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Vocal responses to emotional picture viewing

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Abstract
Vocal changes in emotional situations may identify contributing factors in behavioral voice disorders and direct more efficient therapies. Finding appropriate measures of voicing that detect emotional conditions is a first step in this line of investigation. The purpose of this study was to determine whether electroglottography (EGG) contact quotient is a viable measure to detect vocal changes in different emotion states. Vocal responses in 18 vocally healthy participants were measured using EGG contact quotient during picture viewing from the International Affective Picture System. Results demonstrated that in negative emotional conditions participants employed significantly greater EGG contact quotient than in neutral or positive conditions. EGG contact quotient appears to be a viable measure to investigate voice and emotion.

Key words: *Electroglottography, emotion, normal voice, voice*

Introduction

The relation between voice and emotion is compelling. It is difficult to imagine the enjoyment of artistic vocal expression or the power of verbal communication without the unique contribution of personality and emotion to phonation. Despite colloquial interest in this topic, research in this area has proved challenging (1–5). One of the difficulties in investigating this area is finding a sensitive measure to detect the vocal changes in transient states of emotion. In order to circumvent some of this difficulty, research in this area employs actors to typify emotional vocalizations (1–8). Analyses of acoustic profiles of those vocalizations find profiles that can predict the detection of an emotional signal above the level of guessing. Much of this line of research investigates the detection of emotional signals for the development of synthesized emotional signals via computers (7,8). This line of research has identified high-arousal emotion (e.g. anger) with increases in vocal frequency and intensity, and low-arousal emotion (e.g. sadness) with decreases in vocal frequency and intensity (6). Identifying specific emotions through acoustic measures continues to be investigated and, as it turns out, is not straightforward because vocal quality measures are based on sophisticated inverse filtering techniques (7,8). Despite this, there remains a strong case for perceptual judgments of emotion being more sensitive than potential acoustic recipes. Another difficulty in this research approach is that emotional vocalizations typified by actors may not truly reflect emotional vocalizations in natural environments (9) or even by non-actors (5). Thus, generalizing findings of stereotypical emotional vocalizations employed by actors to study perception of emotional vocalizations might not necessarily help in detecting individual physiological vocal responses to discrete emotional stimuli (2,5,9). Although acoustic profiles may reflect some aspects of physiological production (7,8), these methods are indirect and have the potential to lose sensitivity to *in vivo* emotional experiences by a vocalizer.

Despite these drawbacks, measuring vocal expression of emotion and the unique contribution of temperament, or emotional reactivity, on vocalization may be important in understanding the development of some voice disorders. Differences in the way we react to our environment and behaviorally express (or not express) ourselves lie in the realm of our

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personality or temperament (10). Research in personality and temperament possesses rich history suggesting that those with certain personality traits (specifically temperamental traits) have prototypical physiological reactions to emotional stimuli. Because a temperamental trait is an individual's propensity to experience and behaviorally express specific emotions (11), understanding differences in temperament could explain emotionally expressive behaviors (i.e. vocalizations) of those with behaviorally acquired voice disorders.

The Trait Theory of Voice Disorders (TTVD) (12–14) proposes that those with behaviorally acquired voice disorders (e.g. vocal fold nodules and functional dysphonia) possess differences in temperamental traits compared to those with voice disorders that are medically acquired (e.g. unilateral vocal fold paralysis). The authors of the TTVD developed this theory based on well-validated psychometric, self-report measures of temperament and found that those with vocal fold nodules presented with a temperamental trait consistent with increased extroversion, increased stress reactivity (neuroticism), and decreased behavioral inhibition. They also found that those with functional dysphonia presented with temperamental traits consistent with introversion, increased stress reactivity (neuroticism), and increased behavioral inhibition. In finding differences in temperamental traits with two voice populations with behavioral voice disorders, they presented strong evidence that behavioral voice disorders may be the result of personality tendencies. These findings have also been independently supported in other research using related self-report questionnaires (15,16). Further investigations into the TTVD added to the psychometric evidence by experimentally testing behavioral reactions to emotional stimuli of those with functional dysphonia (17). Indeed, those with functional dysphonia presented with behaviors that suggest a temperamental trait resulting in the inhibition of their expression of emotions, particularly in the muscles of the face, compared to those with social anxiety and a healthy control population (17). Specifically, those with functional dysphonia demonstrated reduced baseline activation of the corrugator supercilii activity during negative mental imagery and reduced zygomaticus major activity during positive mental imagery. Although this behavioral paradigm lends support to the TTVD, it did not address whether the behavioral reactions to emotional stimuli are observed during vocalization: a necessary step in relating temperamental traits to the development of a voice disorder. To date, assessing vocal emotional expression in those with behaviorally acquired voice disorders has not been accomplished. This oversight may be in part because specific acoustic profiles capturing emotional expression have not been focused on *in vivo* emotional reactions; rather they have been focused on the identification of perceptual characteristics of emotional vocal expression (5).

