

# Vocal Responses in Heightened States of Arousal

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**Summary: Objectives.** The purpose of this study was to investigate electroglottography (EGG) contact quotient modulation with emotional state in the presence of increased arousal.

**Study Design.** A within-subject reversal paradigm using multiple experimental conditions.

**Methods.** A total of 11 healthy undergraduate students underwent emotion induction with intermittent startles to increase physiologic arousal. During emotion induction, they vocalized on the vowel /u/ while EGG was recorded.

**Results.** EGG contact quotient was significantly greater for negative emotions compared with positive emotions with increased arousal commensurate with past research. In addition, overall EGG contact quotient was greater with elevated arousal. However, the effect sizes were small.

**Conclusions.** EGG contact quotient appears to increase with elevated arousal and be greater for negative mood states than positive mood states confirming that emotion states directly influence vocal functioning.

**Key Words:** Voice–Arousal–Emotion–Electroglottography–Voice Disorders.

## INTRODUCTION

Investigations into the nature of certain voice disorders, specifically those with a behavioral etiology, have included the study of personality, particularly temperament (an individual's propensity to respond in a specific manner to emotional stimuli).<sup>1-4</sup> The Trait Theory of Voice Disorders put forth by Roy and Bless<sup>1,2</sup> posits that those with behaviorally acquired voice disorders (eg, vocal fold nodules and functional dysphonia) differ in temperamental traits compared with those with medically acquired voice disorders (eg, unilateral vocal fold paralysis and spasmodic dysphonia) and that these traits may predispose or contribute to the development of their voice disorder.

Numerous follow-up studies have begun experimentally investigating the nature of voice,<sup>3-6</sup> as it relates to temperament, emotion, and stress, and have found promising, albeit tenuous, links between voice use and personal experience/reactions to emotional states. van Mersbergen et al<sup>4</sup> found that those with functional dysphonia presented with less emotionally expressive muscular activity in the muscles of the face, which appeared to reflect previous research that noted that those with functional dysphonia scored high in temperamental constructs of behavioral constraint and negative emotionality/neuroticism. This finding established a link between communicative expressions of emotion via muscles of facial expression and temperament. Unfortunately, in this study, no voice measures could confirm a direct relation between temperament and vocal output.

Dietrich and Verdolini Abbot<sup>5</sup> investigated healthy controls and found a temperamental difference in voicing-related measures of extrinsic laryngeal muscular activity. Those who scored highly in the construct of introversion demonstrated greater infrahyoid muscle activity during a perceived stress inducer, suggesting that temperament may influence vocal expression. However, the link between vocal fold activity and tempera-

ment was tacitly measured through extrinsic laryngeal activity. Nonetheless, these findings suggest that temperament is related to vocally expressive behaviors.

To establish a more immediate link between temperament and vocal output, van Mersbergen and Delaney<sup>6</sup> found that in healthy controls, electroglottography (EGG) contact quotient modulated up for negative mood states compared to those in neutral or positive mood states. Establishing a vocal response in emotional states proved a promising tool to begin to study the link between voice and temperament. However, effect sizes were small, which lead to the question whether the mood induction employed was strong enough. Although not entirely necessary, having a measure with greater effect sizes between conditions may facilitate greater success in this line of research. Elevating the arousal level of the stimuli may create a greater distinction in EGG contact quotient between moods, particularly for negative moods.

One way to increase the arousal level during a task is to introduce a noxious distractor, such as an acoustic startle. Noise is well known to influence arousal levels in individuals and affect performance,<sup>7</sup> potentially elevating the base level of arousal during a task. Acoustic startles have been used extensively in emotion research<sup>7-10</sup> and have been thought to underlie a negative, avoidance neural system.<sup>11</sup> Although noise (that is, acoustic startles) is considered negative, it does not dominate current mood states such that neutral or positive states are overshadowed.<sup>11</sup> An introduction of an acoustic startle may prove an expeditious method to increase arousal without erasing the relationships between negative, neutral, and positive emotions.

## Purpose and hypothesis

The purpose of this study was to investigate EGG contact quotient modulation with emotional state in the presence of increased arousal. Mood induction via picture viewing of scenes with emotional content served as the trigger for emotional modulation. An acoustic startle (white noise presentation of 50 milliseconds at 102 dB with an instantaneous rise time) was randomly presented during 37% of trials to elevate the participant's arousal state. Based on past research, negative mood states should have elevated EGG contact quotient compared with neutral states and positive states. Increased arousal should influence the degree and

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separation of EGG contact quotient in negative mood states compared with other conditions.

