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The Effect of Tongue Position on Spectra in Singing

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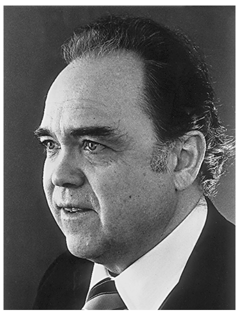
Richard Miller


Harm Kornelis Schutte

For every kind of beasts, and of birds, and of serpents, and of things in the sea, is tamed, and hath been tamed of mankind.

But the tongue can no man tame: it is an unruly evil, full of deadly poison. (James 3:7,8)

Although St. James's charge against the tongue was leveled on the moral plane, James has earned hagiolatrous appreciation from succeeding generations of singers and teachers of singing who must deal physically with that "unruly evil" during singing.

Attached to the hyoid bone, the tongue extends forward to the lips, thus occupying nearly the entire vocal tract. The tongue is the most important of the articulators, and by the shape it assumes and the space it occupies in the resonator tube, it helps to determine the acoustic and phonetic aspects of any phonatory event (Kantner and West 1960).

The tongue may be hypothetically divided into several regions (see Figure 1 [next page]). The tip (foremost edge) of the dorsum (the upper surface of the tongue) is nearest the front teeth; the blade, or front part of the tongue (the tip included) is located below the upper alveolar ridge; the front area of the dorsum lies beneath the hard palate, the back area beneath the soft palate; the root of the tongue (the most posterior area) is fastened to the hyoid bone, to the soft palate, and to the pharynx (Daniloff 1973). The undersurface of the tongue is connected to the mandible. The tongue is free anteriorly, laterally, and dorsally (Zemlin 1968).

Hardcastle (1976) identifies seven articulatory parameters for the specification of tongue movement and tongue configuration during phonation: 1) horizontal, and 2) vertical movements of the body of the tongue; 3) horizontal, and 4) vertical movements of the tip-blade of the tongue; 5) convex-concave configurations of the tongue body in relation to the palate; 6) central grooving throughout the entire length of the tongue; 7) spreading or tapering of the dorsum of the tongue.

According to Malmberg (1963), articulation may be classified with regard to the extent of tongue engagement at the teeth (dental), at the gum ridge (alveolar), at the front of the hard palate (pre-palatal), at the highest part of the palate (medio-palatal), at the junction of hard and soft palates (post-palatal), and at the uvula (velar).

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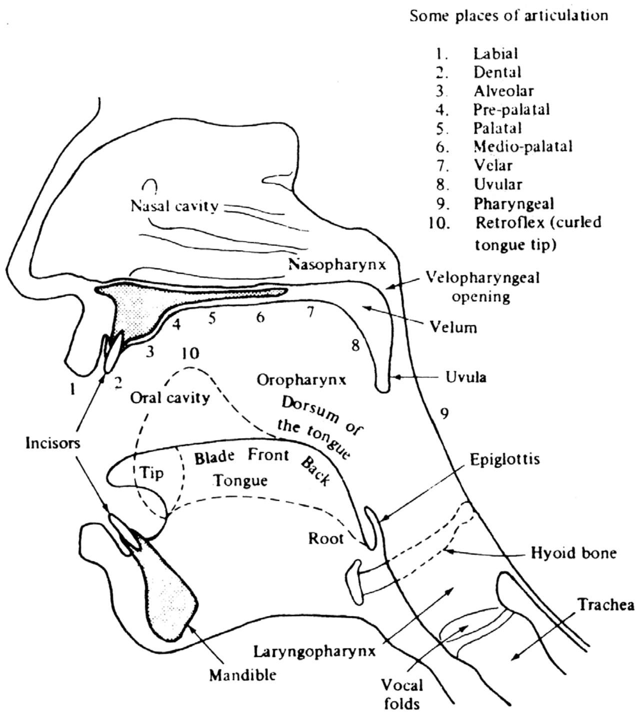

Figure 1. A schematic view of the articulators, vocal tract cavities, and places of articulation. From *Normal Aspects of Speech, Hearing, and Language* (1973), edited by Minifie, Hixon and Williams. Used by permission of Prentice-Hall, Englewood Cliffs, New Jersey.

