SA group was the only group with increased levels of N/NE; the FD group only scored with trend-level increases in N/NE. However, on the subscales of the MPQ-bf, those with FD did not differ from the SA group on the Stress Reactivity subscale, a scale that loads onto the factor N/NE (Tellegen & Waller, in press), suggesting that those with FD do present with some tendencies for N/NE. However, due to the small and uneven group sizes, the power to detect personality differences or tendencies was poor.

The three groups scored similarly on the CON factor, which is not consistent with past research (Roy et al., 2000b). Again, participant group size was small in comparison with past research, and therefore power to detect personality differences was poor. Despite this, on the

Figure 5. Differences among groups in physiological activity for each script affect condition. Graphs A–D (electromyography [EMG] activity is in mV, expressed as the difference from baseline): Graph A represents corrugator activity; Graph B represents zygomaticus major activity; Graph C represents submental complex activity; and Graph D represents thyrohyoid activity. Graph E represents heart rate activity in beats per minute (bpm), expressed as the difference from baseline.

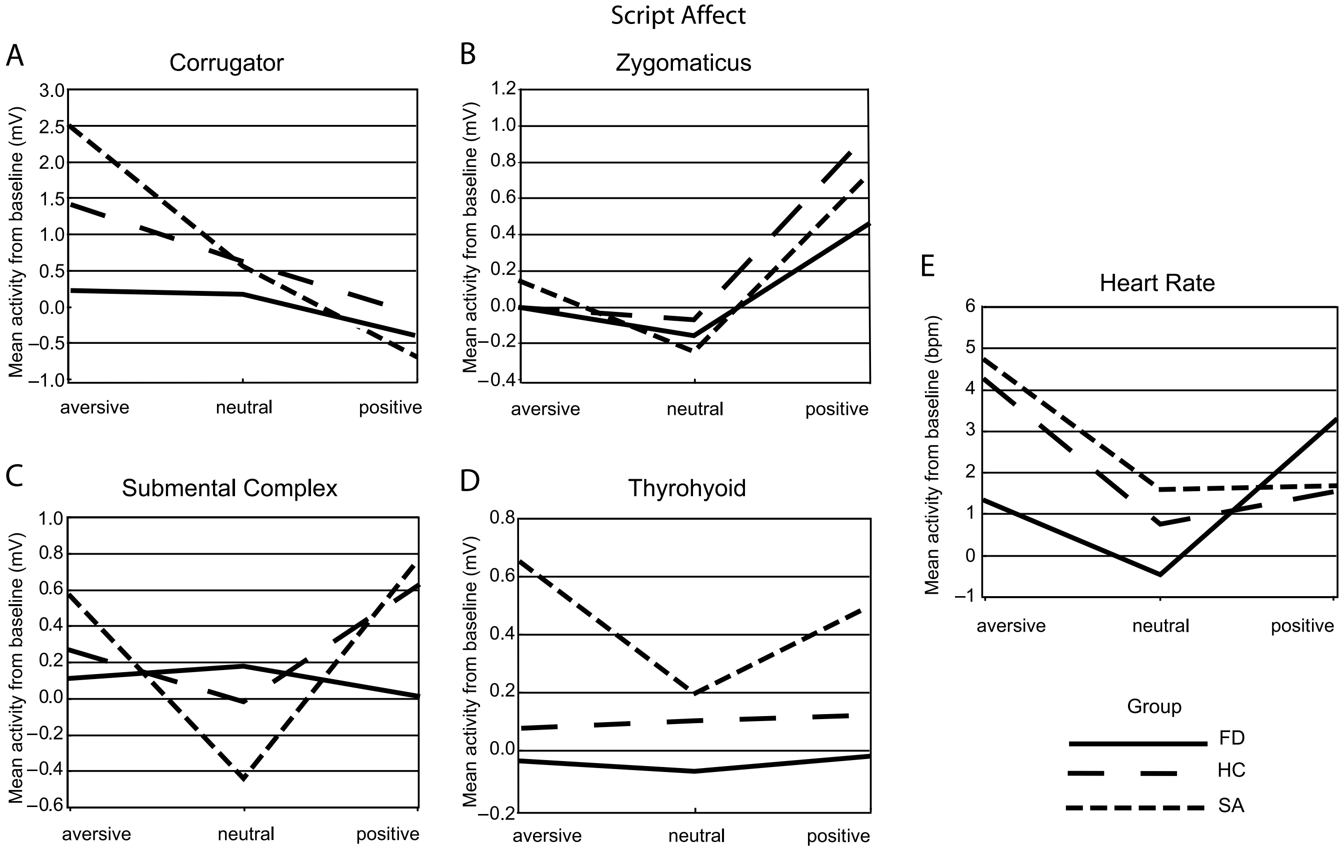


Table 6. Mean differences (first line of each physiologic measure) and standard deviations (second line of each physiologic measure) in physiological activity from baseline for each experimental group for each script valence category.

