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Lecture-Recital Monograph Final

**Acoustic Pedagogy: An Exploration and Application in the Voice Studio**

This project is intended to serve three purposes: (1) To review basic concepts of voice acoustics as they pertain to the singing voice, (2) to cultivate critical listening skills by exploring sounds in the VoceVista Video[[1]](#footnote-1) and Madde Voice Synthesizer[[2]](#footnote-2) software, and (3) to gather together and present a survey of the current research regarding voice acoustics and acoustic pedagogy.

Review of Voice Acoustics and Harmonics

For many years we have known about the relationship between the vocal tract and its role as the resonator of the singing voice. We know that the vocal tract, or the space that exists between the glottis of the vocal folds and the mouth or nostrils, has “pitch,” and that its pitch exists separately from the fundamental frequency that one sings.[[3]](#footnote-3) We can demonstrate this by whispering our cardinal vowels [i e a o u] and noticing that our perception of the pitch moves from higher to lower, respectively.[[4]](#footnote-4) We can also demonstrate this by flicking the side of the thyroid cartilage while the glottis is closed, creating a lower pitch on [i] and [u] and a higher pitch as the vowel opens towards [a].[[5]](#footnote-5) In both instances the vocal folds do not vibrate, but rather the air inside the vocal tract is being excited and resonated according to its shape. This phenomenon exists because the vocal tract is a quarter-wave resonator.[[6]](#footnote-6) In acoustic pedagogy, the pitches of the vocal tract are labeled as “vowel resonance frequencies” (fRx, x=number of the vowel resonance frequency). The vowel we are attempting to sing changes the shape of the vocal tract and therefore changes the location of fRx. Later, we will discuss how the vowel resonance frequencies of the vocal tract interact with the pitch we are attempting to sing.

Harmonics exist naturally above the fundamental frequency (1F0). We can calculate the frequencies of these harmonics by multiplying 1F0 (measured in Hertz/Hz) by whole integer numbers. For example:

*A4 normally equals 440Hz (1F0=440), which in terms of singing means that the vocal folds are coming into contact 440 times a second. We can calculate the second harmonic (2F0) by multiplying 440 by 2.*

*2F0=880Hz, 3F0=1320Hz, 4F0=1760Hz, etc.*

The terminology regarding labeling harmonics varies across texts. For the sake of this project, I will refer to the fundamental frequency as “1F0,” and any harmonic above as “xF0,” with “x” equaling the number of the harmonic. Harmonics exist at predictable musical intervals above the fundamental frequency. 2F0 exists at an octave above the fundamental frequency, 3F0 exists a perfect fifth above 2F0, 4F0 exists a perfect fourth above 3F0, 5F0 exists a major third above 4F0, 6F0 exists at a minor third above 5F0, and the pattern continues with intervals becoming successively smaller. For the sake of acoustic pedagogy, we must remember only a portion of the pattern, perhaps up to 5F0. It is rare that we find interaction between higher harmonics and the meaningful vowel resonance frequency locations (fR1 and fR2), except for when producing extremely low pitches.[[7]](#footnote-7) As singers, we can change the location of the harmonics (i.e. change pitch) without changing the location vowel resonance frequencies (i.e. without changing vowel or shape), and vice-versa.

Modes of Phonation

We must remember that the vocal tract does not produce sound. Its main function in the singing voice is to resonate and amplify the harmonics that are fed into it by the vibrating vocal folds. In this respect, when examining voice acoustic pedagogy, we should look first at how phonation affects the acoustic signal.

As a general principle, harmonics tend to lose power, measured in decibels/dBs, as they ascend.[[8]](#footnote-8) Even after resonation in the vocal tract, one could observe (using a spectrogram analysis program such as VoceVista Video) that harmonics weaken as they ascend. Without analysis software, one could still describe the quality of a singing voice. We can observe the differences in these sounds by looking at the spectrogram of the voice-in-question using acoustical analysis software such as VoceVista Video. We will observe three general modes of phonation: “breathy, pressed, or balanced.”