Because emotions are a physiological response to an internal psychological state (18), it would seem reasonable to employ vocal measures that directly quantify vocal fold physiology. Directly measuring physiological responses to emotional stimuli would also be commensurate with the large body of research exploring other physiological measures such as heart rate and skin conductance in emotion research (19). One such physiological vocal measure is electroglottography contact quotient. Electroglottography (EGG) contact quotient reflects the duration of the vocal fold contact phase to the duration of the complete glottal cycle. It reflects laryngeal adduction characteristics by measuring the fluctuating change in electrical resistance of laryngeal tissue presented by vocal fold oscillation (20). Using EGG contact quotient may be one way to measure whether vocal fold vibration is sensitive to emotional stimuli.

The purpose of this study was to determine whether or not EGG contact quotient is a viable measure to differentiate vocal changes in response to emotional stimuli. Increased contact quotient, among other factors, might reflect increased muscular activity in phonation (21–23). In turn, this might reflect vocal fold activity changes to emotional stimuli. This supposition is based on prior research (17) where those with functional dysphonia, social anxiety, and a healthy control population, when exposed to mental imagery of communication events, all reported greater perceived vocal effort in response to negative emotional stimuli and less perceived vocal effort in positive emotional stimuli. Although the relation between vocal effort and physiological activity is not completely understood, it is plausible that increased muscular effort may contribute to perceived vocal effort (21) thereby explaining this effect observed in other studies (17).

This study tested the hypothesis that EGG contact quotient would be greater in negative emotion states. It also explored the possibility that positive emotion states would have less EGG contact quotient. Finding a reliable and appropriate vocal measure that differentiates vocal expression to emotional stimuli in a vocally healthy population will prove useful in assessing temperamental differences in those with behaviorally acquired voice disorders.

Methods

Experimental design

The experimental design was a within-subject reversal paradigm using multiple experimental conditions (negative, neutral, and positive emotion induction) where experimental stimuli were counterbalanced within and between subjects to avoid order effects. All participants were exposed to all stimuli.

Participants

Participants included 16 female and 2 male students of Northern Illinois University, ranging in age from 21 to 28 years with an average age of 23.6 years. Recruitment for this population came from class announcements in the department of Allied Health and Communication where they received course credit for participation. Inclusion criteria for this group were the absence of any current acute or chronic vocal difficulties or a history of a chronic voice disorder such as vocal fold nodules, unilateral vocal fold paralysis, or functional dysphonia as determined through a non-identifying score (<18) on the Voice Handicap Questionnaire (24), an informal self-report questionnaire, and auditory perceptual determination by a certified speech–language pathologist specializing in voice disorders. In addition, they did not currently experience psychological ailments such as depression, generalized anxiety disorder, or any other personality disorder as determined through an informal self-report questionnaire.