Physiologic measure	FD			HC			SA		
	Aversive	Neutral	Positive	Aversive	Neutral	Positive	Aversive	Neutral	Positive
EMG corrugator (mV)	0.23[a]	0.17	−0.39	1.42[b]	0.63	−0.09	2.48	0.56	−0.68
	0.38	0.21	−0.34	2.76	0.58	0.89	6.14	0.62	0.98
EMG zygomaticus major (mV)	−0.00[c]	−0.16	0.46	−0.00[c]	−0.07[c]	0.96	0.14[a,b]	−0.24[a]	0.73
	0.08	0.18	0.83	0.23	0.15	1.60	0.48	0.42	1.34
EMG submental complex (mV)	0.11	0.18	0.01[a,c]	0.27	−0.01[c]	0.62[b]	0.57	−0.44[a]	0.76[b]
	0.60	0.54	0.58	0.51	0.49	0.98	1.50	1.15	1.28
EMG thyrohyoid (mV)	−0.04	−0.07	−0.02	0.08	0.10[c]	0.12	0.65	0.20[a]	0.50
	0.07	−0.04	0.01	0.47	0.38	0.58	2.27	0.91	1.28
Heart rate (bpm)	1.3	−0.45	3.27	4.25	0.76	1.56	4.72	1.59	1.68
	2.99	2.50	4.13	5.47	3.64	2.96	4.79	4.65	3.25

Note. A = aversive; N = neutral; P = positive; mV = millivolts; bpm = beats per minute.

[a]Significantly different from HC; [b]significantly different from FD; [c]significantly different from SA.

Figure 6. Differences among groups in physiological activity for each script communication condition. Graphs A–D (EMG activity is in mV, expressed as the difference from baseline): Graph A represents corrugator activity; Graph B represents zygomaticus major activity; Graph C represents submental complex activity; and Graph D represents thyrohyoid activity. Graph E represents heart rate activity in beats per minute (bpm), expressed as the difference from baseline.