Breathy Phonation

In breathy phonation, we notice a moderate/strong fundamental frequency and a steep roll off in harmonics.[[9]](#footnote-9) This results in weaker high harmonics and therefore a softer sound. Some may say that this quality of voice lacks “warmth.” However, this phonation modes still presents warmth due to its moderately strong 1F0. The result of weaker high harmonics is less vowel clarity, due to the absence of strong harmonics in the range of the second vowel resonance frequency.

Pressed Phonation

Pressed phonation could be described as “strident, metallic, or abrasive.” In the spectrogram, we notice a moderately strong 1F0. However, higher harmonics are significantly boosted, resulting in a brighter quality.[[10]](#footnote-10) This is a result of hyperfunction of the adductory muscles in the larynx. A teacher might benefit from utilizing semi-occluded vocal tract exercises to encourage a more balanced phonation.

Balanced Phonation

In an ideal Western classical singing style, we desire a balanced mode of phonation. This mode features a strong 1F­0 and a consistent roll off in harmonic strength, about 12dBs per octave.[[11]](#footnote-11) Because of this, we find ample strong harmonics that can be resonated by the vocal tract, resulting in a sound that is “warm” and “clear.”

Registration

We can also observe how the roll off in harmonic strength is affected by registration. The thyroarytenoid (TA) muscle is primarily responsible for determining which vocal register we are singing in. The vocal folds thicken as the TA contracts, resulting in a “chestier” sound. The opposite is also true; as the TA releases the sound becomes “headier” in quality. Both actions (contracting/releasing of the TA muscle) have a corresponding impact on the spectral slope.

A thicker vocal fold configuration (“chest” voice) has a greater vertical phase difference and requires a stronger subglottal breath pressure to achieve a balanced mode of phonation. The result is a boost in strength of higher harmonics, and a “brass-like” sound, for instance.[[12]](#footnote-12)

A thinner vocal fold configuration (“head” voice) results in less vocal fold mass coming into contact during the vibratory cycle which leads to subtler changes in air pressure. Because of this, higher harmonics tend to lose strength earlier in the spectrum, resulting in “flute-like” sound quality, for example.[[13]](#footnote-13)

It would be well to mention here the effect of “louder” or “softer” singing on the spectral slope. In order to sing “louder,” the singer increases subglottal pressure, which requires more glottal resistance to maintain balanced phonation. This results in a greater range of motion for the vocal folds (higher amplitude) when they separate and a higher velocity when the mass of the folds comes back together (a more drastic change in air pressure). There is a larger closed quotient during the vibratory cycle, or a larger amount of time that the vocal folds are in contact during one cycle. Higher harmonics gain a boost in strength, and the perceived singing voice is “louder.”[[14]](#footnote-14)

Takeaway – Modes of Phonation and Registration

For the purposes of acoustic pedagogy, as it pertains to Western classical singing, we require a “clean” signal from the vocal folds. That is, we need a balanced mode of phonation and a balance between “head” and “chest” registers. It should be noted here as well that registration and the modes of phonation are not mutually exclusive, as we have all heard breathy chest singing and strident head voice sounds. The “ideal” for Western classical singing is not a new phenomenon. Singing teachers have sought this from their students for many years. However, the study of voice acoustics provides new ways to objectively critique the sounds we hear. In addition, as more transgender singers feel empowered to enter the voice studio, this new terminology provides an avenue for a non-gendered approach to talking about the singing voice.[[15]](#footnote-15)

