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Does Vocalization Increase the Positive Valence of Emotion?

Joshua Hyde

DOES VOCALIZATION INCREASE THE POSITIVE VALENCE OF EMOTION?

by

Joshua Hyde

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Abstract

This study aims to determine if the act of voicing can have an effect on mood in a within-participant reversal paradigm, where each participant served as their own control. Following a baseline condition, participants underwent three experimental conditions: breathing, articulating, and voicing. Following baseline and experimental conditions, participants underwent an emotion-induction paradigm by looking at pictures. They rated their current mood and arousal levels following each picture. Additionally, psychophysiological measures of facial electromyography, electrocardiography, and electrodermal responses were gathered throughout the experiment. Results were mixed, revealing that there was a mood change during aversive picture viewing toward positive moods in the articulating condition and arousal levels were lower in the articulating and voicing conditions for positive picture viewing. However, the power to detect many of the results remained poor. Findings tentatively showed that the act of making speech sounds, not simply voice may influence the way we process emotions.

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Introduction

The interaction between emotion and the human voice is complex. We inherently know that the voice can communicate the emotional status of a speaker, from immediately knowing that a friend is distraught when you pick up the phone, to recognizing that a coworker is in a good mood simply by the way they say "good morning". In the same manner, we also experience disruptions in our voice such as vocal strain or tremors when we are upset or nervous. These transient emotional states affect our production of voice.

Emotional experiences include internal sensations of an emotional reaction, mental interpretations of those sensations, and expressions of the emotional experience (Barrett, 2006). The way each person experiences emotion and communicates that experience is highly variable. The voice is involved in emotional experiences from the voice functioning as a reaction to an emotional experience to the voice acting as a communicator of emotion. Vocal reactions to emotions have been proven to happen in experimental studies (van Mersbergen & Delany, 2014; van Mersbergen, Lyons, & Riegler, 2017; van Mersbergen & Lanza, 2019; van Mersbergen & Payne, 2021), to which anyone who has used their voice while experiencing intense emotions can relate. In essence, the voice can be an emotionally reactive organ in its response to an emotional trigger and thus be an emotionally expressive tool in its communicative intent.

Most research on the relationship between voice and emotion seeks to understand how the voice is an emotionally expressive conduit, and much of what is known about the voice in regard to emotion is related to how a person's emotional experience is understood or interpreted by a listener. For example, it is known that positive arousing emotions are audibly louder and higher in pitch, whereas negative arousing emotions are also louder but lower in pitch (Banse & Scherer, 1996; Scherer, 1986). It is also understood that the interpretation of another's emotional state is dictated by the linguistic parameters of syntax (Pell, 2001) and morphology (Mauchand & Pell, 2021) used by the speaker. However, this rich body of literature does not necessarily address the direct relationship between voice and emotion *within* an individual. If emotional experiences can create a vocal reaction within an individual, exactly how does this emotional state affect the voice? It would seem the relationship between voice and emotion is more complex than simple acoustic profiles of prototypical emotional states.

To expand upon this notion, the connection between voice and emotion can be even more intricate. What is known about this relationship has been studied from the perspective that emotions affect voicing. However, there may be another direction in this exchange. Voicing may affect emotions. Voicing in this case refers to any use of the voice, either during speaking or singing. Forays into this perspective shift have revealed a nascent understanding of how voicing influences our emotional state. Colloquially, singing has been associated with positive moods. For example, people often enjoy singing by themselves in the shower or the car, or with a group such as in a choir. Sustained voice use has also been thought to produce a positive mood by engaging in activities such as chanting or humming while meditating (Rao *et al.*, 2018). Research on other mammals besides humans has revealed that simply the act of vocalizing is in service of emotional drives (Brudzynski, 2010). Finally, the function of bodily rhythms could be synchronized during vocalization, which could have a positive effect on mood (Vickhoff *et al.*, 2013; Somayaji *et al.*, 2022). Group singing, in particular, has been heavily researched for its potential mental, physical, and emotional health benefits, and much of that research will be used as a starting point for this study (Bailey & Davidson, 2003).

To elaborate on some of the potential reasons behind a change in emotional state due to voicing, there is some evidence to suggest there may be multiple causal factors at play.

Vocalization is an integral part of some meditative practices. Chanting or toning during meditation (often termed an "OM" mantra) could induce a state of relaxation by affecting the body-mind relationship (Harne & Hiwale, 2018). In theory, this sense of peace would allow a person to process negative emotions less critically and reduce the amount of time spent ruminating on negative moods.

Another causal factor in the relation between voice and mood may be the involvement of the audio-vocal system for communication. Audio-vocal communication is commonly studied in biology, specifically zoology and anthropogeny (Brudzynski, 2010), and is a mammalian system that usurps the functions of the larynx and vestibular systems for communication and survival. In this context, employing the voice may be an evolutionarily hardwired function designed to provide connections between members of a given species. Seminal papers in these fields have laid the groundwork for understanding how animals might receive positive feedback for using this method of communication, and the consensus from these multiple viewpoints explains that it likely promotes social bonds for continued existence. For example, mammalian mothers need to forage food for their young, and to maintain a connection between mother and young, vocalization becomes necessary. Vocalization within groups can also warn other group members of an impending threat or locations to avoid. Therefore, voicing becomes an important part of survival.

The final factor that could mediate the relationship between voice and emotional processing is the coordination of multiple bodily rhythms and their functions, governed by pacemaker cells in the heart and stomach or electrical signals throughout the brain and body. This alignment could influence and balance the autonomic nervous system, and thus affect our overall experience of emotional arousal. Synchronization of body rhythms and functions may not directly affect the valence of an emotional experience, but it could affect the arousal, leading to an increased or decreased awareness of that experience. There is research to prove that this effect happens across individuals in a choral setting (Vickhoff *et al.*, 2013), but little evidence yet to say that this phenomenon happens within an individual.

The goal of the current study is to determine if voicing has an effect on how individuals experience emotions. We hope to find that vocalization within an individual affects the way in which that person processes emotion. The implications and clinical applications are vast and could be applied both in and outside the field of speech-language pathology.

Literature Review

The literature pertaining to the intersection of voice and emotion is still in its infancy. Great strides have been made to uncover how human emotions interact with voice production and perception, but many unknown factors remain to be investigated. How the production of voice influences an emotional experience within an individual is an example of one such factor, and the research that relates to this topic comes from a wide variety of fields. These supporting studies provide context for the current project and have been divided by topic, starting with research that pertains to voice production and its benefits, and then moving to research that supports causal mechanisms of a positive mood.

Vocalization

Benefits of Choir Singing

Choral voice use most likely improves emotional outcomes on a qualitative basis. Bailey and Davidson (2003) investigated the effect of group singing on life outcomes for men in a homeless shelter. They interviewed seven of the seventeen active choir members in a choir created for homeless individuals (not randomly assigned) and noted four main therapeutic themes resulting from the open-ended questions asked. The participants reported a large benefit to emotional health, social interaction, and cognitive ability as measured through an informal questionnaire. The choir members felt an increased connection to each other and society at large, which improved their emotional regulation and outlook on life. They also experienced some increased cognitive skills from learning and performing the music.