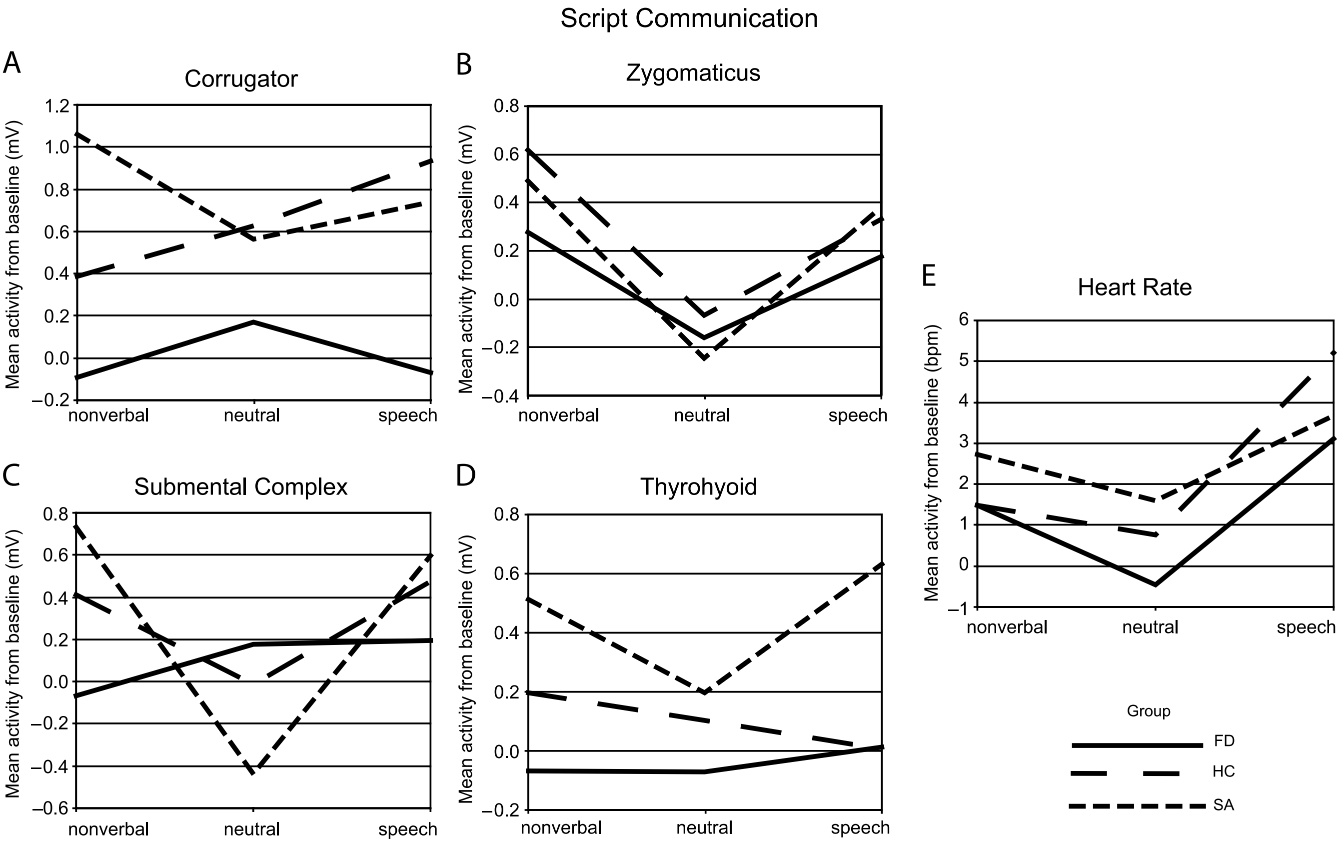


Table 7. Mean differences (first line of each physiologic measure) and standard deviations (second line of each physiologic measure) in physiological activity from baseline for each experimental group for each script communication category.

Physiologic measure	FD			HC			SA		
	Nonverbal	Neutral	Speech	Nonverbal	Neutral	Speech	Nonverbal	Neutral	Speech
EMG corrugator (mV)	–0.09[c]	0.17	–0.07	0.39	0.63	0.93	1.06[a]	0.56	0.74
	0.37	0.71	0.76	0.98	0.86	1.90	3.25	1.29	2.87
EMG zygomaticus major (mV)	0.28	–0.16	0.18	0.62	–0.07[c]	0.33	0.49	–0.24[a]	0.38
	0.48	0.16	0.33	1.03	0.16	0.64	0.88	0.43	0.88
EMG submental complex (mV)	–0.07	0.18	0.19	0.41	–0.01[c]	0.48	0.73	–0.44[a]	0.60
	0.71	0.54	0.49	0.71	0.50	0.64	1.37	1.15	1.37
EMG thyrohyoid (mV)	–0.07	–0.07	0.01[c]	0.19	0.10[c]	0.01	0.51	0.20[a]	0.63[b]
	0.53	0.73	0.49	0.49	0.38	0.49	1.28	0.91	2.23
Heart rate (bpm)	1.48	–0.45	3.11	1.49	0.76	5.23	2.73	1.59	3.67
	3.52	2.50	2.36	3.83	3.64	10.43	3.66	4.66	4.65

[a]significantly different from HC; [b]significantly different from FD; [c]significantly different from SA.

LSAS, the FD group demonstrated a high level of fear but not avoidance in social situations. So, despite reporting fear and anxiety in social situations, participants with FD may not react or modify their subsequent behaviors as a result of their fear, which could be interpreted as evidence toward a tendency for behavioral constraint in situations of social fear. Conversely, increased fear but not avoidance in social situations could be a reflection of adequate training in voice therapy.