Independent measures

Stimuli. Emotion was induced through picture viewing from the International Affective Pictures System (IAPS) (25). This set is a well-validated collection of pictures used in over 1000 research studies (25). There were a total of 60 different slides of negative, neutral, and positive content (20 each). To increase the power for each condition, all pictures were presented three times in a quasi-random order (no two pictures were presented consecutively more than once). Four pictures per condition were presented four times to fulfill conditions for quasi-randomization (no more than two consecutive presentations of pictures of the same valence). Negative and positive pictures chosen possessed validated scores that were high in arousal; neutral pictures were low in arousal. Picture stimuli were chosen based on their similar validated ratings on valence (pleasantness versus unpleasantness) and arousal (calm versus exciting) from the published IAPS data (25). Chosen negative, neutral, and positive pictures were significantly different from one another in valence ratings (*t* tests; positive versus negative, $P<0.001$; positive versus neutral, $P<0.001$; negative versus neutral, $P<0.001$). Arousal ratings between the neutral pictures and two other picture categories were significantly different (*t* test, $P<0.001$), but there were no arousal differences between the positive and negative picture categories. In addition, participants viewed a blank screen with no visual content to serve as a comparison with the pictures; there was no statistically significant difference in the blank screen as compared to the neutral screen, so the blank screens were not included in any further analysis.

Dependent measures

Manipulation variables. Self-report and physiological measures were employed to verify appropriate emotion induction during the experimental procedures. Self-report measures included the Self-Assessment Manikin (SAM) rating protocol, which measures levels of affective valence (pleasantness, SAM-V) and arousal (excitement, SAM-A) along a nine-point Likert-type scale (26). Physiological measures of heart rate and skin conductance provided information about the physical alterations as a result of emotion induction and reflect autonomic activity (19). Heart rate, measured with electrocardiography with its units in beats per minute (bpm), is known to assess arousal and affect (19); and skin conductance with its units in microsiemens is known to measure arousal (19).

Voicing-related variables. A self-report measure of vocal effort, established by using a modified BORG CR-10 scale, a ten-item variable response scale designed to measure perceived effort for voicing (27), provided information about the participant's subjective experience of vocal effort and was used as an anchor for other voice measures. Perceived vocal effort has been shown to vary with emotion conditions (17) and therefore will serve as an additional manipulation variable associated with voicing.

Electroglottography (EGG) contact quotient, which measures the ratio of vocal fold closing to the entire glottal cycle (20), was the primary measure of interest. Characteristics of increased laryngeal adduction are commonly thought to be a hallmark symptom of those with behavioral voice disorders (28) and therefore are thought to be informative in specific laryngeal behaviors following emotional induction.

Respiration activity, as measured through thoracic wall movement, was the last vocal measure investigated. Respiration provides the power source for sustained phonation (29), and chest wall movement has been found adequately to reflect lung volumes during speech (30). In addition, changes in respiration activity have been linked to emotional states (31) and as such might influence voicing behaviors.

Procedures

After the participants provided informed consent, they completed a battery of psychometric tests, whose data are not presented in this study. Upon completion of psychometric tests, participants had a respiratory strain gauge placed around their rib cages. They were then directed to sit in a padded lounge chair, and ECG electrodes (Skintact; Leonhard Lang USA, Inc., Inverness, FL) were placed on the upper right chest and the lower left rib and skin conductance electrodes (JLC EDA; James Long Company, Caroga Lake, NY) on the middle phalanx of the index and middle finger of the non-dominant hand. Finally they had EGG electrodes (EG2-PCX2; Glottal Enterprises, Inc., Syracuse, NY) placed on the laminar edges of the thyroid cartilages. Participants underwent training in the experimental procedure which included watching a computer monitor to view the IAPS pictures. Participants viewed a fixation point for 500 ms prior to the IAPS picture presentation. As soon as the picture was presented they were instructed to phonate on the vowel /u/ until the picture disappeared (about 3 seconds). Participants were instructed to phonate on their comfortable/typical modal pitch and loudness and trained to maintain this as naturalistically as possible. All vocalizations fell within their typical modal pitch and loudness throughout the experiment. They were then presented and asked to complete three self-report measures, the BORG CR-10, SAM-A, and SAM-V. Following completion of the self-report measures the next trial began with the fixation point. Stimuli were delivered via E-Prime2 software (v. 2.0 Professional; Psychology Software Tools, Inc., Sharpsburg, PA) running on a Dell (Optiplex 755; Dell, Inc., Round Rock, TX). Self-report ratings were also generated and recorded through E-Prime2. Participants viewed 6 blocks of 32 pictures for a total of 192 picture presentations. After all pictures were presented, electrodes for the ECG, skin conductance, and EGG and the respiratory strain gauges were removed. The participant was thanked for their time. The total experiment took approximately 75 minutes.