These findings are supported in other studies that also investigated the benefits of choral singing, and surprisingly the same categories of emotional, social, and cognitive factors emerged as themes. Moss and O'Donoghue (2019) ran a study on fifty-four healthcare workers in Ireland who participated in a staff choir for twelve weeks. With standardized self-report measures they tracked aspects of mental health, work engagement, stress level, and depression level before and after choir practice. They found there was a slight increase in positive results afterward, but the qualitative interviews performed after the study revealed a greater benefit than the standardized tests. These results suggest that the effects of choral singing are better captured with qualitative methods rather than quantitative, but it is also possible that these studies used quantitative measures that did not have enough specificity or sensitivity to provide statistically significant findings.

Studies using physiological and cognitive measures during choral singing may shed some more light on the effects of singing on the body. Fancourt *et al.* (2016) conducted a saliva study on one hundred and ninety-three cancer patients, caretakers, and family members who had lost someone to cancer. Results showed that after one hour of singing in a choir, participants had decreased cortisol, beta-endorphin, and oxytocin levels with a general activation of the cytokine network. Findings suggest that the act of vocalizing in a group positively affects immune response and decreases stress inducing chemicals in the body.

Schladt *et al.* (2017) took Fancourt *et al.'*s work one step further and examined oxytocin and cortisol levels in the saliva of thirty-eight students from the University of Regensburg before and after 20 minutes of choral singing and compared it to levels before and after 20 minutes of solo singing. Similarly, Schladt *et al.* found reduced levels of oxytocin in the salivary samples after both choral and solo singing. From these results they proposed singing reflected a state of decreased arousal. However, the oxytocin levels were significantly more decreased after choral singing compared to solo singing. The participants completed self-report measures of general mood before and after both conditions, which revealed an increase in their chosen measures of happiness and a decrease in sadness and worry after singing. They found a more pronounced increase in positive mood after choral singing reflected by the salivary results. Other studies looking at depressive symptoms in older adults or individuals with dementia after a choral singing intervention also report similar findings of decreased feelings of depression and increased interest in activities of daily life (Cohen *et al.*, 2006; Särkämö *et al.*, 2014; Chiu *et al.*, 2016; Särkämö *et al.*, 2016; Särkämö *et al.*, 2017; Williams, Dingle, & Clift, 2018; Johnson *et al.*, 2020; Pentikäinen *et al.*, 2021).

Effects of Vocalization or Chanting During Meditation

Research conducted on choral singing provides a reasonable argument for vocalization influencing emotional experience, but questions remain about a crucial aspect of singing: the phonation itself. Exploration into vocalization performed by a single individual and research on chanting (or humming) during mindful meditation may illuminate the unique contributions of phonation in affecting mood and emotional processing.

Harne and Hiwale (2018) researched brain activation while chanting an "OM" mantra during meditation. They ran twenty-three college students who were not experienced in meditation and measured EEG spectrum before and after the meditation task. As their outcome measure, they used theta frequencies, which have been linked to a relaxed state of mind and body. They found a mild increase in the theta band of brain wave frequencies only during chanting, not before or after, suggesting that vocalizing while meditating could induce a state of relaxation as measured by theta band activity.

Other studies have shown a decrease in communication within and between brain areas during "OM" mantra meditation, which could also result in a relaxed mood. Rao *et al.* (2018) conducted a study on twelve adults varying in their experience with meditation. They found that after a 15 second “OM” production, there was significantly reduced output from the insula, anterior cingulate, and orbitofrontal cortices as seen during fMRI, which they postulate has a downstream effect on autonomic functioning. Reduced brain activity and decreased neuronal communication between areas has been linked to a state of relaxation as well, which also supports the hypothesis that vocalization during meditation can calm the mind and subsequently the body.

<u>Psychosocial Effects of Singing</u>

Singing is a physical activity involving multiple muscle groups and body systems. In this way, singing is similar to a physical sport (Somayaji *et al*., 2022), and could have the same mental and physical therapeutic benefits. Clark and Harding (2012) researched eleven quantitative and three qualitative studies in a meta-analysis of studies exploring the therapeutic benefits of singing. Their findings indicated that studies utilizing quantitative methods were varied and inconclusive. However, qualitative measures such as structured interviews seemed to be more sensitive, revealing various emotional, social, and cognitive benefits to the participants. This conclusion echoes the psychosocial outcomes reported in the choral singing literature.

These psychosocial factors could be conceptualized as part of the broader well-being that Smith, Kleinerman, and Cohen (2022) gathered information on related to singing. They surveyed forty-eight adults over the age of forty who had recently commenced voice lessons to determine if there was any psychosocial growth related to using their voice. Over seventy-five percent of the participants reported a change in their physical health, emotional/mental health, personal relations, and professional relations. Over ninety-five percent reported a positive effect on their emotional/mental health and physical health. The survey included an open response section at the end, and common themes that arose included increased feelings of happiness with decreased depression and alleviated stress with a greater sense of confidence. Limitations in the research methods, specifically response bias because only those interested completed the survey, suggest caution in interpreting the results. Despite this, it provides anecdotal evidence that singing can improve psychosocial and general life outcomes.

Causal or Interactive Mechanisms between Voicing and Positive Mood

There are three theoretical causal factors that could support the hypothesis that vocalization can increase or produce positive moods. These factors include, but are not limited to, feedback from audio-vocal communication, non-judgmental mindsets, and physiological entrainment.

Audio-Vocal Communication

The first, biopsychological feedback, includes the engagement of the mammalian audio-vocal (AV) system that could result in a sense of pleasure in vocalization and support connections between individual members of a species. AV communication, employed by mammals, uses the vocal and auditory systems for a number of social functions, such as warning others of danger, informing others during foraging, bonding with their young, and procreating (Schel *et al.*, 2013; Crockford, Wittig, & Zuberbühler, 2017). Therefore, the use of this system became an important tool for survival. Thus, reward and threat systems in the brain developed to encourage its use. These reward and threat systems are the basis for emotional processing.

Humans share mammalian neurobiology, and so use the AV systems as well. However, given that humans are more complex in their social world, their use of the AV systems is also more complex. Verbal language, the most commonly used mode of communication unique to humans, uses the AV system for its purposes. Despite its highly complex form and purpose to humans, there is still a connection between voiced speech and language (Oller *et al.*, 2019; Oller *et al*., 2021), and the ingrained pleasure in utilizing the AV system remains.

To highlight this vestigial relation between AV systems and emotion in humans, one only needs to look at human and primate infants who use their voice to express wants and needs with crying, and even begin developing emotions with laughter (Tchernichovski & Oller, 2016; Jhang *et al*, 2017; Yoo, Bowman, & Oller, 2018; Yoo *et al*., 2019). Typically, the infant's effort to communicate is rewarded with the attention they seek, and thus the positive feedback loop is strengthened. This positive feedback from using the voice to communicate could potentially remain with a human into adulthood and provide a basis for improving mood. This example is just one way to observe how voice and emotional processing are interconnected. Undoubtedly there are numerous other ways to illustrate this phenomenon, which could be the focus of an entirely separate research trajectory.

Interoception and Mindful Meditation

The second possible reason for an increase in positive mood due to vocalization is that it promotes an increase in interoceptive awareness. Interoceptive awareness is the ability to sense one's own internal bodily functions, such as heart rate (Crow, van Mersbergen, & Payne, 2021). Increasing awareness of what is happening in the body by itself is more likely to be interpreted negatively rather than positively (Schandry, 1981). However, interoceptive awareness is an important precursor to implementing a non-judgmental attitude towards negative emotions (Schwerdtfeger, Heene, & Messner, 2019).