Review – Principle of Vocal Tract Resonance

In general, vowel resonance frequencies boost the strength of harmonics that fall under their influence. Once the vocal folds create an acoustic signal, that signal travels into the vocal tract and the harmonics in that sound gain either a boost or attenuation depending on the shapes present inside the vocal tract. Similarly, when we blow across the opening of a glass bottle, a pitch is produced according to the shape and volume of free air left in the bottle. Because the shape of the bottle is fixed, has hard surfaces, and only a single, narrow opening, there is only one frequency that can be produced. In the vocal tract, we have a seemingly infinite amount of shapes and volumes possible.[[16]](#footnote-16) The surfaces of the tract are made of flesh and can resonate wider bands of frequencies than that of a hard glass bottle.[[17]](#footnote-17) Finally, the vocal tract narrows and opens many times before air exits the mouth and/or nose. We can think of several “bottles” inside the vocal tract selectively boosting harmonics all at once, and thankfully this means we can produce and resonate a multitude of frequencies (harmonics) at the same time. This is how singers can communicate using many vowels and singing colors. It is an immensely complex system, but recent voice acousticians have done their best to simplify this information in a way that voice pedagogues can understand and use to their advantage in the studio.

“Vowel Resonance Frequency” vs. “Vowel Formant”

A “vowel resonance frequency” is a frequency range that will boost any harmonic(s) that falls within its influence. Until recently, much of the popular voice pedagogy literature has supported the term “vowel formant” as the basic term for describing an acoustical peak of energy on a spectrogram.[[18]](#footnote-18) This information is not incorrect, as one should feel free to use the term “fomant” to describe the acoustical energy peaks on a spectrogram once the singing has already happened. However, a problem exists because many authors have chosen to use the term “vowel formant” when describing the potential of the singing voice. This use of the term “vowel formant” when describing sounds that have yet to exist creates a bias towards lower-pitched voices. Because the production of lower fundamental frequencies (i.e. lower pitches) have a greater number of harmonics that are low enough to be resonated by the vocal tract, peaks of acoustical energy on the spectrogram tend to line up with the location of vowel resonance frequencies. This is fine for tenors, baritones, and basses, however, for treble voices singing high fundamental frequencies, the discrepancy between vowel resonance frequency and vowel formant becomes more pronounced. At higher pitches, the harmonics of said pitches are few and far apart. It is imperative that the singer adjust their vowel resonance frequencies to resonate harmonics because one cannot change the note that is written in a musical score. If the singer does not adjust their fRx, the resulting spectrogram will still display acoustical peaks of energy. However, any singing teacher could hear that the singing voice is not operating efficiently or producing a sound conducive to Western classical singing.

This project aims to challenge the bias against higher voices that exists by using “vowel resonance frequency” instead of “vowel formant.” I acknowledge that this is an ongoing conversation and terminology will undoubtedly continue to evolve.

Roles of Vowel Resonance Frequencies – fR1 and fR2

It has come to be understood that the vowels we perceive are created by the locations of fR1 and fR2.[[19]](#footnote-19) fR3 through fR5 cluster together to produce the “singer’s formant cluster” when favorable conditions exist in the vocal tract.[[20]](#footnote-20) Vowel resonance frequencies above fR5 rarely contribute to a Western classical singing style.[[21]](#footnote-21)

The term *chiaroscuro* describes an ideal quality of sound in Western music when the voice possesses both “warm” and “clear” timbres at the same time. While the resulting sound is heard as homogenous, these sounds can be analyzed separately by understanding how fR1 and fR2 contribute in the sound spectrum. In the voice acoustic literature by Kenneth Bozeman, he attributes the “warm” part of the sound to fR1 and the “clear” part of the sound to fR2.

First Vowel Resonance – fR1

The first vowel resonance contributes primarily to the depth of the timbre, i.e. “warmth, *oscuro.*” For most singers, their set of fR1 locations has the potential to exist approximately between D4 (~300Hz) and G5 (~800Hz).[[22]](#footnote-22) This is true for all matured voices, regardless of gender, sex, or Fach. For memory purposes, we can notice that these pitches all lie on the treble staff.

