Mixed Up and Upside Down

Underdeveloped Registers in Men and Women Due to Vocal Trends in Popular Music: Turning Two Pedagogic Challenges into Opportunities in Today's Voice Studio

April Young

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INTRODUCTION

In 1967, William Vennard labeled falsetto the unused register for men and chest the unused register for women, and at that time, it was true.[1] Voice teachers, especially those with young or beginning students, can no longer have this expectation. Untrained singers often imitate two trends in contemporary commercial music (CCM) that shape some of the challenges these students bring into the voice studio; one trend is now familiar and the other comparatively recent. Trend one is demonstrated by female singers, who utilize primarily chest voice and carry this production higher than is generally acceptable in classical singing. They usually have not undergone training for high "belt," and rarely use head voice, which is often weak and has limited range. Trend two is demonstrated by male singers, who frequently utilize falsetto and less often use chest voice, which is commonly lacking in strength, scope, and coordination.

Definitions for registers have changed over time, as voice science and technology have progressed. For the purposes of this discussion, the following definition of physiological vocal registers will be used: "the muscular adjustment of the vocal folds; the relative participation of the thyroarytenoid (TA . . .) muscles and the cricothyroid (CT . . .) muscles."[2] TAD for Thyroarytenoid Dominance will refer to chest, mode 1, or heavy mechanism; CTD for Cricothyroid Dominance will refer to head, mode 2, or light mechanism. The word "dominance" is important, as otherwise there would be many registers; under this model there are not. The term "falsetto" will be used to designate the CTD mechanism in the male voice. Classical head voice, in the male singer, will be indicated as the "upper extension" of TAD. Register shifts that are not physiological will be specified as "acoustic registers."

Register transition occurs in the same general location on the frequency scale for men and women, with slight variations for voice types; however, men's and women's ranges are situated differently on either side of this transition. Some writers have used the terms "primary" or "natural," to label the register for each gender where most of the pitches in the range fall, without significant intervention. For the purposes of this exploration, the primary register for most men is TAD and the primary register for most women is CTD. The physiological register containing the least amount of notes will be referred to as "secondary," or "auxiliary." The aim of this investigation is to show that, even with students attempting to use a form of *voix mixte*

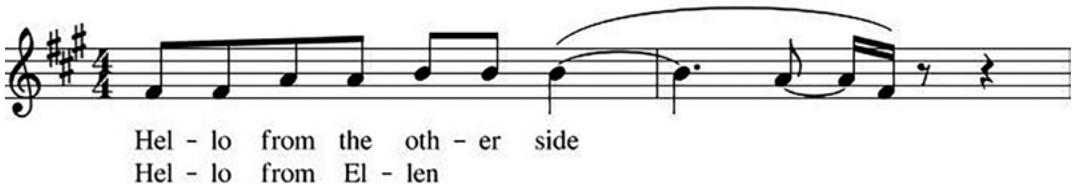

Figure 1. Musical phrase from the score by Greg Kurstin and Adele Adkins, "Hello" (N.p.: Universal Music, 2015), 3. (See permissions, page 151.)

and struggling with weakness in their primary registers, effective paths forward exist for remediation, and, additionally, that strengths from trends in popular music can be utilized successfully in voice training, regardless of repertoire direction.

Some teachers may wonder if responding to these two vocal trends in CCM styles is relevant to every voice instructor. Most teachers acknowledge that students are singing music in their everyday lives over which teachers have little control. Even if students bring a piece to a lesson, they do not always sing it in the style they would outside the studio.[3] Students rarely have the musical background necessary to select their own repertoire. Usually they sing songs in the same key as the artist (whether they are the same gender and voice type, or not). An awareness of what students are singing in their free time opens a window to see how this repertoire is impacting their technique.