Practicing a non-judgmental mindset is one of the main components in the art of mindful meditation, which is known to have positive effects on mental and physical health (Segal and Walsh, 2016). Favre *et al*. (2021) breaks down the most common and widely used mindful meditation practices into three components: attention and interoceptive awareness, socio-affective skills such as compassion, and socio-cognitive skills such as theory of mind. The results from that study showed that the only component which changed emotional processing was the socio-affective skills training, which taught the participants how to maintain a non-judgmental attitude toward negative thoughts and feelings. Vocalization has not been shown to directly train a non-judgmental mindset, but it has the potential to increase the skills needed to implement such a mindset.

Systemic Entrainment

The last potential cause for the impact vocalization has on emotional reactivity could be explained by the alignment of multiple bodily rhythms and functions. Many organs in our body are known to function best when oscillating in a certain rhythm (Patton & Thibodeau, 2012). The heart, the stomach, and even the firing of neurons in the brain are all examples of rhythms happening inside the body. The average resting heart rate of an adult is 72 beats per minute (BPM), with normal fluctuation between 60-100 BPM, although a lower resting heart rate implies better fitness (Patton & Thibodeau, 2012, p. 681-721). Similarly, the stomach also has pacemaker cells that cause it to beat around 0.05 times a second (Choe *et al*., 2021; Robello, Wolper, & Tallon-Baudry, 2021). Additionally, neurons in the brain also fire at a certain rate with a large dynamic range depending on the structure of the neuron, its efficiency, and use.

Each system's rhythm reflects various aspects of their function. For example, as stated earlier, the heart beats around 72 BPM for optimal resting function. It will beat faster when the sympathetic nervous system is engaged to allow for increased blood flow to the tissues (Patton & Thibodeau, 2012, p. 695). Vocalization is a whole-body activity that engages many of the body's systems that rely on rhythm, specifically respiration, which can effect a change in respiratory rate, heart rate (Baldaro, Battacchi, & Trombini, 1990), gastric musculature activation (Vianna &

Tranel, 2006; Vianna *et al.*, 2009), and neuronal firing. Therefore, the act of voicing has the potential to coordinate these systems' functions through regulation of breath and subsequently, heart rate (Mather & Thayer, 2018; Tort, Brankačk, & Draguhn, 2018; Maric, Ramanathan, & Mishra, 2020; Folschweiller & Sauer, 2021; Somayaji *et al.*, 2022)

Furthermore, emotions can be thought of as labels we have assigned to physiological events happening in the body in reaction to certain stimuli (Barrett, 2006). These physiological events could then be defined as emotional experiences with positive and negative valence and high and low arousal. It is conceivable that vocalization coordinates the previously mentioned body systems in a meaningful way so as to facilitate clearer interpretation of physiological events happening within an individual.

This coordination of multiple systems can be observed in choral singing. Studies show that external synchronization happens across individuals in a choir setting (Vickhoff *et al.*, 2013). Shared sensory experiences (Shteynberg & Apfelbaum, 2013) and entrainment (Clayton, 2007; Kawagishi *et al., 2013)* between singers when they synchronize their breathing and phonation with each other may be a mediating factor in why singing in groups is so powerful. However, does this internal synchronization, presumably achieved by vocalizing alone, have the same benefits?

Purpose

The purpose of this study is to investigate the contribution an individual's vocalization has on an emotional experience. Given that previous research has found self-reported and physiological changes in singing and in chanting, this study will employ both self-report measures of mood and physiological measures of emotional experience. We hypothesize that voicing will have an effect on how an individual processes emotion as measured by self-report measures of transient and general mood, electromyographical measures of the muscles of facial expression, and physiological measures of electrodermal activity (skin conductance).

Specifically, we hypothesize that following a voicing task an individual will rate their mood as more positive (or less negative) immediately after viewing pictures of emotional content. This self-report rating will be mirrored in their behaviors of facial expression. Thus, following a voicing task, participants will present with greater zygomaticus activation (smile) during picture viewing and less corrugator supercilii activation (frown). Additionally, participants will rate their level of arousal as reduced following voicing tasks particularly for aversive stimuli, given that meditation literature reports this effect.

We further hypothesize that following each condition participants will rate a change in overall mood (valence) and present with a change in physiological engagement (arousal). In other words, we expect that participants will have an overall increase in positive mood following the voicing task and their level of arousal will be decreased.

Methods

Design

This study is a within-participant reversal paradigm where each participant served as their own control. All participants were exposed to all stimuli and conditions.

Participants

Participants were 26 vocally healthy individuals (8 males) with an average age of 27.7 years (range 20-48 years) with no history of a voice disorder, neurological disease, head and neck surgery, respiratory and cardiac disease, head and neck cancer, or major psychiatric disorder. One participant provided partial data due to technical issues. Normal voice functioning was determined through an informal self-report and an auditory-perceptual voice screening performed by a certified and licensed speech-language pathologist specializing in voice disorders. Participants were English speaking and had a reading level above 3rd grade to complete questionnaires. The participants largely reflected the racial, ethnic, and gender makeup of the University of Memphis and the greater Memphis area. Participants had sufficient cognitive abilities to participate in following the directions of the study.

Measures

Independent measures

Emotional Stimuli

International Affective Picture System

The International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) is a repository of standardized pictures regarding both emotional valence and arousal. This database was used as the emotional stimuli to induce a temporary emotional state in the participants during viewing. The pictures selected for this study consisted of 24 pictures of positive (8), neutral (8), and negative (8) images, which were presented to the participants via a large computer screen (television). These stimuli were presented to the participants in a randomized order immediately following each experimental block, and they are the main method for eliciting emotional states within the participants.

Experimental Tasks

Breathing

A breathing pattern designed to mimic the breathing pattern during voicing was used as the breathing task. Exact inspiration and expiration rates differed between individuals, but the target ratio was 10% inspiration and 90% expiration. The participants were asked to release their air slowly and quietly. The intent was to approximate their natural exhalation time. This measure was used as a control to compare breathing's relative contribution to vocalization.

Articulating (Sustained Voiceless Fricative)

The articulation task was designed to mimic sustained voiceless speech. The participants were asked to hold out the /ʃ/ phoneme repeatedly until they felt the need to inspire. Again, the exact rates varied between participants, but a ratio of 10% inspiration and 90% expiration was the target. This measure was also used as a control to compare articulation's relative contribution to vocalization.

Resonant Voice Therapy

Modified activities from Lessac-Madsen Resonant Voice Therapy (Verdolini-Marston et al., 1995; Verdolini et al., 1998) were used as the vocalization task. Resonant voice therapy was chosen to instruct the voicing task because it is a constrained teaching technique to enhance the harmonics of the voice and increase the participants' oral vibratory sensations. The therapy focuses on getting an individual to use their clearest voice with a production that is not forced during a hybrid singing/speech task. This therapy was given as the last experimental task in the procedure, and the researcher trained the participants one-on-one, as in the other experimental blocks.

Dependent measures

Positive and Negative Affect Schedule

The Positive and Negative Affect Schedule (PANAS; Carver & White, 1994) is a 20-item self-rating scale designed to measure positive and negative affect. This measure was given after each block to record general emotional state and served as a measure of general mood to control for shifts in general mood between each block. It was presented to the participants on a LG LK5700 television monitor, and they used a detached number pin pad to submit responses.