The changing relationship of the buccal and pharyngeal resonators, necessary to vowel definition, is largely determined by the changing positions of the mobile tongue within the resonator tube. In the vowel [i], the elevated frontal tongue posture diminishes the volume of the mouth, thereby increasing pharyngeal volume. As a result, the high formants rise to more than 3000 Hz. (The regions of the spectrum in which frequency components are relatively large are known as formants [Ladefoged 1962].) Contrariwise, when the back of the tongue rises toward the velum, as in the vowel [u], the lower formant is characteristic, and pharyngeal volume is decreased and mouth volume increases. Ladefoged (1962) has illustrated this relationship of tongue posture both to vowel definition and to the spectral envelope (see Figure 2).

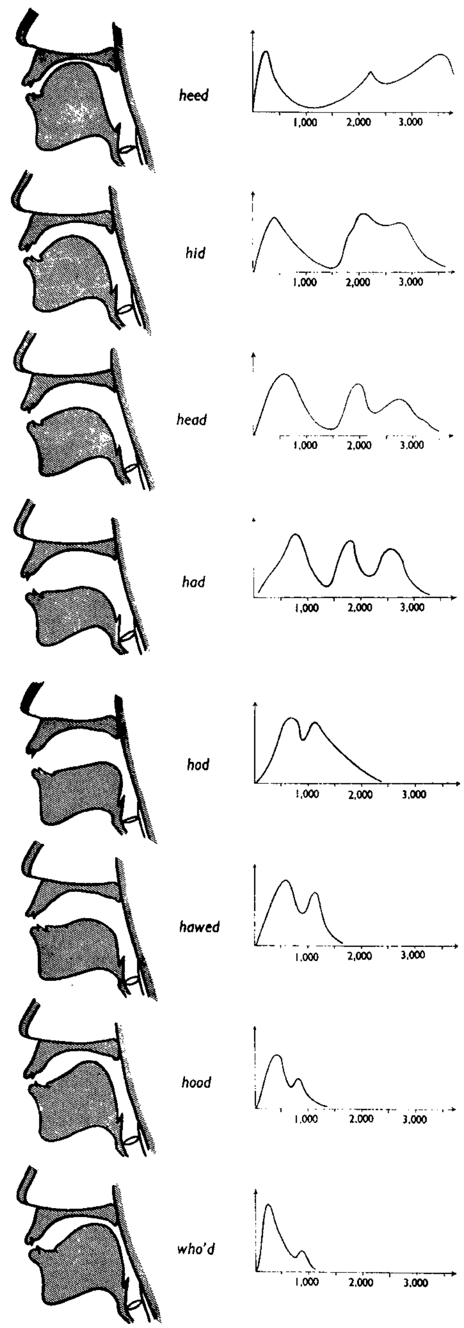

Figure 2. Based on data obtained from X-ray photographs of the vocal tract during phonation of various vowels. Reprinted from *Elements of Acoustic Phonetics* (1962), Peter Ladefoged, by permission of The University of Chicago Press. All rights reserved. Tenth Impression, 1974.

Laryngeally-generated sound may be distorted by improper tongue position in relation to vocal fold adjustment. For example, if the tongue assumes the position for [i] when the vowel [ɔ] is required, acoustical conflict and vowel distortion may occur. Elsewhere in the vocal tract, additional adjustment must be made to compensate acoustically for the "wrong" tongue position. This may result in a less effective formation of the

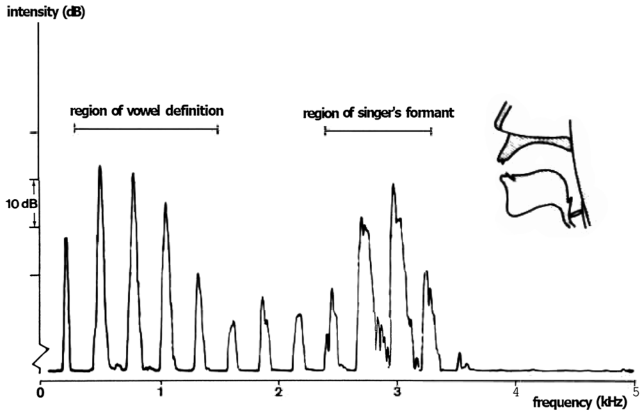

Figure 3. **The vowel [ɔ] (as in "hawed") sung at approximately 262 Hz (C_4), with proper tongue posture. The spectral envelope indicates desirable vowel definition and singer's formant. (Note the favorable balance in sound energy between the region of vowel definition and that of the singer's formant.)**