THE VOCAL TRENDS

Women Trend Number One: Heavy Belting

It is not the purpose of this exploration to make judgments about popular singers, but to examine some possible results when students are imitating them. The training of the singers evaluated is unknown. The female artist selected to illustrate trend one is Adele, singing an adaptation of "Hello." The sample chosen is live, *a cappella*, and amplified with a lapel microphone, specifications unknown. The sound is characterized by strength, volume, and straight tone. Most teachers would identify the register as TAD. In this selection, the lyric is modified to "Hello from Ellen" and the second syllable of "Ellen" is the pitch that will be examined (Figure 1). The vowel [ɛ] is modified toward the [æ] shape, a more spread position. The singer's jaw is dropped, and her tongue is forward.

For acoustic analysis, the audio was shortened to avoid distortion from the vocal "push" that caused a jump in decibel level. The parameters for the spectrogram were adjusted to 6000 Hertz (Hz) and there was no significant harmonic presence above this level. The display reveals a flatter spectral slope with energy in the upper frequencies which is one indicator of TAD (Figure 2). Straight tone is suggested by the thin shape of the harmonic.[4] The fundamental frequency is B_4. As one would predict in belt production, the second harmonic (H2) is amplified and there is very little presence of the fundamental. As one could also expect, there are other harmonic boosts which temper TAD, so it isn't as coarse.[5] These boosts occur at H6 and H10; H10 is beyond the limits of the piano so its perceived tonal contribution is not as significant.[6]

The singer's dropped jaw would raise formant one (F1) (Figure 3). Her spread mouth position would raise F1 and F2 due to a shortened vocal tract. Her tongue constriction in the front would also raise F2. Energy in the frequencies above 4 kHz (kilohertz) indicates the possibility of either a raised larynx or pharyngeal narrowing.[7]

Men Trend Number Two: Frequent Use of Falsetto

The male artist selected to illustrate trend two is Sam Smith, singing "Too Good at Goodbyes." The sample is taken from an isolated live microphone feed, specifications unknown. The sound is characterized by lightness, flexibility, and straight tone. Most teachers would identify the register as CTD or male falsetto. The lyric is "And every time you walk out," and the syllable "walk" is the pitch that will be evaluated (Figure 4). The singer's jaw is moderately open, his mouth is slightly widened, and his tongue is slightly forward. The [ɔ] vowel is modified