Self-Assessment Manikin-Valence and Self-Assessment Manikin-Arousal

The Self-Assessment Manikin-Valence (SAM-V) and Self-Assessment Manikin-Arousal (SAM-A; Bradley & Lang, 1995) are a 5-figure, 9-point picture rating scale used to measure in-the-moment emotional reactions (see Appendix). To represent emotional valence (pleasurable vs not pleasurable), SAM ranges from a smiling, happy figure to a frowning, unhappy figure. To represent the arousal dimension, SAM ranges from an excited, wide-eyed figure to a relaxed, sleepy figure. See Appendix for a visual representation of these rating forms. SAM-V (valence) and SAM-A (arousal) were presented to the participant visually on the television monitor and they responded by typing in the one-digit number on a pin pad that best represented their current emotional state. This served as the main dependent measure of interest.

Surface Electromyography

Tonic levels of muscle activation in the corrugator supercilii muscle and zygomaticus major muscle were constantly measured during the emotional reactivity assessments to reflect changes in positive and negative mood. Cleaning and analysis of these measurements adhered to published guidelines *(Cacioppo at al., 1986; Fridlund & Cacioppo, 1986).* Research has shown that activity in the corrugator supercilii muscle is associated with negative affect and activity in the zygomaticus major muscle is associated with positive affect. These measures served as indicators of emotional reactivity and behavioral expression of mood during the IAPS picture viewing. The data were recorded unilaterally (non-dominate side) with Ag-AgCl miniature electrodes positioned in accordance with published guidelines. EMG activity was sampled at 20 Hz throughout each emotional reactivity block and for the seconds preceding each block. The data were epoched and averaged around stimulus trigger codes in each of the 24 pictures presented.

Electrodermal Responses

Electrodermal responses (EDR; *Bradley & Lang, 2000)*, most often associated with palm sweat, reflect an individual's autonomic response to novel stimuli by increasing sweat gland production and subsequently increasing the skin's electrical activity. EDR, commonly known as skin conductance, has been studied extensively as an index of the degree of experienced arousal to both cognitive and emotional stimuli. Skin conductance was measured by placing BrainVision (Morrisville, NC) electrodes filled with 0.05-m NaCl Unipaste (Moscow, Russia) paste on the first and second metacarpal of the fourth digit on the non-dominant hand. For the purposes of this study, EDR was used to measure the degree of autonomic arousal and as confirmation that a physiological response was experienced in response to the emotional stimuli.

Procedures

The study took place entirely in the Voice, Emotion, and Cognition Laboratory at the Memphis Speech and Hearing Center. The participant was given a copy of the consent form when they arrived and was given time to read the form independently. Once the participant verbally agreed to participate, they signed the consent form, and the researcher provided a copy of the form for the participant's own records.

After consent, the participant was oriented to the laboratory and tested for skin irritation by applying a small sample of the contact gel to their wrists. While they were waiting for the results, they completed the informal intake form. Following the skin test, respiratory bands were placed around the chest and torso, electrodes for heart rate were placed on the arms and forehead, and electrodes for surface electromyography of the muscles of facial expression were placed on the face. Finally, electrodermal response electrodes were placed on the first and second metacarpal of the fourth digit on the non-dominant hand. The participant sat in a relaxed position while baseline data from the sensors was collected. Once the baseline measures were collected, the participant underwent training on how to view pictures and complete rating scales.

Following training, the participant underwent four experimental blocks, all ending with a return to baseline. For experimental block 1, the participant sat quietly for 7 minutes. They then viewed the emotional stimuli, the IAPS pictures, and rated their reaction and general mood using the SAM-V and SAM-A. Participants viewed each slide for 6 seconds, according to the accepted protocol (Lang, Bradley, & Cuthbert, 1999) and there was a 1.5 second interstimulus rest following the completion of the valence and arousal ratings. The emotional stimuli were presented in a randomized order for each block, and precautions were taken to ensure that the participant did not receive a stimuli of the same valence more than 3 times in a row.

For experimental block 2, the researcher explained a breathing task to the participant meant to mimic the breath pattern used for speech. The participant then executed the breath pattern for the same amount of time as block 1 with the help of a visual reminder on the television screen. Afterward, the participant was immediately shown the emotional reactive pictures and rated their reaction and general mood.

For experimental block 3, the researcher explained an articulation task where the participant held the voiceless fricative /ʃ/ in the same pattern as the breathing task. The participant then executed the articulation task for the same amount of time. Afterward, the participant was immediately shown the emotional reactive pictures again and rated their reaction and general mood.

For experimental block 4, the researcher spent several minutes teaching the participant a voicing task based on Lessac-Madsen Resonant Voice Therapy designed to bring awareness to the sensations of vibration in the anterior oral cavity during humming. The participant then executed the task for the same amount of time. Afterward, the participant was immediately shown the emotional reactive pictures again and will rated their reaction and general mood.

For the final baseline, the participant was given a few minutes to return to baseline while data was collected. After the experiment was finished, the researcher removed all sensors and equipment from the participant's skin. The researcher thanked the participant and showed them to a bathroom where they could clean off residue from the sensors if needed. The entire experiment lasted approximately 90 minutes, with 60 minutes collecting data and 30 minutes preparing and cleaning up. Please refer to Figure 1 for a graphical display of the procedures.

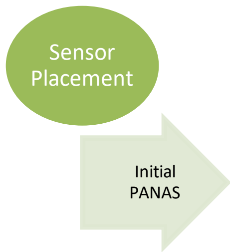

Figure 1: A visual depiction of the experimental procedure.

Instrumentation and Experimental Set Up

Visual Stimuli were presented using E-Prime (3.0 Psychology Software Tools, Pittsburgh) running on a Dell OptiPlex 7050 MT, (Austin, TX) and displayed on a 60-Hz, 1,080-p, 48” high-definition monitor (LG LED LK5700, Seoul, South Korea). Physiological data were collected using Brain Recorder (BrainVision; Morrisville, NC) running on a Dell OptiPlex 7050 MT (Austin, TX). Data processing for the self-report measures during the experiment consisted of downloading recorded responses from E-Prime, organizing SAM-V and SAM-A responses according to block and IAPS valence, and organizing PANAS recorded responses according to block and valence. Data processing for EMG of the corrugator supercilii and zygomaticus major muscles included segmentation of the data according to block and IAPS valence, filtering of the data between .01-40 Hz, and averaging the signal within each valence and block. Data processing of the electrodermal measures included segmenting the data according to emotional condition and block, filtering the data between .01-40 Hz, and averaging the signal within each valence and block.

Analysis

Self-report measures

Transient Mood

Self-report data of transient mood from the SAM-V and SAM-A following each IAPS picture viewing were averaged within each block and across all participants for positive, neutral, and aversive pictures.

Valence. A two-way ANOVA comparing mood (positive, neutral, aversive) by condition (baseline, breathing, articulating, voicing) determined any significant differences in transient mood across the four conditions. A Bonferroni pairwise post hoc analysis was performed in addition to main effects.

Arousal. A two-way ANOVA comparing arousal (high, low) by condition (baseline, breathing, articulating, voicing) determined any significant differences in arousal across the four conditions. A Bonferroni pairwise post hoc analysis was performed in addition to main effects.

General Mood

Self-report data of general mood from the PANAS following each block assessed the overall effect of each condition across participants.

Valence. A one-way ANOVA of the self-report data of overall mood from the PANAS across conditions (baseline, breathing, articulating, voicing) determined any significant differences in general mood.

Physiological measures

Physiologic data was used to support and confirm self-report data.