A singer’s fR1 locations fall within an octave, with [i] and [u] having the lowest fR1 and [a] having the highest fR1. The set of fR1 locations can move up or down, depending generally on the length of the vocal tract. A longer vocal tract will have lower fR1 locations and a shorter vocal tract will have a higher set of fR1 locations.[[23]](#footnote-23)

fR1 also contributes to the “open-close dimension” of the vowel we are singing.[[24]](#footnote-24) We know this because close vowels [i] and [u] have the lowest fR1 and the open vowel [a] has the highest fR1. fR1 raises as vowels modify from close to open. Because we know that fR1 of the vowel [a] exists at the top of the treble staff and that soprano and mezzos are often asked to sing above said staff, we can imagine that [a] is a favorable vowel when singing above the treble staff because of its ability to resonate higher 1F0. When singing below the treble staff, we can similarly understand the benefits of singing [i]/[u] because of their low fR1 locations.

Another way to understand fR1 as a contributor to timbral depth is to once again look at musical intervals between harmonics. 1-5F0 exist at consonant intervals (the interval between 4F0 and 5F0 is a major third). Because those frequencies exist lower in the sound spectrum, they have a better opportunity to be amplified by fR1. This results in a “purer” perceived timbre. Later in this discussion, we will discover that the intervals above 5F0 become increasingly more dissonant, resulting in a “buzzier” component in the sound.

We would do well to remember that the locations of fR1 in a voice are not dependent on the vocal range of the singer nor do they determine the comfortable tessitura. It is because of this that we have different timbres as singers. A recording of Joan Sutherland singing coloratura, with a rather long vocal tract and therefore a lower set of fR1, will sound much “darker” than a recording of Beverly Sills singing the same repertoire. When looking at the approximate locations of fR1 for each voice type, we notice that the tenor and the mezzo have similar fR1 locations.[[25]](#footnote-25) The locations of fR1 within a given voice do not directly determine its “Fach,” but could be helpful in the classification process.

Second Vowel Resonance – fR2

The second vowel resonance contributes primarily to vowel clarity. The locations of fR2 for each vowel exist above the treble staff, approximately between G5 (~800Hz - for [u]) and D7 (~2,350Hz - for [i]).[[26]](#footnote-26) We notice that fR2 rises as we move across the vowel spectrum from [u] to [a] to [i]. fR2 varies across all sung vowels. It is because of this that we can attribute fR2 to the “front-back dimension” of the vowel.

Singer’s Formant Cluster – “Singer’s *Resonance* Cluster?”

The singer’s formant cluster (SFC) is an acoustical phenomenon that results from the clustering of the third, fourth, and fifth vowel resonances. This phenomenon results from singing with a low larynx, open throat, and narrowed epilaryngeal sphincter. Research shows an ideal ratio of 1:6 between the size of the epilaryngeal exit and the size of the pharynx to achieve a clustering of fR3-5.[[27]](#footnote-27)

For years, audiences have perceived this as a voice having “ring” or “ping.” Indeed, many professional singers in the Western classical tradition seek this quality in their sound because of its ability to allow the voice to “cut” through an orchestra without electronic amplification. With amplification, as would be present on Broadway or in CCM (Contemporary Commercial Music) singing styles, the presence of the SFC becomes less important. The SFC also becomes less of a contributor for sopranos who are already producing an extremely high 1F0.[[28]](#footnote-28)

The location of the SFC is once again dependent on the physiology of the vocal tract, but it exists approximately between 2,400-3,200Hz, located in the highest octave of a piano.[[29]](#footnote-29) One could think of the SFC as contributing a hyper-bright [i] sound because it exists higher than the fR2 location of [i]. Because the SFC exists higher in the sound spectrum, one needs strong enough harmonics within that range for those harmonics to receive amplification. Again, these higher harmonics gain power when the singer has a balanced mode of phonation and a balance between laryngeal registers.

