The Effects of Emotional Expression on Vibrato

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Summary: Objectives/Hypothesis. The purpose of this study was to investigate the effect of emotional expression on several acoustic measures of vibrato, including its rate, extent, and steadiness. We hypothesized that singing a passage with emotional content would influence these variables.

Study Design. This study used a within-subjects, repeated-measures design. Singer performance under different conditions was analyzed.

Methods. Ten graduate student singers (eight women, two men) completed a series of tasks including sustained sung vowels at several pitch and loudness levels, an assigned song that was judged to have relatively neutral emotion, and a personal selection that included passages of intense emotion. Vowel tokens were extracted from the recordings and averaged for each task. Dependent measures included the mean fundamental frequency (F_0), mean intensity, frequency modulation (FM) rate, FM extent, and measures of FM rate and extent variability.

Results. The FM rate and extent were higher and the modulation variability was lower for the more emotional song than for the sustained vowels. Mean F_0 and intensity were higher for the emotional song than for the neutral song.

Conclusions. Singing an emotional passage influences acoustic features of vibrato when compared with isolated, sustained vowels. The wider dynamic and pitch ranges for emotional passages only partly explain vibrato differences between emotional and neutral singing.

Key Words: Vibrato–Singing–Emotion–Vibrato extent–Vibrato rate–Modulation.

INTRODUCTION

Vocal vibrato has been the subject of research for many years. C.E. Seashore pioneered the use of acoustic measures to examine vibrato in as early as the 1930s. Seashore[1] defined vibrato as "a periodic pulsation, generally involving pitch, intensity, and timbre, which produces a pleasing flexibility, mellowness, and richness of tone" (p. 623). Vocal vibrato is understood to be a natural feature of a well-balanced singing voice,[2] contributing to a listener's perception of the performer's technical and artistic skill. Vibrato is also considered one of the means a singer may use to express emotion.[1,3]

Vibrato acoustics and vocal beauty

On the surface it may seem simple to define a specific set of acoustic and physical measures that characterize a pleasing voice, but many factors are involved in beautiful singing. One factor identified in the literature is vibrato. Robison, Bounous, and Bailey[4] compared the vocal ratings from a panel of expert judges to several acoustic measures of vocal performance. Singers with the highest ratings of vocal beauty were those whose vibrato occupied proportionally more of their total singing time. Other predictors of vocal beauty included cleanness of voice and adequate breath management.

Several acoustic features of vibrato have been studied in detail since Seashore made his first observations, including the rate, extent, and periodicity of the vocal modulations.[3,5] Vibrato rate is defined as the number of fundamental frequency (F_0) and amplitude pulses per second.[1] Frequency modulation (FM) and amplitude modulation (AM) both contribute to vibrato rate. In vibrato, AM is largely an epiphenomenon that arises from the resonance-harmonic interaction or RHI.[6,7] The RHI is the interaction between rising and falling harmonic frequencies (as a result of fluctuating F_0) and the formant peaks in the vocal tract transfer function that determine the overall intensity of a sound. This interaction creates an involuntary modulation in amplitude with the modulation in F_0. There is also a laryngeal component of AM that can be measured through electroglottography,[8] although the target behavior for a singer is believed to be the modulation of fundamental frequency. Therefore, for the remainder of this article, FM of vibrato will be the focus of measurement and discussion, and AM will not be considered further.

The rate of vocal vibrato for an individual is not fixed; it can be modified by the singer with conscious effort. However, singers have a natural speed of vibrato, and rate can only be changed modestly with volitional control.[9] The average rate of vibrato has been reported to be within the 5–7 Hz range,[1,3,5] with higher or lower rates depending on when the note occurs within a musical passage,[10] or the amount of vocal training.[11] Prame's[10] research showed that vibrato rate does not always remain the same throughout a sustained note. Several studies have also shown that with vocal training, the vibrato characteristics of an individual singer may change.[12,13] With training, inexperienced singers with an unusually fast rate tend to gradually slow down closer to an average pace, and singers who begin with a slow rate tend to speed up and move closer to the average rate over a period of time.[13]

As defined by Seashore,[1] vibrato extent is the distance between the crest and trough of the F_0 trace, and is measured in semitones (ST). The average extent of vibrato is reported to lie between 0.41 and 1.58 ST.[3] Vibrato extent has generally increased over the course of the past century,[12] and it also increases in individual singers after a significant period of vocal training.[13] In a study of the link between acoustics and listener ratings, excessive amplitude modulation, delayed onset of vibrato, and complete absence of vibrato all had negative

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effects on perceptual measures of the voice.[2,3] A moderate vibrato rate and extent are also important for professional singers, and a balance in rate and extent has been identified as important to vocal beauty.[2,4] Diaz and Rothman[14] concluded that extent was an important aspect of vibrato, one that was reflective of overall vocal quality. They suggested that periodicity of vibrato, or the regularity of the modulation, was also among the most significant indicators of vocal beauty. Although much has been learned about the contributions of vibrato rate, extent, and periodicity to the overall performance and beauty of singing, much remains to be discovered, including the effects of emotional expression on these measures of vibrato.