## METHODS

### Experimental design

The experimental design was within-subject reversal paradigm using multiple experimental conditions (negative, neutral, and positive mood induction with and without startle) where experimental stimuli were counterbalanced within and between subjects to avoid order effects. All participants were exposed to all stimuli. The study was approved by the Internal Review Board at Northern Illinois University.

### Participants

Participants included eight female and three male students of Northern Illinois University ranging in age from 18 to 26 years with an average age of 23.4 years. Recruitment for this population came from class announcements where they received course credit for participation. The inclusion criteria for this group were the absence of any current 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 nonidentifying score on the Voice Handicap Questionnaire,<sup>12</sup> an informal self-report questionnaire, and an auditory perceptual rating by the primary author who is a certified speech language pathologist specializing in voice disorders. In addition, they did not currently experience upper respiratory infections or psychological ailments such as depression, generalized anxiety disorder, or any other personality disorder as determined through an informal self-report questionnaire.

### Measures

#### Independent measures

**Stimuli.** Mood induction through picture viewing from the International Affective Pictures System<sup>13</sup> included 60 different slides of negative, neutral, and positive content or valence (20 each). Picture stimuli were matched on ratings of valence (pleasantness vs. unpleasantness) and arousal (calm vs. exciting). Negative, neutral, and positive pictures were significantly different from one another in valence ratings (*t* tests; positive vs. negative,  $P < 0.001$ ; positive vs. neutral,  $P < 0.001$ ; negative vs. neutral,  $P < 0.001$ ). The neutral pictures differed in arousal compared with those in two other picture conditions (*t* test,  $P < 0.001$ ), but there were no arousal differences between the positive and negative pictures. There was a total of 8 blocks of pictures with 24 pictures per block. Each block contained 8 negative, 8 neutral, and 8 positive pictures in a quasirandomized order such that no block contains more than 3 of the same valence in a row to avoid habituation effects. The pictures were presented multiple times. In addition, 37% of the trials included an acoustic startle (50 milliseconds at 102 dB white noise instantaneous rise time)<sup>8</sup> occurring at either 1000 milliseconds, 1500 milliseconds, or 2500 milliseconds postpicture presentation. The varying time points were designed to avoid habituation effects.<sup>11,14</sup> Each valence type had an equal number of acoustic startles in each block and at

each time point. Startles were quasirandomized within each block and trial run. The presence and timing of these startle trials were meant to increase overall arousal during the experiment. Because startle trials provided a means to increase arousal during the entire experimental run, vocal data from the startle trials were not independently analyzed.

### Dependent measures

#### Manipulation variables

Self-report measures verified mood induction during the experimental procedures and included the Self-Assessment Manikin (SAM) rating protocol of affective valence (pleasantness vs. unpleasantness) and arousal (calm vs. exciting) along a 9-point Likert-type scale.<sup>15</sup> Perceived vocal effort, using a modified Borg CR-10 (Borg) scale<sup>16</sup> provided subjective experience of vocal effort, which was an anchor for the other voice measure.

#### Voicing-related variables

EGG, which measures vocal fold contact area,<sup>17,18</sup> was the primary measure of interest. Previous research found that EGG contact quotient varies with emotional valence via mood induction<sup>6</sup> and therefore is thought to also vary in the presence of increased arousal.

### Procedures

After the participants consented to the procedures, EGG electrodes (Glottal Enterprises) were placed on the laminar edges of their thyroid cartilages and in-the-ear headphones (Sony MDR-EX57LP) were placed binaurally. Next, they underwent instructions in experimental procedures where they were instructed to look at a fixation point on the computer screen (ApexX233H) to prepare for an upcoming picture (500 milliseconds before presentation). They were instructed to say the vowel /u/ for 3–4 seconds once the picture appeared, which was the duration of the picture presentation. They were informed that some of the pictures would have a loud noise and that they are to ignore this noise as it is not important. After the picture disappeared, they were instructed to fill out a brief mood inventory to verify their perceived vocal effort and current mood and arousal; the Borg, SAM-V, and SAM-A, respectively. Following completion of the self-report measures, the next trial began with the fixation point. Stimuli were delivered via *E-Prime software* (v. 2.0, Psychology Software Tools, Inc.) running on a Dell (Optiplex 755). Self-report ratings were also generated and recorded through *E-Prime*. Participants viewed 8 blocks of 24 pictures for a total of 192 picture presentations. After all pictures were presented, EGG electrodes and headphones were removed, and the participants were thanked for participating. The total experiment took approximately 60 minutes, 30 minutes of which was the experimental paradigm.

### Instrumentation and data reduction

EGG data were acquired using dual-channel electrodes, digitized with an EG2-PCX2 (Glottal Enterprises) and recorded onto *Audacity* (1.3 beta). EGG signals were analyzed by *EggWorks*

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