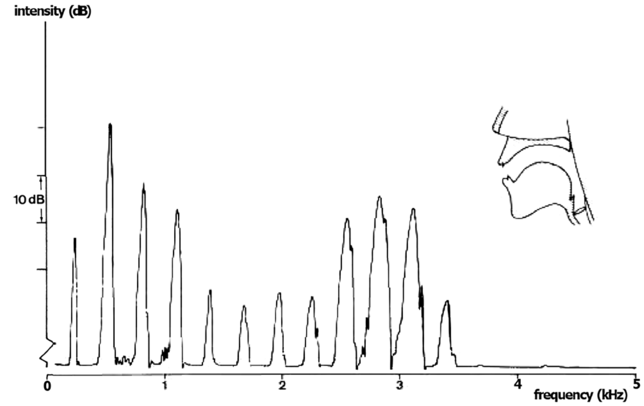

Figure 4. **The vowel [ɔ] (as in "hawed") sung at approximately 277 Hz ($C^{\#}_4$), with tongue below roots of the lower teeth and somewhat elevated in the middle. (Although the singer's formant remains intact, some vowel distortion occurs. A strong secondpartial is evident.)**

singer's formant, or in extraneous muscle tension, and may even exert influence on pitch accuracy. Any such adjustment violates efficient function, and demands additional effort at the level of the larynx.

During the production of a number of speech sounds (including all vowels and a number of consonants in most Western languages) the entire front portion of the tongue lies behind and in contact with the lower teeth, as in the posture for the neutral vowel [ə]. The dorsum of the tongue assumes varying degrees of flattening or of elevation, but the anterior rim of the tongue remains engaged with the lower teeth, as when one says *"um-hm!"*

Spectrograms may be used to indicate the influence of varying tongue positions on the character of vocal sound. Spectrograms in this study were obtained through the use of a Ubiquitous Spectrum Analyser, Type UA-6B (Federal Scientific). The nominal frequency resolution was chosen at 10 Hz. The microphone was positioned 30 cm from the singer's mouth. The designated tone was produced by the singer under normal (as opposed to nonechoic) acoustical conditions; a hold circuit was activated, and the spectrograms were recorded on an X-Y recording device.

Figure 3 indicates the spectral analysis of the vowel [ɔ] at approximately C_4 (262 Hz), sung by a professional tenor. The tongue is here located behind the lower teeth (just above the roots) inducing proper vocal-tract configuration generally considered essential to the vowel selected. In the spectrogram (Figure 3), the regions defining the vowel, and those which define the singer's formant ("the ring of the voice") are readily distinguished. Between these two regions the partials of the sung tone are damped out, for the most part, indicating that the tone is not open or spread, a factor that is significant for "good" singing timbre.

The same subject who recorded the spectrogram in Figure 3 also recorded three spectrograms at similar pitch level, vowel and intensity, with the tongue however in postures frequently considered to be vocal faults:

1. The tip of the tongue is positioned *below* the roots of the lower teeth (Figure 4).
2. The tip of the tongue is curled *backward* into the buccal cavity (Figure 5).
3. The tip of the tongue is positioned at the lower teeth, but humped *forward* in an exaggerated [i] position (Figure 6).

It may be seen that when the tongue position does not correspond to the position normally associated with the production of the vowel [ɔ], the spectral envelope is considerably altered, which leads to distortion of the vowel, and to deterioration of the singer's formant.

Although singing and speaking differ in significant ways, the phonetic aspects of both forms of phonation are in some ways remarkably similar in some ranges of the voice. The several undesirable tongue postures indicated in Figures 4, 5, and 6 are often encountered

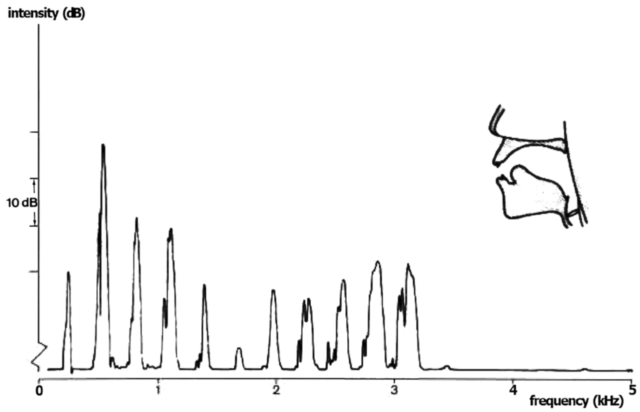

Figure 5. **The vowel [ɔ] (as in "hawed") sung at approximately 277 Hz ($C^{\#}_4$), with tongue curled backward into buccal cavity. In relation to the region of vowel definition, there is much less energy in the region of the singer's formant. The vowel distortion is about of the same degree as that found in Figure 4.**