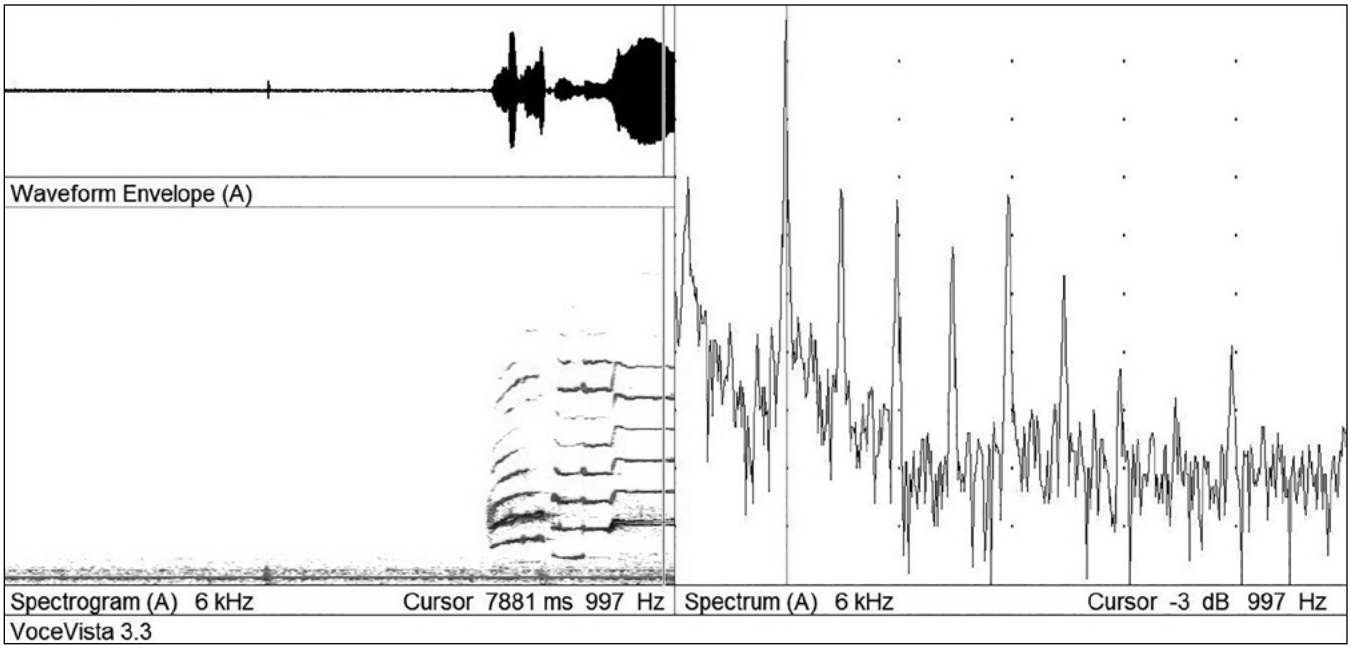

Figure 2. Acoustic analysis of Adele. Taken from video between 1:16 and 1:20, by Ellen DeGeneres, host, "Hello, It's Adele (on Ellen's Voicemail)" (video of interview), posted February 18, 2016; https://www.youtube.com/watch?v=QjHncnLpV5M (accessed January 5, 2018).

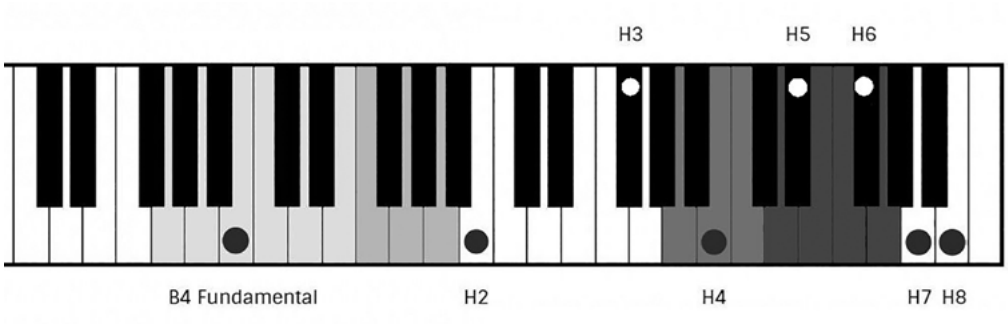

Figure 3. Harmonics for B_4 and formants for [ɛ] on a keyboard. Colors extend to the black notes. F1 is light grey, (F1 for the [æ] vowel is added in medium light grey), F2 is medium-dark grey and SF is dark grey. Data, for men and women, of all voice types, converted from graph by Johan Sundberg and Jörgen Skoog, "Dependence of Jaw Opening on Pitch and Vowel in Singers," *Journal of Voice* 11, no. 3 (September 1997): 302.

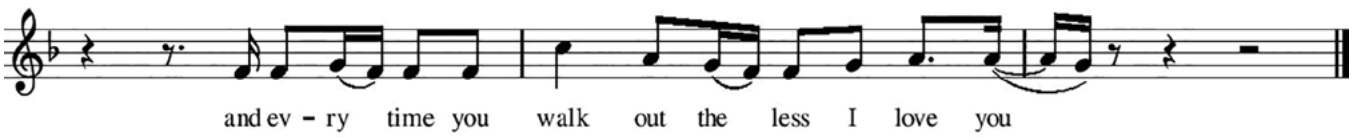

Figure 4. Musical phrase from the score by Sam Smith and James Napier and Tor Erik Hermansen and Mikkel Eriksen, "Too Good at Goodbyes" (N.p.: EMI Music, 2017), 3. (See permissions, page 151.)

toward [æ]. The shadows from the lighting make it difficult to see the angular thyroid cartilage to determine the position of the larynx.

The fundamental is C_5. The spectrogram looks like the previous singer's in terms of distance between the harmonics because the pitches are only a semitone apart (Figure 5). Again, the narrow profile of the overtones indicates that vibrato is not present.[8] Boosts are visible once more at H2 and H6.