Absolute Spectral Tone Color – ASTC

Recent research by Ian Howell introduces a new concept to voice acoustics called “absolute spectral tone color.” Howell defines ASTC as “Any two or more simple sounds (e.g. a sine wave, single harmonic of a complex tone) of identical frequency, regardless of their sources, will produce an identical tone color percept independent of other spectral fluctuations considered aspects of timbre. If these simple sounds are located within a complex sound, their inherent absolute spectral tone color is never lost or changed, only expressed or masked. These tone colors may be placed on a continuum, and bear a meaningful similarity to several vowels.”[[30]](#footnote-30)

Howell’s research provides another means of understanding the roles of vowel resonances. According to Howell, any simple sound below C#5 has a perceived [u] quality. The perceived vowel changes as the frequency ascends, moving through the vowel spectrum from [u] to [a] to [i]. The following chart is property of Ian Howell.[[31]](#footnote-31)

A screenshot of a cell phone

Description automatically generated

Using ASTC, we can conceive that fR1 contributes to the “warmth” of the singing voice because it amplifies frequencies in the [u] to [o] range of the spectrum.[[32]](#footnote-32) We can also conceive that fR2 contributes to vowel clarity because its location lies above G5 where the perceived vowel quality changes at smaller, more frequent intervals.[[33]](#footnote-33) Finally, ASTC places the location of the SFC in the [i] to bright [i] range, contributing to the cutting ring of an operatic voice.[[34]](#footnote-34) The implications of Howell’s research are already seen in the voice acoustics community. Kenneth Bozeman adopted this research into his recent literature,[[35]](#footnote-35) including writing an article on how ASTC can be used in kinesthetic voice pedagogy.

Tuning the Vowel Resonances

After previously exploring the interactions between harmonics and vowel resonance frequencies, we can now explore how one may adjust the location of the vowel resonance frequencies to aid in the efficiency of singing. In the tradition of Western classical singing, the fundamental frequency and its resulting harmonics (the “pitch) are dictated for the singer by the composer. The singer should not change what is in the score, nor is it possible to change the frequencies of harmonics unless you change pitch. However, one can change the location of their vowel resonance frequencies by shaping the vocal tract in several ways.

We discussed earlier how the entire set of fR1 locations, located within an octave for any voice, can move up or down depending on whether one’s vocal tract is shorter or longer, respectively. Baritones and sopranos often produce frequencies that are more than an octave apart, but their fR1 location for [u] may only be a minor third apart.[[36]](#footnote-36) We can adjust the length of the vocal tract in order to better resonate a harmonic or several harmonics. Common ways to adjust vocal tract length are raising/lowering the larynx or by spreading/protruding the corners of the lips. The body does this naturally when we want to yell, as the larynx rises while the corners of the mouth spread.[[37]](#footnote-37) We must keep in mind for Western classical singing, however, that adjusting vocal tract length affects the entire set of vowel resonance frequency locations. Therefore, Western classical singing advocates for a comfortably low larynx, as this promotes an even timbre as well as the presence of the singer’s formant cluster.[[38]](#footnote-38)

Another way to raise or lower fR1 is to open or close the vowel we are singing, respectively, as we discussed earlier that open vowels such as [a] have a higher fR1. This technique of active vowel modification is hardly new to voice pedagogy, and historic pedagogy suggests one must be careful when adjusting vowels in order to maintain intelligibility on stage.[[39]](#footnote-39)

Acoustic Registers – Kenneth Bozeman

Kenneth Bozeman introduced the concept of acoustic registers to acoustic pedagogy. An acoustic register is a segment of the singing range in which tones are of a similar quality and are produced using the same mechanism.[[40]](#footnote-40) However, the “mechanism” in this definition refers to an acoustical mechanism, not a laryngeal mechanism.

Stated simply, the acoustic register that one is singing is determined by the number of harmonics located at and/or below fR1.[[41]](#footnote-41) There is an audible event that occurs when a harmonic passes through fR1. This event happens when a singer changes pitch while maintaining the intended vowel shape. In Bozeman’s texts, the timbre closes when a harmonic ascends through fR1 and opens when a harmonic descends through fR1.[[42]](#footnote-42) According to Bozeman, three acoustic registers exist: open timbre, close timbre, and whoop timbre.