Instrumentation and data reduction

Physiological data (heart rate, skin conductance, and thoracic wall movement) were acquired with a four-channel SAI Bioamplifier (James Long Company, Caroga Lake, NY), digitized using a Dataq DI-720-P A/D converter, and recorded and processed using HEM Snap-Master software (James Long Company, Caroga Lake, NY). EGG data were acquired using dual-channel electrodes, digitized with an EG2-PCX2 (Glottal Enterprises, Syracuse, NY), and recorded onto Audacity (1.3 beta, freeware). EGG signals were analyzed by EggWorks (UCLA Phonetics Lab Software, freeware). The signal underwent an initial lower-frequency cutoff 20 Hz followed by a five-point smoothing function. Closed quotient cut-off percentages put forth by Orlikoff (32) used a baseline criterion of 25% of the peak-to-peak EGG signal (33,34). EGG signals for the first 1000 ms of phonation were used in the initial analysis. To guard against drift from potential outliers, the median values for the first 300 ms for each participant were used in the final analysis because this reflected the most stable phonation time for all participants. Data were synchronized via a generated tone presented through E-Prime2 and sent through a parallel port to both psychological and the voice acquisition systems.

Analysis

All hypotheses were tested using repeated-measures ANOVA with condition assignment (emotion: negative, neutral, and positive) as the independent variable (IBM SPSS v. 18; Chicago, IL). Self-report measures of valence and arousal, physiological arousal, including heart rate and skin conductance,

Table I. List of group mean values for each measure and their standard deviations.

Measure	Condition	Group means ± SD
SAM-V	Negative	4.93 ± 2.35
	Neutral	7.77 ± 1.25
	Positive	6.96 ± 1.51
SAM-A	Negative	7.85 ± 1.06
	Neutral	3.74 ± 1.79
	Positive	2.91 ± 1.15
Heart rate (bpm)	Negative	76.14 ± 13.05
	Neutral	76.61 ± 13.28
	Positive	76.22 ± 13.15
Skin conductance (microsiemens)	Negative	15.59 ± 5.21
	Neutral	15.48 ± 5.16
	Positive	15.49 ± 5.19
BORG CR-10	Negative	1.21 ± 1.57
	Neutral	0.79 ± 1.12
	Positive	0.81 ± 1.12
EGG Contact Quotient	Negative	0.51 ± 0.05
	Neutral	0.50 ± 0.05
	Positive	0.50 ± 0.05
Thoracic wall movement (percentage)	Negative	94.43 ± 5.55
	Neutral	100.60 ± 7.97
	Positive	97.20 ± 7.59

and voicing-related factors, including EGG contact quotient area, vocal effort, and thoracic wall movement were the dependent variables. Significance levels were at $P = 0.05$.

Results

The data were examined for evidence of outliers that could compromise the interpretation of the results. Skewness and kurtosis indicators suggested that all variables were normally distributed, and several important assumptions for analysis of variance were met; the residuals appeared to be both normal and homoscedastic. Group means and standard deviations for each measure are listed in Table I.

To confirm appropriate emotion induction, the data were submitted to a one-way ANOVA to verify the valence and arousal evoked by negative, neutral, and positive emotions. The results show significant differences in valence ratings between pictures, $F(2, 34) = 26.53$, $P < 0.01$, $\eta^2 = 0.61$ (Figure 1). Tukey *post-hoc* test revealed that both the neutral picture (M 7.77, SD 1.25) and the positive picture (M 6.96, SD 1.51) were more pleasant than the negative picture (M 1.2, SD 1.56), $P < 0.01$. The neutral picture was not statistically different from the positive picture.

Additionally, results show that negative, neutral, and positive pictures were significantly different from one another in arousal ratings, $F(2, 34) = 119.28$, $P < 0.01$, $\eta^2 = 0.88$ (Figure 2). Tukey *post-hoc* tests revealed that negative images (M 7.85, SD 1.06) were significantly more arousing than positive images (M 2.91, SD 1.14), $P < 0.001$, and neutral images (M 3.74, SD 1.79), $P < 0.001$. Neutral images were more pleasant than positive images, $P < 0.01$.