Transient Mood

Valence. A two-way ANOVA comparing mood (positive, neutral, aversive) by condition (baseline, breathing, articulating, voicing) for the zygomaticus major (smile) determined any significant differences in transient mood across the four conditions. A separate two-way ANOVA for the corrugator supercillii (frown) with the same mood-by-condition analysis determined any significant differences in transient mood across the four conditions. A Bonferroni pairwise post hoc analysis was performed in addition to main effects.

General Mood

Arousal. Two, one-way ANOVAs across baseline and conditions (breathing, articulating, voicing) determined any significant differences between voicing and the other conditions for heart rate and skin conductance, respectively.

Results

Self-report measures

<u>*Transient Mood*</u>

Valence. To answer the question whether voicing affects mood following picture viewing, a two-way ANOVA comparing mood (positive, neutral, aversive) by condition (baseline, breathing, articulating, voicing) showed a significant main effect for mood, F(2, 2388) = 1485.17, *p* < 001, no significant main effect for condition, F(3, 2388) = 1.63, *p* =.180, and no significant interaction of mood and condition, F(6, 2388) = 1.71, *p* =.115. Results are graphically displayed in Figure 2. A Bonferroni pairwise comparison post hoc analysis showed that participants rated positive slides more positive than neutral slides *p* < .001, or aversive slides *p* < .001, and neutral slides were rated more positively than aversive slides *p* < .001. Participants rated aversive slides as less aversive in the articulating condition compared to the baseline *p* = .042 and breathing *p* = .011 conditions; compared to the voicing condition, participants ratings did not reach significance *p* = 092.

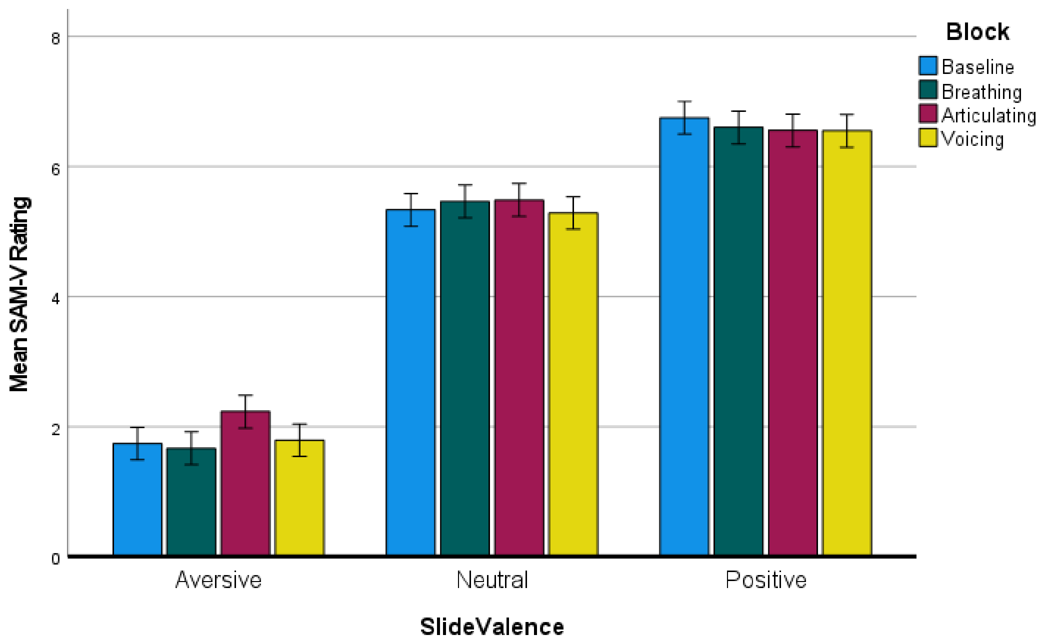

Figure 2: Participant responses to IAPS pictures by valence using the SAM-V

Arousal. To answer the question whether voicing affects arousal following picture viewing, a two-way ANOVA comparing arousal (calm, neutral, excited) by condition (baseline, breathing, articulating, voicing) showed a significant main effect for arousal, $F(2, 2388) = 365.07$, $p < .001$, a significant main effect for condition, $F(3, 2388) = 8.21$, $p < .001$, 1, and a significant interaction of arousal and condition, $F(6, 2388) = 2.63$, $p = .015$. Results are graphically displayed in Figure 3. A Bonferroni pairwise comparison post hoc analysis showed that participants rated positive slides more arousing than neutral slides $p < .001$, but less arousing than aversive slides $p < .001$, and participants rated neutral slides less arousing than aversive slides $p < .001$. Participants also rated positive slides as less arousing in the voicing condition compared to the baseline $p < .001$ and breathing $p < .001$ conditions, and in the articulating condition compared to the baseline condition $p = .008$.

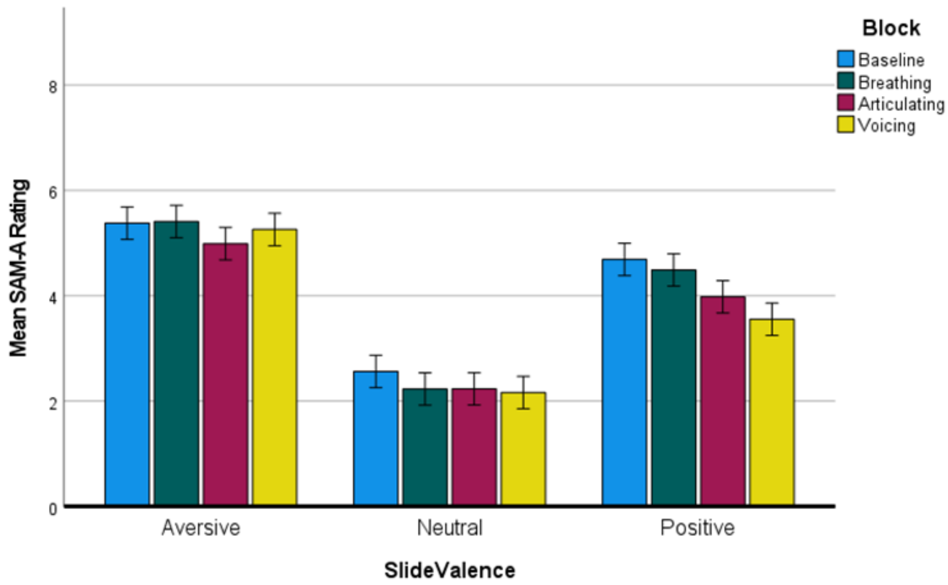

Figure 3: Participant responses to IAPS pictures by arousal using the SAM-A.

<u>*General Mood*</u>

Valence. To answer the question if voicing effects general mood, a one-way ANOVA was completed of the self-report data of overall mood from two PANAS subscales: the PANAS positive scale and the PANAS negative scale. The one-way ANOVA for both subscales were across conditions (baseline, breathing, articulating, voicing) and showed no significant main effect for condition in either the positive subscale, $F(3, 96) = 2.38$, $p = .074$ or negative subscale $F(3, 96) = 1.21$, $p = .312$. Results for the PANAS positive subscale and the PANAS negative subscale are graphically displayed in Figure 4 and 5, respectively.