Natural versus simulated emotion

The role of emotions in the human experience has been investigated extensively. It has been suggested that the primary purpose of emotional reaction in any species is to either protect an organism from impending threats (negative valence emotions linked to fight or flight), or to increase the chances of both short and long-term survival of the species (positive valence responses linked to food or mating).[15] Researchers differ in their views as to whether specific emotions such as anger, fear, joy, or surprise have their own autonomic hallmarks, or whether emotional arousal is less finely differentiated at a physiologic level. Kreibig's thorough review of the data from 134 studies suggests that the body's autonomic response tends to be specific for a given emotion.[16]

In theater, the ability to assume the role of a character while convincingly portraying emotion is a vital skill. An actor is both himself and a fictional character at once. This duality of an actor on stage is an essential element of theater. An actor makes what is artificial seem genuine, and evokes an emotion in the audience that is not necessarily felt by the actor, but by the character. The skilled simulation or feigning of emotion can be sufficient to invoke autonomic responses in a theatrical or operatic audience. Baltes, Avram, Miclea, and Miu[17] found that experiencing music through listening, watching, and learning the plot of an opera led to physiologic changes in a viewer. It has been suggested that emotional responses to music may be linked to the mirror neuron system, which activates a subset of motor neurons when an action is observed, in much the same way those neurons would be active in actually performing a task. In the case of an artistic expression, an audience member experiences an emotion that is evoked not by the listener's direct experience of an event, but by a potentially innate capacity, mediated by mirror neurons, to respond emotionally to a musical performance.[18]

Given the capacity of musical performance to arouse an affective response in the listener, it could be speculated that certain acoustic features might characterize singing that is more rather than less emotional. This reasoning has led to a number of studies of the connection between emotion and the physiology of human phonation.

Emotion and the voice

During his early research on vibrato, Seashore briefly addressed emotion as a contributor to vibrato characteristics. At that time it was suggested that vibrato had been found throughout the ages in many cultures, and that it occurred during emotional singing, or singing with feeling. Although Seashore[1] suggested an emotional contribution to the emergence of vibrato, there was no clear evidence at the time that emotion had a direct effect on the characteristics of vibrato.

The respiratory system is the energy source for phonation, and because it is under autonomic and volitional control, it is reasonable to anticipate that emotional arousal may influence its activity, which in turn may have an impact on the voice. Foulds-Elliott and collaborators[19] asked professional opera singers to sing in two ways. One involved technical singing, as the artist might use during warm-up or rehearsal, and the other was emotionally connected singing, or the type of singing that meaningfully communicates with an audience during a performance. The key respiratory difference was that the emotionally connected singing involved initiating phonation at a higher lung volume level and using more air. An examination of sound pressure levels showed that the dynamic range was greater in the emotional singing and more uniformly loud in the technical condition. The authors speculated that performers may rely on autonomic nervous system activation to allow a convincing performance, in much that same way that a photographer elicits a more natural smile from a subject by telling a joke than by asking for a smile.[19]

The work of Klaus Scherer in the study of emotion in communication has been extensive. He succinctly summed up the rationale for using acoustics to understand the mechanisms of emotional expression: "If it is demonstrated that emotion can be correctly diagnosed from the voice, then clearly the emotions must differentially affect the vocalization mechanism and, in consequence, yield demonstrable differences in acoustic patterning of the resulting sound waves" (p.236–237).[20] He acknowledged the ethical challenges associated with invoking true emotions in a laboratory, and noted that in most research into the acoustic features of individual emotions, actors have supplied the samples, raising the concern that the results may not reflect the features of a truly emotional experience. In discussing singing, Scherer noted that strong emotional involvement appears necessary for a successful performance, but that we cannot be sure whether these emotions were actually felt as opposed to skillfully feigned.[20]

The autonomic nervous system has been suggested as potentially responsible for functional voice disorders, where no organic pathology can explain the dysphonia. This reasoning led to a study of laryngeal muscle activation during a task known to invoke an autonomic response. Helou et al[21] had their volunteers immerse a hand in ice water, and compared the activity levels of several intrinsic laryngeal muscles to cardiovascular indexes of autonomic activity. Along with the anticipated increases in heart rate and blood pressure, activation of vocal fold adductors, abductors, and tensors was observed, which lasted beyond the return to baseline of the cardiovascular measures after the ice water task was over. The authors concluded that the larynx is sensitive to autonomic nervous system activation, which in the present study may imply that vibrato characteristics could be affected by emotion.