It is common for the fundamental to be reinforced in falsetto; in this case F1 is already near it (Figure 6a). The singer's mouth position shortens the vocal tract,

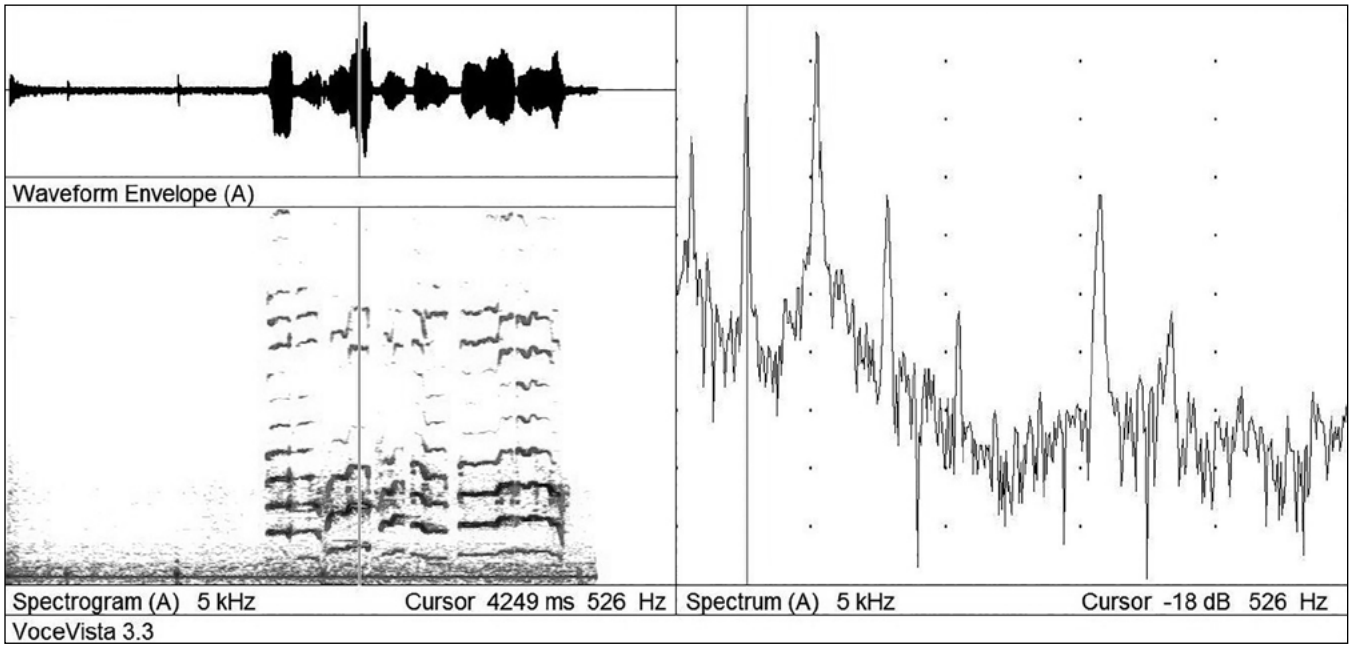

Figure 5. Acoustic analysis of Sam Smith. Taken from video between 1:00 and 1:05, by Pop Deconstructed, channel, "Too Good at Goodbyes: Live on SNL (Mic Feed)" (audio of Sam Smith), posted October 8, 2017; https://www.youtube.com/watch?v=TUDLejkupEM (accessed January 7, 2018).

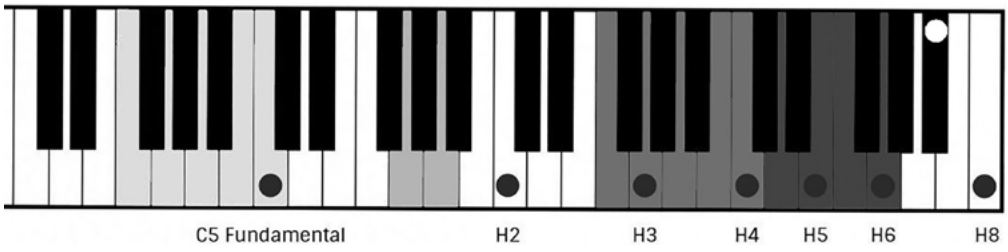

Figure 6a. Harmonics for C_5 and formants for [ɔ] on a keyboard. F1 is light grey, F2 is medium-light grey (F2 for the [æ] vowel is added in medium-dark grey) and SF is dark grey. Data, for men and women, of all voice types, converted from graph by Sundberg and Skoog.