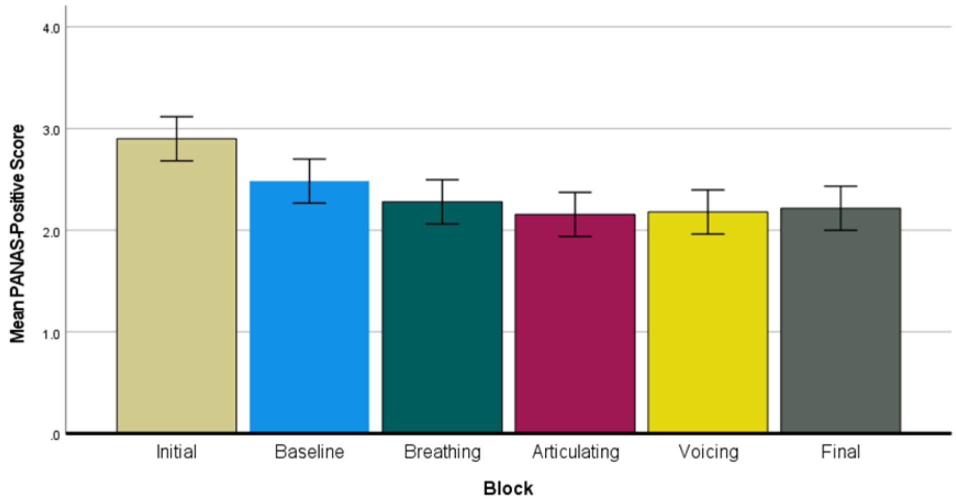

Figure 4: Participant responses following each experimental condition using the PANAS scale of positive mood.

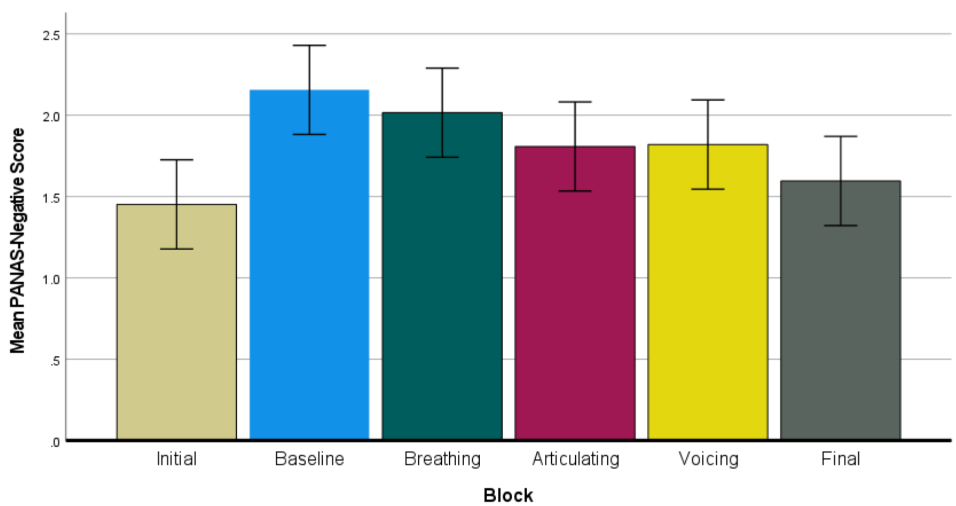

Figure 5: Participant responses following each experimental condition using the PANAS scale of negative mood.

Physiological measures

Transient Mood

Physiological/Behavioral data partially supported the findings that the voicing condition affects mood.

Valence. A two-way ANOVA comparing mood (positive, neutral, aversive) by condition (baseline, breathing, articulating, voicing) for the zygomaticus major (smile) showed no significant main effect for mood, F(2, 297) = 3.01, $p < .051$, condition, F(3, 297) = 0.66, $p =$ .576, or interaction of mood and condition, F(6, 297) = 0.492, $p = .814$. Results are graphically displayed in Figure 6. Post hoc analysis found no significant comparisons.

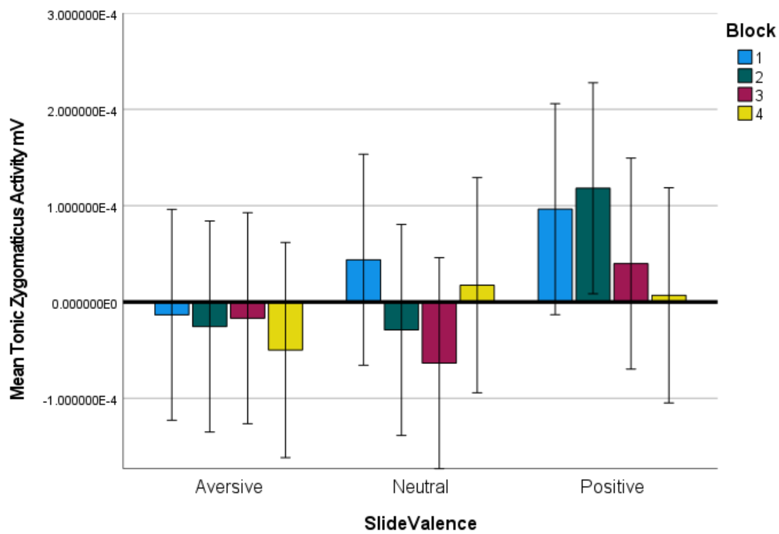

Figure 6: Zygomaticus major muscle activation during IAPS picture viewing.

A two-way ANOVA comparing mood (positive, neutral, aversive) by condition (baseline, breathing, articulating, voicing) for the corrugator supercilii (frown) showed no significant main effect for mood, F(2, 297) = 1.59, $p < .205$, condition, F(3, 297) = 0.92, $p < .434$, 1, or the interaction of mood and condition, F(6, 297) = .94, $p < .465$. Results are graphically displayed in Figure 7. There were no significant post hoc comparisons.

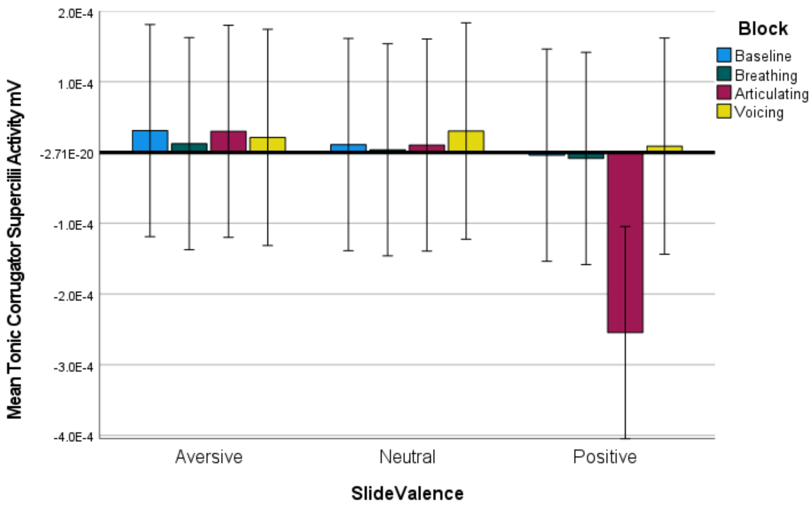

Figure 7: Corrugator supercilii muscle activation during IAPS picture viewing.

<u>*General Mood*</u>

Arousal. Physiologic data showed overall arousal following each condition. A one-way ANOVA of skin conductance across condition (baseline, breathing, articulating, voicing) showed no significant effects for condition, $F(3,98) = 0.48$, $p = .700$. Results are graphically displayed in Figure 8.