Open Timbre – *Voce aperta*

Open timbre exists anytime there are two or more harmonics located below fR1.[[43]](#footnote-43) If we remember the pattern of the musical intervals between harmonics, we will remember that an octave exists between 1F0 and 2F0. If we know where fR1 is located, likely on the treble staff, we can assume that any pitch located at least an octave below fR1 will be in open timbre. As more harmonics pass descend below fR1, the timbre becomes more “open.”[[44]](#footnote-44)

For tenors, baritones, basses, and contraltos this suggests the existence of additional “transition” points below the first and second *passaggi* (*passaggii* are laryngeal registration events). Of course, these transition locations are an acoustical event and not a laryngeal event, but nonetheless require the singer to maneuver changes in singing sensations in order to navigate.[[45]](#footnote-45) Again, memorizing the pattern of harmonics will aid in locating these acoustic register transition points.

Close Timbre – *Voce chiusa*

A singer is in close timbre anytime there is only one harmonic (1F0) below fR1.[[46]](#footnote-46) If we know that any pitch that is at least an octave below fR1 is in open timbre, then we can assume that starting at the octave below fR1 the voice will be in close timbre until 1F0 approaches fR1. Again, this timbre is achieved by the singer allowing the pitch to rise without modifying the space inside the vocal tract. In Western classical pedagogy traditions, this transition from open to close timbre has often been described as “covering” or “turning” the vowel.[[47]](#footnote-47)

The location where the voice moves from open to close timbre depends on the intended sung vowel, which will affect the location of fR1. For tenors, baritones, and basses, the voice will likely remain in open timbre when singing open vowels in the middle voice (below the second passaggio, depending on the vowel). However, closed vowels such as [i] and [u] will already be in close timbre in this same range because of their low fR1 locations. For sopranos and mezzos singing on the treble staff, vowels will already be in close timbre. This close timbre tracks until 1F0 rises and meets fR1, above which the singer is required to actively modify their vowel in order to raise fR1 and track whoop timbre.

Whoop Timbre

Whoop timbre exists when 1F0 (the intended singing pitch) is equal to and is being resonated by fR1.[[48]](#footnote-48) The vocal quality in this register is indeed quite powerful, aptly named for its use to cut through a roaring crowd at a sporting event, or its use to project oneself over an orchestra.

For sopranos and mezzos singing above the treble staff, the tracking of 1F0 by fR1 is essential for a well-balanced sound. If one were to allow the pitch to continue ascending above fR1, without modifying the vowel to raise fR1, the resulting sound would be weak in power and hard to hear. In general, the raising of fR1 can be achieved by modifying to a more open vowel or opening the vertical space inside the mouth.[[49]](#footnote-49) For extremely high pitches in the soprano range (B6 and above), one even needs to allow the larynx to subtly rise in order to shorten the vocal tract and raise fR1.[[50]](#footnote-50)

Kenneth Bozeman – Active Vowel Modification vs. Passive Vowel Migration

With the concepts of acoustic registers, Bozeman also advocates for the differentiation between active vowel modification and passive vowel migration, and advocates knowing when to use each strategy.[[51]](#footnote-51) Both strategies produce a change in vowel quality, but that quality differs depending on which strategy is used. In general, Bozeman recommends using passive vowel migration up until 1F0 approaches fR1, after which the singer needs to utilize some active vowel modification in order to avoid or track whoop timbre.

Passive Vowel Migration

Passive vowel migration suggests a change in pitch without a change of shape in the vocal tract.[[52]](#footnote-52) Because the location of harmonic frequencies changes for every pitch, passive vowel migration suggests that the vowel color will migrate with every change in pitch, especially when a harmonic passes through fR1. This strategy of maintaining the vowel shape can be for all pitches up until the voice reaches whoop timbre, especially when the voice moves from open timbre to close timbre.