Our second hypothesis predicted that those with FD would demonstrate increased measures of autonomic activation associated with emotion, specifically increased HR, as compared with the HC group, but similar autonomic measures of emotion, as compared with the SA group. Although all groups demonstrated elevated HR for affective and communication conditions, it was the HC and SA groups that scored similarly, not the SA and FD groups. The HC and SA groups had higher HR during aversive scripts, whereas the FD group showed higher HR during both aversive and positive scripts. Nonetheless, those with FD did demonstrate predicted autonomic activity to affective and communication stimuli, confirming their subjective response of emotion.

Finally, our third hypothesis predicted that the FD group would demonstrate reduced measures of behavioral expression of emotion compared with the HC group but similar to the SA group. Our findings clearly demonstrated that the FD group showed less EMG activity in muscles of facial expression of emotion, compared with both the HC and SA group, partially confirming our hypothesis that those with FD demonstrate reduced emotional expression.

The results for EMG activity for muscles of speech were less clear. Those with FD demonstrated less EMG activity in the submental complex for affective and communication scripts compared with the HC and SA groups. In addition, those with SA demonstrated greater tonic EMG levels during affective and communication scripts, showing the opposite effect compared with the FD group. The opposite pattern of behavior between the FD and SA group appears at odds with the idea that those with FD present with a specific form of SA related to voicing (Gerritsma, 1991). Results for EMG activity for the thyrohyoid muscle were inconclusive for all groups, which could reflect the difficulty in detecting adequate EMG signals for certain participants with shorter, wider necks and/or the inability to differentiate tonic levels of thyrohyoid muscle versus other strap muscles across the 60-min experimental paradigm. Finally, the current experimental paradigm measured tonic changes in EMG activation during mental imagery, not during overt speech. Although preliminary analysis of overt speech tasks during sentence reading revealed similar findings to mental imagery tasks, these results might have been different if the experimental paradigm were designed to measure overt speech tasks. Lastly, our subhypothesis—that the FD group would present with exaggerated decreases in behavioral expression with speech scripts compared with nonspeech scripts—remains unproven.

Behavioral Inhibition

Overall, results from this experimentally controlled paradigm appear to support the trait theory of voice disorders put forth by Roy and Bless (2000) by showing that in emotional conditions, those with FD demonstrated reduced levels of tonic EMG activity in muscles of behavioral expression but increased activity in autonomic measures of emotional experience. In their theory, they suggest that those with FD present with neurotic, introverted, and behaviorally constrained personality traits that predispose them to acquiring a functional voice disorder and theorize that this is a reflection of the behavioral inhibitory system (BIS). The BIS, as defined by Gray (1991), arises from the septo-hypocampal system and closely corresponds to neuroticism and constraint because this system facilitates the interpretation of external stimuli as potentially threatening or punishing. Once a threat is detected, the BIS interrupts and modifies current behavior, and adjusts future behavior accordingly. Roy and Bless (2000) suggested that increases in behavioral constraint seen in FD speakers might activate the BIS, which could explain their aberrant speech and vocal technique (e.g., increased breath-holding and extra-laryngeal tension). Reduced tonic levels of activation in muscles of behavioral expression, despite evidence through increased autonomic activity of a subjective emotional experience, could be a result of the BIS.

Reduced Activation

An alternative explanation for the pattern of results observed for the three different measures (psychometric, self-report, and physiological) could be that those with FD engage in reduced psychomotor motivation or arousal activation of the speech and voice muscles during emotional or communication content as compared with HC and SA control groups. This reduced motivation in the muscles of speech could be the cause of dysphonia in those with FD. Participants with FD demonstrated reduced EMG activity for the submental complex for all nonverbal, speech, aversive, and positive script conditions compared with the other two groups. Similarly, they demonstrated reduced activity in the facial expressive muscles during nonverbal and speech scripts compared with the other two groups. However, their EMG activity during neutral stimuli did not differ from the HC or SA groups. The reductions in muscle activity during experimental manipulations were not reflected in their self-ratings of vocal effort, which had significantly higher ratings compared with the other groups. Additionally, those with FD rated more handicaps because of their voice complaints and displayed elevated autonomic arousal (heart rate) for affect and communication scripts. Thus, those with FD demonstrate increased psychometric and self-reported difficulties in voicing and increased autonomic activation but reduced muscular activation in the speech muscles for affect and communication scripts, all of which suggest that their personal experiences of vocal effort, impairment, and autonomic readiness do not motivate or inspire action in the speech and voice muscles.