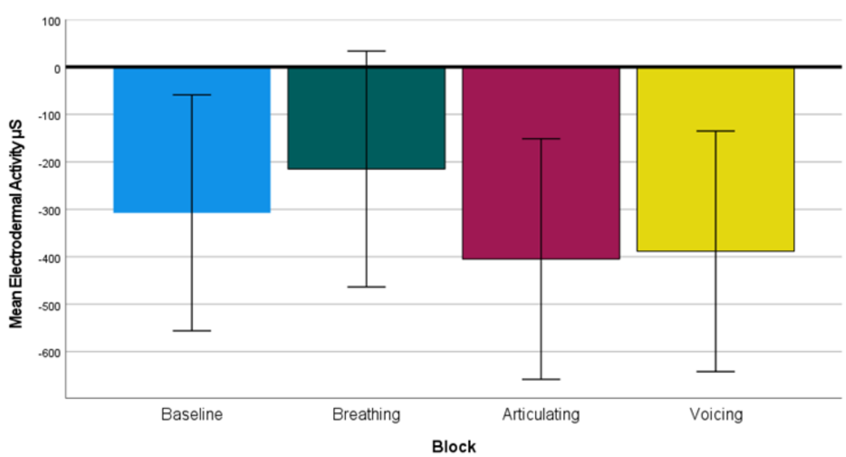

Figure 8: Electrodermal responses following each experimental condition.

Discussion

After reviewing the available literature on how voicing may affect emotional states, we hypothesized that an individual would experience change in their emotional state after a brief period of vocalizing towards a more positive mood. We proposed that this change would be evident in transient mood immediately following an emotional experience and would also affect their overall mood following experimental conditions. Subsequent to the voicing condition, we anticipated finding an increase in positive ratings following picture viewing of slides with a positive valence (pleasant mood), a decrease in negative ratings following picture viewing of slides with a negative valence (unpleasant mood), or a decrease in ratings of emotional arousal particularly for aversive pictures. Our findings only partially confirmed these hypotheses with mixed results among the four experimental conditions.

Valence Effects

The self-report data we collected from our participants indicated there was a significant change in transient negative mood during the IAPS picture viewing of aversive pictures after the articulating task. The participants rated the aversive pictures less negatively after sustaining the voiceless fricative /ʃ/ repeatedly. We also found that our participants rated the aversive pictures less negatively after the voicing task compared to the baseline and breathing conditions, but that result only approached significance. Expanding the number of participants in the study is likely to shift our findings because power was poor.

The physiological data reflecting the behavioral expression of an emotional experience through the changes in tonic muscular activity of the zygomaticus major and corrugator supercillii failed to elucidate any further conclusions that could be made about participants' self-report data. There was a strong correlation between an increase in the tonic muscular activity of the zygomaticus during stimuli of pleasant content compared to aversive or neutral content, but that result only approached significance.

The unanticipated finding that articulating presented with a stronger effect brings into question the unique contribution that voicing by itself makes to mood modulation. In Fancourt *et al.* (2016) and Schladt *et al.*'s (2017) studies, the independent variable used to modulate mood was the choral singing. In our study, we separated elements of singing into the three components of breathing, articulating, and voicing. Perhaps the increase in positive mood and physiological health benefits reported from the two studies mentioned here reflect the additive effect of articulating and voicing together, but when separated articulating is the most impactful. Further studies should investigate the relative contribution to mood that both articulating on a sustained fricative and voicing provide.

There are several potential reasons why a change in transient positive mood was not observed in the responses following the voicing condition besides a lack of power. The participants may have habituated to the emotional experiences induced by the pictures as the study progressed, and thus any increase in transient positive mood due to voicing as the final task was attenuated. It is also possible the resonant voicing task of humming on an /m/ with a focus on sensory awareness was not stimulating enough to affect a change in mood. Perhaps other sensory processes such as auditory feedback compared to tactile sensory experiences would have produced the desired effect. Additionally, participants may have experienced a negative bias towards the aversive pictures, with a negative mood lasting longer than intended and carrying over to subsequent slides. This would make it difficult to see any change in transient positive mood on subsequent trials.

Arousal Effects

Interestingly, we did find a significant difference in the level of emotional arousal across experimental conditions, but not entirely in the hypothesized valence interaction. We observed no reduction of arousal ratings during viewing of aversive or neutral IAPS pictures for any condition. However, there was a significant difference in arousal ratings directly following the voicing task for positive, not aversive, pictures compared to the baseline and breathing tasks. Participants rated their arousal as less intense. Additionally, lower arousal ratings occurred following the articulating task compared to baseline. Arousal ratings that were lower after viewing positive pictures presents a paradoxical conclusion; that voicing has a moderating effect on arousal, but only for positive transient mood states and by lowering it, not increasing it (or facilitating a greater positive experience).

This might demonstrate a unique aspect of the positive stimuli that can be changed. It could be that the positive stimuli were not as arousing as the negative and neutral stimuli, and therefore were freer to vary by participant. The aversive stimuli were all high in arousal and any effect of voicing or articulating on arousal might have been obfuscated due to a ceiling effect. Similarly, the neutral pictures were all low in arousal, and it is possible there was a basement effect transpiring.

One way to investigate if this is the case is to change the articulating or voicing task. Both humming and shushing are colloquially considered soothing tasks and might have served to reduce arousal. The act of producing a /ʃ/ phoneme or lightly humming are naturalistically observed in calming individuals, particularly infants and children. Engaging in other articulating and voicing tasks might have produced a different effect on arousal. Despite this, it is notable that both articulating and voicing can serve as a moderating effect on arousal.

This effect echoes the findings of studies that explored the physiological affect meditation with vocalization has on the body and also the proposed causal mechanism of systemic entrainment. Vocalization is a whole-body activity that engages the respiratory system in such a way that modulates heart rate (Baldaro, Battacchi, & Trombini, 1990), gastric muscular activity (Vianna & Tranel, 2006; Vianna *et al*., 2009), and neuronal firing (Harne & Hiwale, 2018; Rao *et al*., 2018). That modulation may result in a lowered state of arousal. That was the statement we made after reviewing the literature on possible physiological effects of vocalization, but perhaps articulating also affects human physiology in a similar manner. If both voicing and articulating affect physiology, and the physiological state is what determines arousal to stimli, then this would also help to explain why we found a greater main effect in arousal compared to the valence of emotion.

Future studies might investigate if this moderating effect is observed in aversive conditions that have the same degree of physiological engagement. In other words, does this moderating effect occur in aversive conditions if they are not as highly arousing? Because we chose highly arousing aversive stimuli and our positive stimuli was less arousing, controlling for arousal in the stimuli would serve to answer this question.

Additionally, there may be differential effects of voicing and articulating on emotional states. This can be observed when studying emotion's effect on the voice. van Mersbergen & Lanza (2018) found that relative fundamental frequency was modulated in positive moods and the effect was to reduce tension in the intrinsic laryngeal muscles, specifically the cricothyroid. However, there was no specific effect observed in negative mood states. Negative moods instead appear to influence medial compression by increasing it (van Mersbergen & Delaney, 2014; van Mersbergen, Lyons, & Reigler, 2015). In essence, positive and negative moods might not be comparable because they affect different aspects of the speech system.

General Mood

This study did not confirm any hypothesis about general mood following experimental conditions, as both PANAS responses and electrodermal activity remained relatively flat throughout the experiment. The only result that approached significance was the difference between the PANAS subscale of positive mood compared to the subscale of negative mood. Despite demonstrating no significant findings, this outcome is not entirely unfortunate. While general mood remained relatively stable, transient mood states following picture viewing fluctuated, which may highlight differences in the modulating effect that voicing or articulating has on transient mood. Both the voicing and articulating conditions changed the way individuals experienced transient moods (especially with regard to arousal), but did not necessarily affect their general mood, suggesting that general mood and transient mood might be different phenomena (Derryberry & Rothbart, 1984).