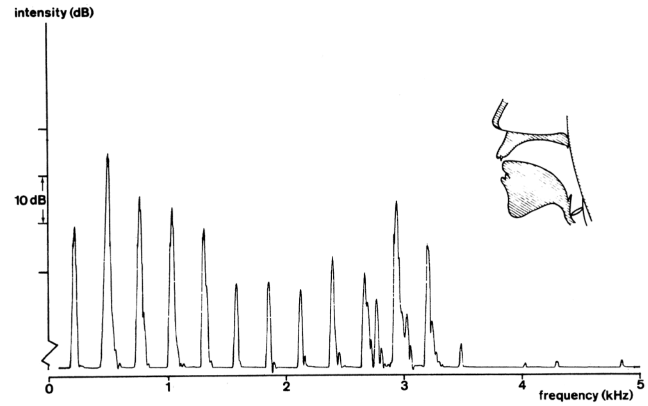

Figure 6. **The vowel [ɔ] (as in "hawed") sung at approximately 262 Hz (C_4), with tongue humped forward, the tip positioned at the lower teeth ridge. (Partials located between the region of vowel definition and the region of the singer's formant are undesirably high.)**

during singing, and they require pedagogical attention and the application of corrective vocalises. Singers often assume a variety of tongue positions in response to requests to "open the throat," "relax the jaw," "drop the jaw," or, "make space in the throat"; such requests may inadvertently cause violation of phonetic function. Tongue positions inappropriate to specific phonemes are frequently the result of tension and of inefficient vocal techniques.

A useful pedagogical tool for achieving proper tongue position for the execution of all vowel sounds can be found in those consonants which bring the tongue into contact with the lower teeth. The continuant [v], in which the upper incisors meet the bottom lip, and the tongue contacts the lower teeth, and its voiceless counterpart [f], as well as the neighboring continuant [z] and its voiceless paired consonant [s], strongly recall the phonetic "at-rest" position (which includes the neutral phonetic posture of the tongue). Certain modifications of the neutral phonetic position must occur in order to achieve the physiological postures essential to the production of these phonemes: 1) slight mandibular adjustment, 2) approximation of the vocal folds during the pitch consonants, 3) contact between the upper incisors and the lower lip, and 4) (in all probability) nearly complete closure of the nasopharyngeal port. However, it is significant in singing that during the execution of [v] and [z], and of their voiceless counterparts [f] and [s], the tongue need move scarcely at all from its neutral "at-rest" posture. These sounds require no change in tongue posture within the vocal tract throughout the course of their execution within a single expiratory gesture. Although the vowel may be changed at will, the point of the tongue should remain in contact with the teeth when prefaced by these consonants.

When an incorrect tongue posture occurs (as shown in Figures 4, 5, and 6), the student should be instructed to observe in a mirror the precise position of the tongue. When coupled with the consonants [v, f, b, p, z, and s], any vowel may maintain the same tongue-teeth contact throughout its execution. A familiar pitch-pattern, such as 5-4-3-2-1, in any comfortable key, may serve as an appropriate vocalise for observing tongue action. When the tongue has been trained to remain at the teeth, the vowel may then be sung without the prefacing consonant, constant contact being retained between the tongue and the teeth.

It is clear that unless the tongue occupies the proper position in the vocal tract, vowel distortion, tongue tension, and an imbalance of resonance must result. In this study, the differences representing the vowel [ɔ] in a singing voice using several tongue positions were investigated through the use of spectrograms. Results suggest that unless the "unruly" tongue can be properly schooled, inefficient acoustical filtering of the vocal tract can be anticipated in the singing voice.

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Richard Miller, Professor of Singing, Oberlin College Conservatory of Music, Editor of *The NATS Bulletin,* has performed extensively in opera, oratorio, and recital. A frequent teacher of master classes in Europe and America, Miller is author of *English, French, German and Italian Techniques of Singing.*

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ANNIVERSARY FACTOID

On April 29, 1945, the California–Western Region held an audition for students of singing "for the purpose of grading and evaluating the artistry, personality, musicianship, and career potentialities"—81 students participated in our first student auditions.