Several physiological factors, including heart rate and skin conductance, were measured to further confirm appropriate emotion induction. The results of a repeated-measures ANOVA revealed a significant difference in heart rate across emotion induction, $F(2, 28) = 3.61$, $P = 0.04$, $\eta^2 = 0.40$ (Figure 3). Specifically, when individuals were exposed to negative or positive images they experienced a lower heart rate than when exposed to neutral images. There was no significant difference in heart rate between negative versus positive images. Given this pattern of relationships, tests of within-subjects contrasts revealed that heart rate can be modeled quadratically, $F(1, 14) = 9.72$, $P < 0.01$. Additionally, the results of a second repeated-measures ANOVA revealed significance in skin conductance, $F(2, 28) = 3.37$, $P = 0.05$, $\eta^2 = 0.19$ (Figure 4). More specifically, individuals, when exposed to negative images, had higher skin conductance than when exposed to neutral or positive images. There was no significant difference in skin conductance between those exposed to neutral and positive images. Given this pattern of relationships, tests of within-subjects contrasts revealed that skin conductance can be modeled linearly, $F(1, 14) = 6.00$, $P = 0.03$. These results, in full, suggest that participants physiologically experienced appropriate emotion induction for negative, neutral, and positive conditions.

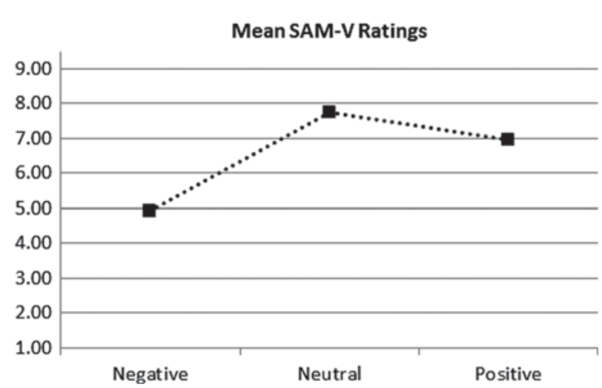

Figure 1. Neutral and positive images were significantly more pleasant than negative images.

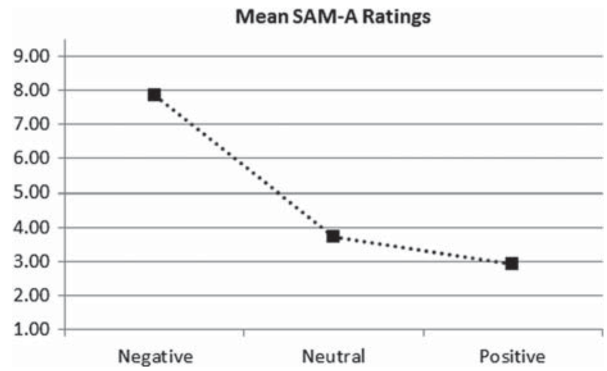

Figure 2. Arousal is significantly higher when individuals were exposed to negative images compared to neutral and positive images.

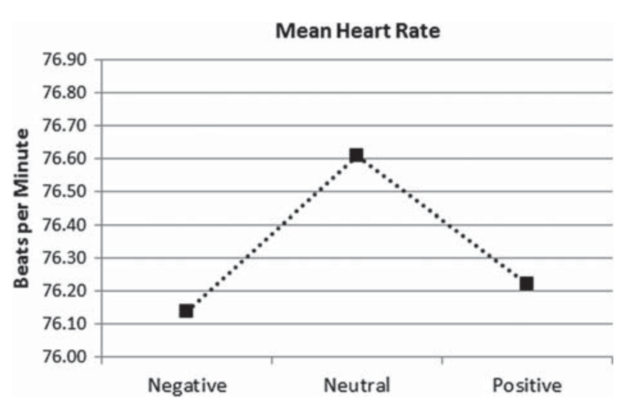

Figure 3. Heart rate is significantly higher when individuals are exposed to neutral images compared to negative or positive images, suggesting an orienting effect.