Limitations of the Study and Future Directions

There are several limitations of this study. While the three conditions for this study (breathing, articulating, and voicing) were selected in an attempt to isolate the components and subsystems used during speech and vocalization, it is possible the tasks may have been too similar, as evidenced by the similarity in results between the articulating and voicing conditions. Future studies desiring to ferret out the relative contribution of voicing to emotional experiences, as compared to breathing or articulating, might consider the nature of the task. On the one hand, the fact that the articulating and voicing conditions responded similarly in this study might suggest that these similarities should be controlled for in future studies. However, those studies run the risk of finding similarly vague results as observed in this study.

Additionally, future studies could seek to investigate the similarities between voicing and articulating to find the shared contribution to emotional modulation. For example, in this study the articulating condition used the voiceless fricative /ʃ/ and the voicing condition used a resonant hum on /m/. These phonemes may provide similar sensory experiences with respect to breathing behavior, the location in the oral cavity where vibrotactile sensations occur, and the loudness level of the task. Future studies might find that it is not necessarily voicing that affects mood, but these other physiological and sensory factors. It is possible a larger difference would have been observed if the voicing task had more intensity (resonant humming is relatively quiet), or the articulating task had a different place or manner of consonant production (a plosive or a velar placement).

Considering the sensory experiences of voicing and articulating, the relationship and direction of how speech and singing acts might influence emotional experiences is worthy of future studies. This study found a reduction in arousal during voicing conditions, which may have intriguing clinical implications. Could it be that certain speech or voice tasks could be used to moderate individuals who have difficulty moderating their arousal levels, as observed in some anxiety or executive functioning disorders?

It is also possible temperament might moderate the effects of articulating and voicing. If sensory experiences are contributing to the modulation of emotional experiences and arousal, could it be that this effect might be more apparent with individuals who have temperaments conducive to new sensory experiences, such as those high in reward sensitivity (Cloninger, 1993; Eysenck, 1990; Lang, 1994)? Future studies might find that voicing (and articulating) are only experienced positively in certain individuals.

Broader methodological limitations include aspects of the research design. The stimuli employed to manipulate mood present some inherent drawbacks. The stimuli were only presented for 6 seconds, which may not have produced a strong enough emotional response for participants. Furthermore, there was little time between the presentation of each slide, which might have blunted a full emotional experience from occurring. Future studies could consider employing different emotion induction paradigms, such as movie presentations, mental imagery, or environmental simulations that occur over longer periods of time and would allow for stronger emotional experiences. Effects of voicing might be observed if emotional experiences were more salient because the processing time of that emotion was more conducive to a modulating affect. Additionally, future studies might choose to only study one valence at a time in blocks, or on different days. Although habituation effects may present some problems, the possibility of isolating one valence would allow for a more in-depth study of how voicing affects habitation of emotions.

The experimental conditions might also show more significant differences if they were randomized. The rationale for not randomizing the conditions in this study was an attempt to measure any lasting effect the voicing task would have on overall mood. If voicing did indeed modulate mood, then we did not want that effect to carry over into subsequent blocks, thus muddying the data. However, the data we collected for general mood was inherently noisy and did not show a lasting effect for mood due to voicing. It could be that the effect of the conditions on emotional processing had more to do with familiarity with the overall experimental procedure than the conditions themselves. Counterbalancing experimental conditions would determine if there were order effects that should be considered for future studies.

A final limitation of this study is the instructions for each experimental condition might not have elicited the true desired effect. For example, the instructions for breathing and articulating might have produced a different effect compared to voicing because they took less time to administer. Future studies might consider a more tightly controlled training procedure to ensure similarity in training across conditions. Alternatively, training procedures could be less controlled experimentally and more ecologically valid within each participant. Participants varied greatly in their vocal experience and allowing each participant to use their voice as they naturally would might produce stronger effects on the emotional experience. Previous studies have shown differences in muscle activation of the cheeks (specifically the zygomaticus and masseter) between individuals with varying musical backgrounds. So, it stands to reason that tailoring vocal training to accommodate each participant's background may change their outcome (Fisher, Hoult, & Tucker, 2020).

Conclusion

This study investigated the effects that voicing has on emotional experiences by having participants rate their current mood following picture viewing of emotional content after a number of conditions. Results showed that not only does voicing effect emotional experiences, articulating in the form of a voiceless fricative also influences the way one experiences mood. Findings from this study may inform future studies investigating the relative influence that voicing and speech has on emotional processing.

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Appendix

SAM-V and SAM-A Visual Scales

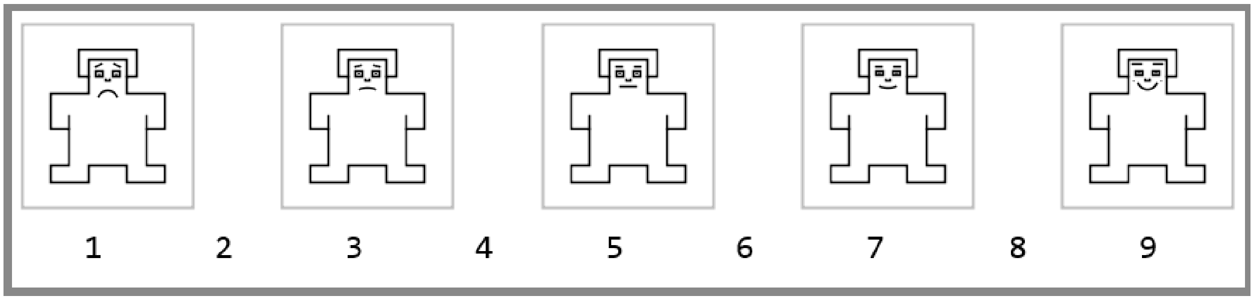

Figure A1: The visual representation of the SAM-V rating scale presented to participants after every IAPS stimuli.

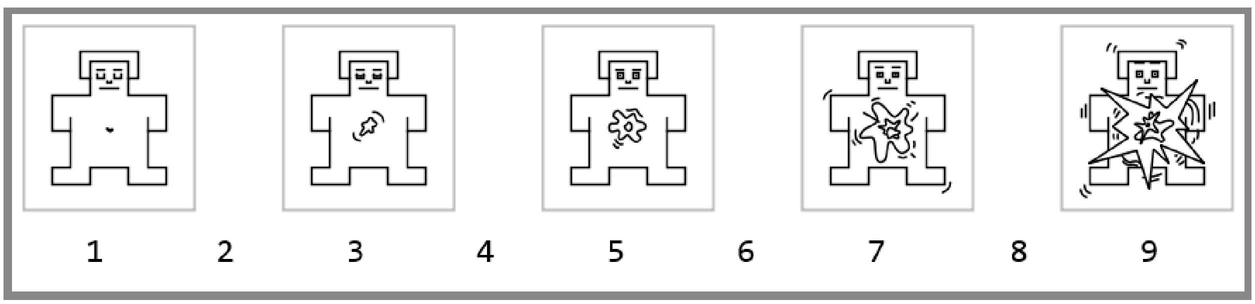

Figure A2: The visual representation of the SAM-A rating scale presented to participants after every IAPS stimuli.