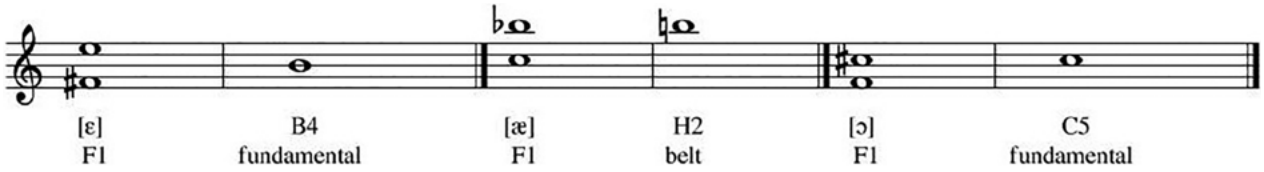

Figure 6b. Frequency ranges for F1 of each vowel displayed next to the fundamental frequency of each sample. The frequency range for F1 of the [æ] vowel modification displayed with H2 of the belt example. Data converted from graph by Sundberg and Skoog.

which raises all of the formants. The tongue appears to be somewhat constricted in the front which also raises F2 (Figure 6b). H6 falls within the range of the traditional Singer's Formant Cluster (SFC). This could be an example of "reinforced falsetto" that meets Scott McCoy's description of having energy in the upper frequencies,[9] where one would generally not anticipate them in male CTD.

Female Student Imitation

Jess is in her mid-twenties, an intermediate student who has taken several years of classical technique before beginning to study belt production, and is a soprano with a resonant and agile CTD voice. In classical singing she maintains a low laryngeal position and displays consistent vibrato and balanced, flow phonation. She has been working on belt for approximately six months. Jess was asked to imitate the phrase sung by Adele, in belt, copying her vowel strategy, with straight tone (Figure 7). To confirm formant locations, Jess produced a vocal fry on the [ɛ] vowel, with some [æ] influence.

The main difference in the acoustic results for Jess was greater presence of the fundamental (Figures 8 and 9). Like Adele, Jess had boosts at H2, H6, and slightly at H10. F1 and F2 are revealed in the power spectrum of the vocal fry and align with the first two boosts (Figure 9).

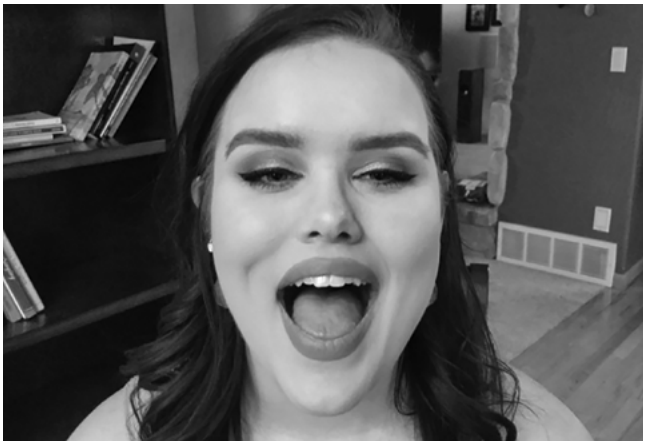

Figure 7. Female student approximating the modified vowel for the audio and vocal fry samples used in analysis. Student is aiming for similar vocal tract adjustments (dropped jaw, tongue constriction in front, spread mouth position) to the artist.