Bozeman suggests several methods to encourage passive vowel migration. The singer should allow migrations in sensation, vowel color, and timbre to occur when changing pitch. Passive vowel migration also requires that the singer find a dynamic means of maintaining vowel shape and vocal tract length (i.e. maintaining a comfortably low larynx and an elevated soft palate). He suggests using a sincere affect to motivate a stable vocal tract shape. Examples include feeling a warmness in the heart or maintaining a loving sigh. Teachers could create their own examples or devices that achieve this goal of passive vowel migration.[[53]](#footnote-53)

Active Vowel Modification

Active vowel modification involves a change in vowel shape, with or without a change in pitch. This deliberate change in vowel shape will result in a change in vowel timbre.[[54]](#footnote-54) Active vowel modification is necessary for tracking whoop timbre, but can also be used for avoiding whoop timbre by raising fR1 for tenors, baritones, and basses singing high on an [i] or [u] vowel.[[55]](#footnote-55) Active vowel modification is also important for tenors, baritones, and basses singing operatic high notes, and in the acoustic sensation of belting.[[56]](#footnote-56)

The method of active vowel modification usually involves some degree of vowel opening. For Western classical singing, we still want a stable tube length (comfortably low larynx) and we want it to appear as “natural” as possible. Active vowel modification can still retain some vowel clarity when singing high in pitch. Singers should aim to open the mouth first, followed by lowering the tongue dorsum once necessary. Bozeman suggests again using a sincere affect to motivate active vowel modification.[[57]](#footnote-57)

Closing Thoughts

The field of voice acoustics is rapidly growing. The newest edition of *Your Voice: An Inside View 3*, a popular voice pedagogy textbook by Scott McCoy, updated its second chapter to include a musician-friendly crash course in voice acoustics. A poll in the New Forum for Professional Voice Teachers Facebook Community asking members which topics they were most interested in when looking for posts and “Acoustics” received the 4th highest votes behind “Anatomy, Voice-types, and Motor Learning.” The New England Conservatory hosts a week-long workshop focusing on acoustic voice pedagogy. The workshop has been gaining interest and adding new features every year.

As the field of voice acoustics is growing, there is an accompanying increase in demand for women and nonbinary singers to get involved. Voice acoustics, as it pertains to the singing voice, first came from the work of voice scientists, who initially focused their research on the male speaking voice. This bias has followed the field of voice acoustics, and the field would greatly benefit from the insights of women and non-binary individuals.

More nonbinary and transgender singers are feeling empowered to begin studying voice. This is a fantastic development, and the voice community must be responsible for embracing singers of all backgrounds and genders. Because the terminology used in voice acoustics is not exclusive to gender or sex, I believe it offers potential to be used with nonbinary and transgender singers.

Finally, there is a common misconception that in order to help a student understand voice acoustics, a teacher is required to use technology excessively in the studio. While the occasional reference to VoceVista Video might help a student understand a concept faster, the use of technology should be viewed as any other tool for feedback, such as a mirror. All the topics in this project can be understood without the aid of technology. In fact, historic pedagogues documented different singing qualities and how to achieve them, even before recent analysis software was available. The study of voice acoustics should supplement our functional knowledge of the voice. Regarding the presence of technology in the voice studio, Bozeman writes, “the teacher that can’t teach a good voice lesson without it won’t be able to teach a good voice lesson with it.”[[58]](#footnote-58)

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1. Sygyt Sotware, (http://www.vocevista.com) [↑](#footnote-ref-1)
2. Tolvan Data, (http://www.tolvan.com/index.php?page=/madde/madde.php) [↑](#footnote-ref-2)
3. Kenneth Bozeman, *Practical Voice Acoustics*, (Hillsdale, NY: Pendragon Press, 2013), 9-10. [↑](#footnote-ref-3)
4. Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019), 68. [↑](#footnote-ref-4)
5. Ibid., 68. [↑](#footnote-ref-5)
6. Bozeman, *PVA*, 10. [↑](#footnote-ref-6)
7. Bozeman, *PVA*, 20. [↑](#footnote-ref-7)
8. McCoy, *Your Voice 3,* 43-44. [↑](#footnote-ref-8)
9. Bozeman, *PVA*, 6. [↑](#footnote-ref-9)
10. Ibid., 5-6. [↑](#footnote-ref-10)
11. Bozeman, *PVA*, 6. [↑](#footnote-ref-11)
12. Ibid., 6. [↑](#footnote-ref-12)
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