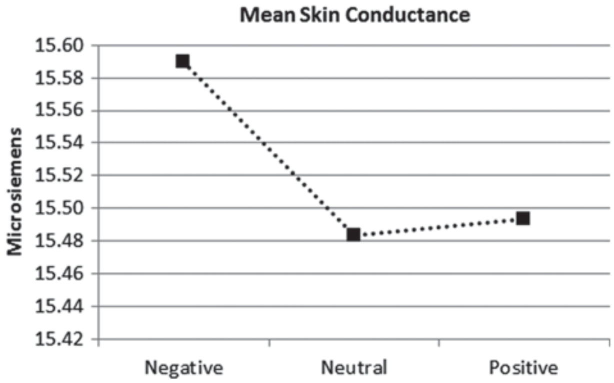

Figure 4. Skin conductance is significantly higher when individuals are exposed to negative images compared to neutral or positive images.

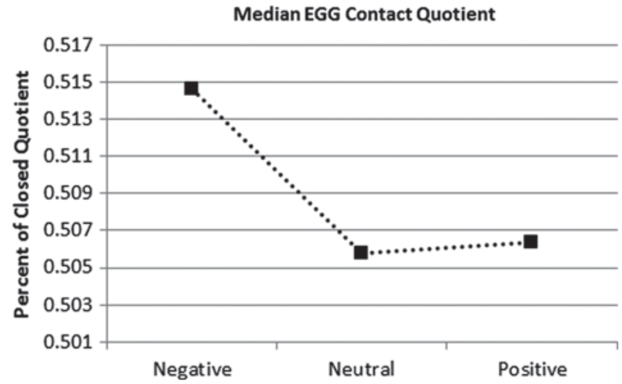

Figure 6. EGG CQ is significantly greater when individuals are exposed to a negative emotional state compared to a neutral or positive emotional state, supporting a-priori hypothesis.

In order to test for differences in vocal effort, mean BORG CR-10 scores were calculated across trials for each participant. To replicate past research and determine if participants would rate increased vocal effort in negative conditions (17), vocal effort was assessed as a function of emotion induction. The results of a repeated-measures ANOVA revealed that emotion induction significantly affected vocal effort, $F(2, 34) = 11.13$, $P < 0.01$, $\eta p2 = 0.40$ (Figure 5). Three paired-samples *t* tests were conducted to make *post-hoc* comparisons between conditions. When exposed to negative images, participants perceived more effort (M 1.20, SD 1.57) than those exposed to neutral images (M 0.79, SD 1.12), $t(17) = 3.68$, $P < 0.01$, and those exposed to positive images (M 0.81, SD 1.12), $t(17) = 3.17$, $P < 0.01$. There were no significant differences in vocal effort between those exposed to neutral versus positive images. Given this pattern of relationships, tests of within-subjects contrasts revealed that data can be modeled linearly, $F(1, 17) = 10.01$, $P < 0.01$, or quadratically, $F(1, 17) = 15.42$, $P < 0.01$.

Following a similar procedure, in order to test for differences in relative vocal fold area, median EGG contact quotient scores were calculated across trials for each participant. To test the hypothesis that EGG contact quotient would be greater in negative emotional conditions, differences in EGG contact quotient were assessed based on emotion induction. The results of a repeated-measures ANOVA revealed that participants had different EGG contact quotients based on emotion induction, $F(2, 34) = 5.58$, $P < 0.01$, $\eta p2 = 0.25$ (Figure 6). Three paired-samples *t* tests were conducted to make *post-hoc* comparisons between conditions. Participants exposed to negative images presented with greater EGG contact (MD 0.51, SD 0.05) than those exposed to positive images (MD 0.50, SD 0.005), $t(17) = 2.41$, $P = 0.03$, or neutral images (MD 0.50, SD 0.005), $t(17) = 2.78$, $P = 0.01$. Those exposed to positive images were not significantly different from those exposed to neutral images. Given this pattern of relationships, tests of within-subjects contrasts revealed that data can be modeled linearly, $F(1, 17) = 5.83$, $P = 0.03$, or quadratically, $F(1, 17) = 5.10$, $P = 0.04$.

Finally, to test for differences in thoracic wall movement, a repeated-measures ANOVA was conducted.