The potential consequences for untrained singers who carry TAD up beyond their transition point are well documented. Generally, these students show one or more of the following: limited upper range, weakness in CTD, a large break between registers, lack of dynamic

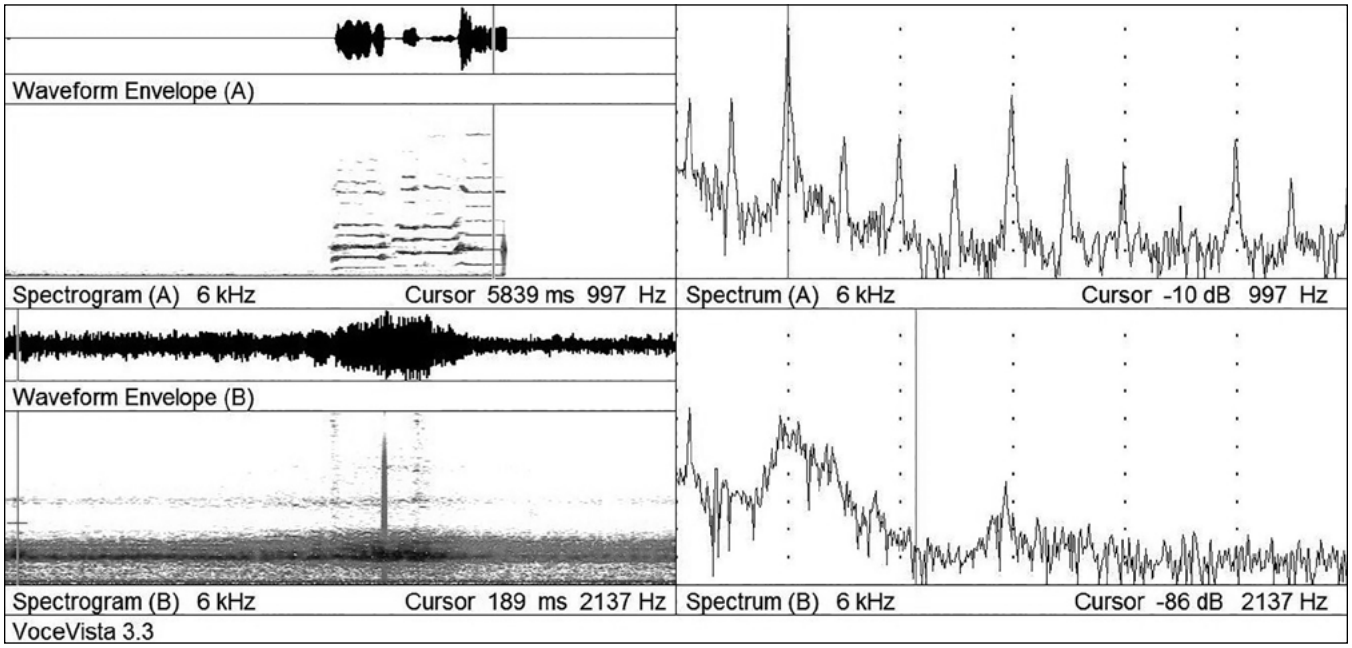

Figure 8. Upper display of female student audio, A (showing similar harmonic boosts to artist). Lower display of vocal fry on modified vowel, B (showing formants lining up to boost harmonics).