This lack of activation in the speech and voice muscles is even more pronounced when compared with the SA and HC control groups for the affect conditions. Based on mental imagery paradigms of speech musculature (McGuigan & Dollins, 1989), these muscles should have responded to imagery of speech scripts. Even when communication scripts were collapsed across affect, the FD group failed to demonstrate increases in muscular activity in response to emotional stimuli. Reduced activation in these muscle groups for both affect and communication scripts over neutral scripts, despite increased autonomic activity and increased reports of effort, may signal that the underlying cause of dysphonia in FD may be a discrepancy between subjective experience and motivation to engage the muscles of speech.

Emotional Regulation

A third explanation for the pattern of response that emerges in all three types of measures is that those with FD may engage in a response-focused emotional regulatory style (Gross, 2002); namely, they regulate emotions by regulating emotional response. First, those with FD present with higher levels of stress reactivity and fear in social situations. These tendencies can be observed on autonomic measures during mental imagery with elevated HR activity for affect scripts. Additionally, those with FD demonstrated normal modulation of EMG activity in the zygomaticus major muscle for positive scripts but limited EMG responses in the corrugator for aversive scripts. Finally, in measures of mood following mental imagery, they respond with increased sensitivity to positive conditions, rating positive speech scripts more pleasant than positive nonverbal scripts. However, aversive scripts in both conditions did not differ with respect to the communication condition. These results suggest that those with FD may be selectively suppressing negative affect while allowing more normal modulation and variation of physiological activity and experienced mood for positive affect. This interpretation has implications for our counseling and treatment focus in this population. Instead of addressing situations that cause the greatest voice difficulty, which inherently emphasize the negative or punishing aspects of voicing, our treatment for FD might be more successful if we highlight and amplify vocally successful experiences to emphasize and strengthen connections to the positive or rewarding aspects of voice use.

Limitations

Independent Measures

One concern regarding this research is that the FD group might have cognitively responded to the stimuli differently than the SA and HC group because stimuli in this research employed original scripts and were validated on a separate HC group. However, the script ratings for both control groups and the initial validation group allow us to more closely investigate the FD response patterns. The SA and HC groups responded to affect and communication scripts with predicted increases in facial expressive muscles, speech muscles, and autonomic activity. Additionally, HR activity predictably increased for both affect and communication conditions. For both control groups, self-ratings of mood and measures of facial expression revealed that the stimuli were indeed eliciting the appropriate mood. Similarly, the predicted directions of speech and voice muscles (submental complex) for communication scripts suggest that these scripts were educing congruent muscular behaviors of speech and voicing.

Participants with FD responded similarly to other control groups for all scripts in both self-ratings of mood and arousal, and in autonomic reactivity. This congruence strengthens our confidence that the scripts were indeed eliciting similar responses across groups. So, the observed difference in muscle of facial expression and speech behaviors do not seem attributable to differences in script interpretation.

Prior Therapy

Another concern in the research is the fact that the FD group underwent prior voice therapy and, therefore, could compromise results. If therapy addressed behavior reactions to voicing, then reduced tonic levels of EMG in the muscles of behavioral expression could be a result of training. However, there are some theoretical and practical considerations that mitigate this concern. First, personality traits are early acquired, long-standing, and biologically mediated (Caspi & Roberts, 1999), so those with FD who possess increases in behavioral constraints as evidenced by past research (Goldman et al, 1996; Roy et al., 2000a, 2000b; White et al., 1997) would presumably have these traits prior to the initial onset of their voice disorder and would continue to have these traits during and after treatment. In addition, the disability hypothesis, which suggests that personality traits were a result of the voice problem, was disproved by Roy et al.

(2000a, 2000b), so these traits were present before the onset of dysphonia and therapy. Treatment might reduce muscular activation during voicing and even imagery of voice tasks, but it would not necessarily change muscular reactions to emotional stimuli in a nonvoiced task—namely, imagery of nonverbal emotional scripts. The FD group demonstrated reduced muscular activation during imagery of all scripts, both speech and nonverbal, and did not differentiate between imagery of speech scripts and nonverbal scripts, which suggests that effects observed were a result of trait behavior, not trained behavior.