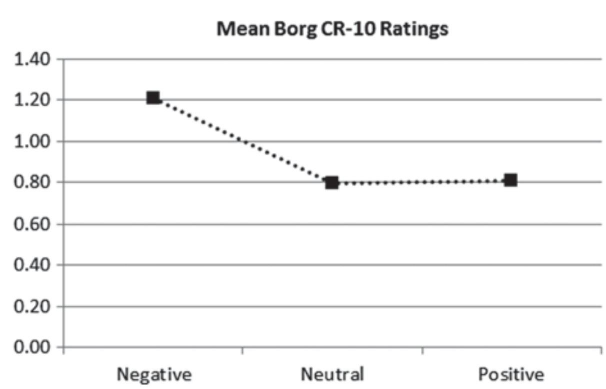

Figure 5. Vocal effort increases when a negative emotional state is induced compared to a neutral or positive emotional state.

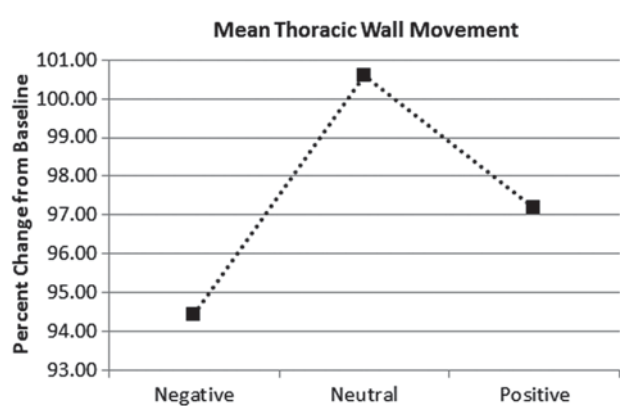

Figure 7. Thoracic wall movement is greater when a neutral emotional state is induced compared to a negative or positive state.

The results revealed that emotion induction significantly affected thoracic wall movement, $F(2, 28) = 7.09$, $P < 0.01$, $\eta^2 = 0.37$ (Figure 7). Specifically, individuals exposed to neutral images experienced greater thoracic wall excursion than those exposed to negative or positive images. Those exposed to positive images experienced greater thoracic wall movement than those exposed to negative images. Given this pattern of relationships, tests of within-subjects contrasts revealed that thoracic wall movement can be modeled linearly, $F(1, 14) = 5.61$, $P = 0.03$, or quadratically, $F(1, 14) = 7.60$, $P < 0.02$.

Discussion

The purpose of this study was to determine whether or not EGG contact quotient is a viable measure to capture vocal changes in different emotion states. More specifically, this study tested the hypothesis that EGG contact quotient would be greater in negative emotion states. The findings of this research support this hypothesis. The theoretical underpinnings of this research lie in the Trait Theory of Voice Disorders (12–14), which states that those with certain propensities to respond to emotional stimuli may develop various types of voice disorders. Finding a method with which directly to study vocal behavior in emotional conditions is a necessary step in vetting this theory and understanding the nature of the emotional system on vocalization. The findings confirmed that EGG contact quotient did indeed significantly increase in negative conditions compared to neutral or positive conditions. Despite this, the absolute value of this difference was quite small, suggesting the influence of emotion on relative vocal fold contact area may be small. However, even small changes to laryngeal configuration can result in large changes in acoustic and aerodynamic output (35,36). Furthermore, although such changes may be small, the cumulative load on daily phonation of even small increases in laryngeal activity may lead to the development of clinical complaints. Additionally, small changes in transient emotional conditions as observed in this study may become greater in real-life situations where emotional states may be more intense or last for a longer period of time. The potential increase in such differences could lead to more clinically notable changes. So, the relative changes in EGG contact quotient as a result of transient emotion might be small but may have a larger influence over total phonation particularly in naturalistic environments. This reasoning might explain the consistent findings that negative emotion states during voicing are accompanied by increased ratings of vocal effort (17).