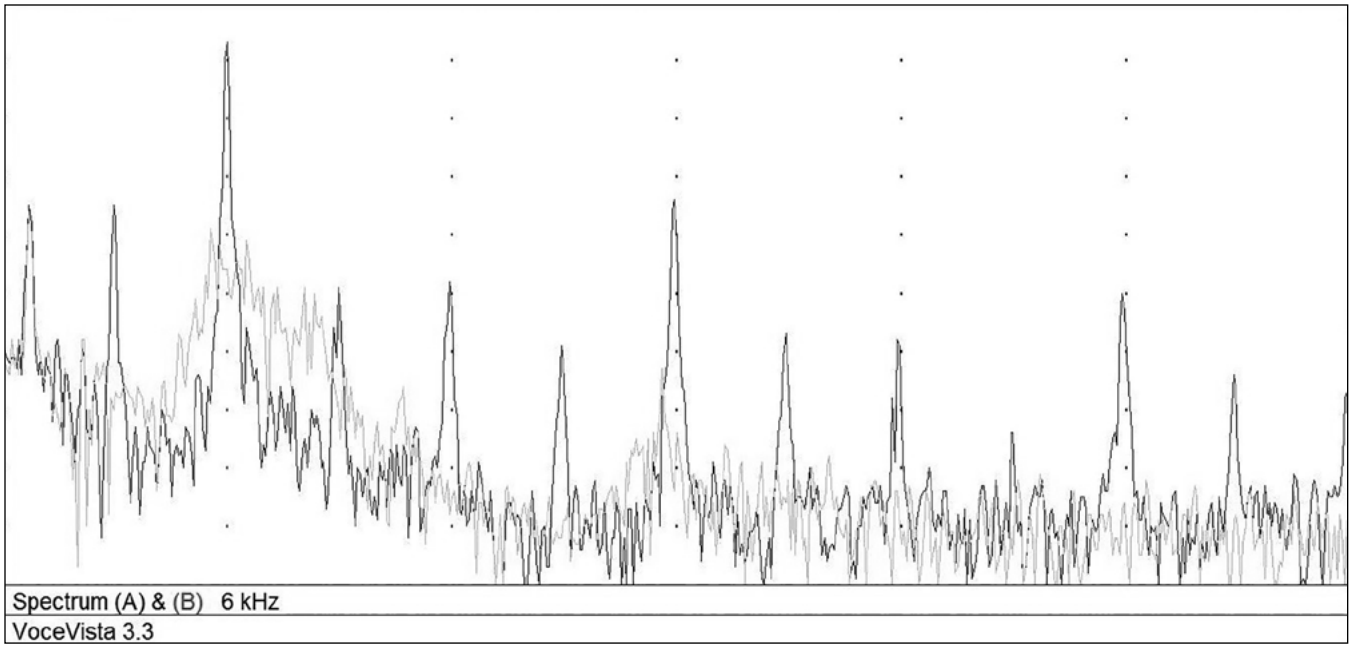

Figure 9. A and B in overlay (female audio and fry), harmonics in black, formants in gray. F1 and F2 align with H2 and H6.

control, tendency to fatigue, limitations in timbre, pitch accuracy problems, lack of vibrancy and agility, and a tendency toward pressed phonation, which can result in a vocal fold pathology. Vocal fatigue and problems with vocal health may shorten the longevity of the voice.

Male Student Imitation

Corbin is in his late teens and would currently be categorized as a baritone. He has a strong choral foundation in vertical vowel positions, a solid range in TAD for his age, and is quite adept in using his falsetto (CTD) register. Corbin was asked to sing the Sam Smith phrase, in CTD, with straight tone, while imitating the same vowel as the artist (Figure 10). Corbin also produced a vocal fry on the [ɔ] vowel with slightly spread lips and his tongue moderately fronted toward [æ].

Corbin had similar results to Smith, but with more energy in the fundamental (and a slightly greater boost at H7). He also had amplifications at H2 and H6 (Figure 11). The first two formants for the modified vowel are evident in the power spectrum of the vocal fry (Figures 11 and 12). F1 and F2 are much closer together for this vocal tract shape and are in position to boost the fundamental and H2. Another potential resonance strategy is suggested in this case. H2 actually lines up between F1 and F2 and the boost could have resulted from a clustering effect of the two formants in close proximity to one another (if the shape of the vocal tract was consistent). This approach has been documented by researchers in several other circumstances, for example, as a female middle voice strategy.[10] Corbin's results also showed energy likely from the SFC (F3, F4, and F5) boosting H6.