Second, the body of literature measuring personality traits and behaviors is consistent in its assessment that those with FD present with increases in traits of anxiety, behavioral constraint, neuroticism, and introversion (Gerritsma, 1991; Goldman et al., 1996; Roy & Bless, 2000; Roy et al., 1997, 2000a, 2000b; White et al., 1997). However, some of this research on those with FD was prior to therapy (Roy & Bless, 2000; Roy et al., 2000a, 2000b), and other research was following therapy (Roy et al., 1997), whereas others employed mixed populations of those with prior therapy and those without therapy (Goldman et al., 1996). Similar personality traits observed between those FD patients prior to therapy and those following therapy suggest that personality traits endure beyond what occurs in therapy and that therapy does not change these traits. So, behaviors as a result of an a priori, controlled experiment designed to elicit reactions based on temperamental traits appears to be a more likely explanation for the data than the possibility of a training effect.

Furthermore, the participants with FD in this research came from multiple medical sites with multiple treating therapists. The difference in practice patterns among voice therapists is acknowledged and has warranted study in our field (Behrman, 2005; Elias et al., 1989). Therefore, the likelihood that treatment for each FD participant contained similar goals, activities, and results is low. Despite the low likelihood that the participants in the FD group had similar therapy, they still demonstrated similar, robust results in their reduced activation of the behaviors of emotional expression. In addition, if training were to directly address specific stress reactions in emotional environments, then those with FD would behave similarly to the HC group. However, their responses to emotional stimuli differ from both the SA and HC groups.

Group Differences

Another limitation in this study is the low participant numbers, which could compromise the power needed to detect psychometric findings and group differences. Furthermore, unequal group sizes might have also contributed to poor power. Nonetheless, between-group differences that were detected were both robust and clear. The mean group age difference between the FD and HC and SA groups (~15 years) might also have influenced the findings. If physiological activity changes with age, then group differences in response patterns between autonomic and behavioral activity might have been stronger if all groups shared similar age-related physiological abilities. Comparisons between groups may have also been influenced by co-morbidity factors, as both FD and SA groups reported greater use of medications that could alter physiological reactivity. Finally, the use of other autonomic measures, including measures such as skin conductance or blood pressure, might have further illuminated differences between autonomic, behavioral, and cognitive responses to emotional stimuli.

Future Directions

Future studies investigating temperamental traits in those with FD should not only attempt to determine the type of traits but also seek to assess the regulatory mechanisms involved in communicative and emotional expression. Adding other psychophysiological measures of autonomic activity (e.g., cortisol production, pupil dilations, or HR variability) and cognitive processing (e.g., electroencephalography, magnetoencephalography, or functional magnetic resonance imaging) may reveal interactions among social, cognitive, behavioral, and physiological contributors to dysphonia (cf. Schultz, Varga, Jeffires, Ludlow, & Braun, 2005). Other physiological and behavioral indicators of emotional expression should also be considered. In the current study, all participants reported increased vocal effort following imagery of aversive scripts, which suggests that direct measurement of laryngeal activity might provide useful supplementary information regarding affective states (Schultz et al., 2005). Also, other forms of stimuli besides mental imagery (e.g., picture viewing or mentally stressful tasks) might help define the type of emotional and expressive regulation used by FD speakers. Finally, varying the emotional content of the stimuli from communication-related topics (nonverbal or speech scenes) to other emotional topics not necessarily associated with voicing or communication (e.g., joy, pleasure, threat, or disgust) might provide information about the extent of the reduced expressiveness observed in the FD population. Other modalities of expression such as facial expressions, acoustic output, language fluency, and gestures might help define the scope of this evidence and improve our understanding of the recalcitrant communication problem experienced in the FD population. If those with FD experience reduced communication and vocal expressiveness, there may be a need to broaden the scope of treatment from specific voice retraining to more global communicative expressiveness. For example, addressing facial expression in communication could reduce the vocal load for the entire communicative message. Finally, in this study, the submental complex demonstrated consistent responses to both communication-related and emotional stimuli. Further defining the covarying relationship between the speech and swallowing muscles (i.e., submental, laryngeal, orofacial, and respiratory) and emotional experiences may help us understand these physiological responses.

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