Furthermore, there may be concern that these small findings do not overcome the variations due to different forms of analysis. Despite the numerous sources of variations in EGG data, including the relative timing of measurement (first part of the utterance versus middle part), cut-off frequency rates, and analysis algorithms, the research design (a within-subject reversal paradigm) would account for such variations. Indeed, even with the numerous sources of noise presented in using EGG contact quotient statistically significant differences in EGG contact quotient among emotion conditions was observed, providing solid evidence that a relation exists between emotional state and EGG contact quotient. Finally, these relatively small changes as a function of emotion condition in physiological measures is expected given the large body of psychophysiological research that shows small but significant and measurable changes over baseline in other physiological measures such as heart rate, skin conductance, blood pressure, and tonic levels of muscle activation (19).

The data for the second hypothesis, that there would be less relative EGG contact quotient area in positive conditions, are less clear. Although there was less EGG contact quotient for positive conditions, there was not a significant difference between the positive and neutral conditions. This finding is surprising given that in prior research vocal effort is significantly reduced in positive emotion states compared to neutral states (17) so one would assume some reflection in vocal physiology as a result. Although a direct relation between perceived vocal effort ratings and their vocal behaviors that underlie this relation remains unknown, one might assume that, in normal healthy participants, a reduction in vocal effort in positive emotion states may accompany a reduction in muscular activation (possibly through reduced laryngeal adduction) during phonation. However, decreased vocal effort could arise from multiple areas in the phonatory, cognitive, and emotional systems, and understanding their relative contributions would subsequently explain these findings.

A more direct explanation for this lack of consistent findings in the positive condition is that the participant population in this investigation did not rate positive pictures in the expected direction for valence or arousal. They rated neutral pictures as more arousing than positive pictures, and there was no significant difference in pleasantness ratings between positive and neutral pictures. The desired relationship among conditions to compare conditions of emotion adequately is to have similar arousal ratings for both negative and positive conditions and reduced arousal ratings for the neutral condition (26). So their subjective experiences matched the data for EGG contact quotient. Despite this, their physiological responses were appropriate for the predicted arousal ratings; negative and positive pictures had reduced heart rate reflective of an increased autonomic orienting response (19), and negative pictures had increased skin conductance reflecting increased arousal (19). Because this manipulation check did not reveal an optimal arousal relationship between negative and positive conditions or an expected difference in pleasantness between positive and neutral conditions, emotional influence on voicing behavior in positive conditions remains unknown. One reason why positive pictures were not commensurate with predictions could be that the nature of the content of the neutral pictures (e.g. office supplies, kitchen utensils) was more salient to the student participants than the positive pictures (e.g. outdoor scenes, romantic couples). Another reason could be that the order of pictures may not have been optimal for complete separation of emotional experience between pictures, thus confounding individual ratings of pictures. For example, if a moderately intense positive picture immediately followed an extremely intense negative picture, the participant may not have fully returned to a baseline neutral emotion after the negative picture before rating the positive picture. A more negative rating of the positive picture would result. Future investigations of this type should control for this possibility with more stringent attention to the equality of valence and arousal ratings of the pictures and to their relative order.

Thoracic wall movement, which reflects respiratory activity in phonation, was reduced in negative conditions compared to neutral or positive conditions. This finding suggests that although emotion states affect phonation through laryngeal contact area, they may also affect phonation through respiratory behaviors. Because phonation is dependent on adequate airflow (29), respiratory behaviors are an important contribution to overall voicing, which leads to an important question in this line of research: Do emotion states affect voicing behaviors directly through laryngeal activity, indirectly through respiratory activity, or both? Previous investigations of the respiratory and laryngeal systems on teachers with and without voice disorders would suggest a complicated relation between the respiratory and laryngeal system, particularly in high-arousal situations (37). Ferreting out this important question is beyond the scope of this investigation but points to future direction in this line of research.

This initial investigation revealed that EGG contact quotient may be a reasonable measure to detect changes in voicing behavior as a function of emotion states. Future research in this area should include other physiological measures of phonation, particularly measures of muscular engagement, such as needle electromyography, and aerodynamic function, such as phonation threshold pressure and estimates of laryngeal resistance. When an increased cadre of physiologic voice measures sensitive to emotion induction is established we can begin testing the differences of response to emotion states in the phonatory systems of those with behavioral voice disorders. Doing so will help determine how emotion and temperament contribute to the development of voice disorders.

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