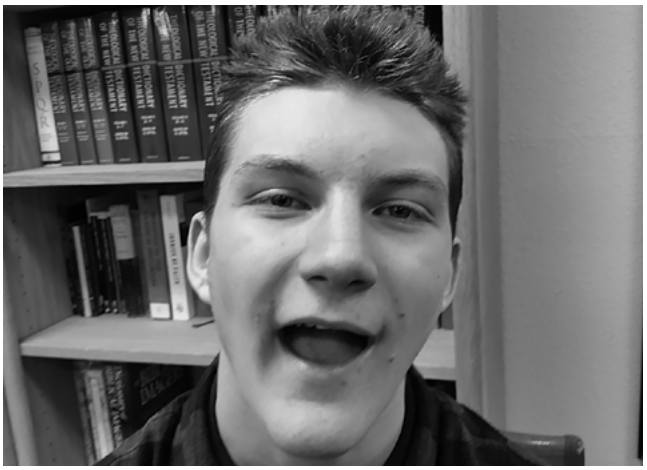

Figure 10. Male student approximating the modified vowel for the audio and vocal fry samples used in analysis. Student is aiming for similar vocal tract adjustments (moderately dropped jaw, slightly spread mouth position, tongue is not retracted) to the artist.

The potential consequences for untrained male singers frequently using falsetto include weakened

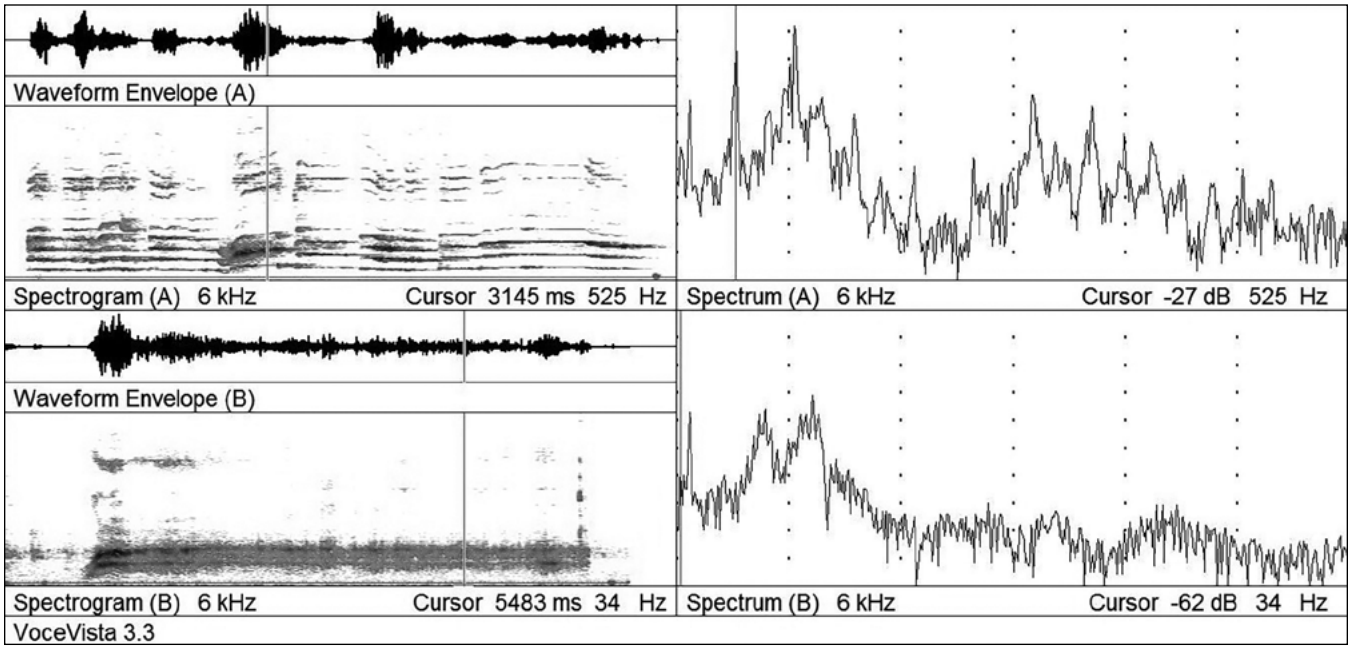

Figure 11. **Upper display of male student audio, A (showing similar harmonic boosts to artist). Lower display of vocal fry on modified vowel, B (showing formants in proximity to harmonic boosts). Energy from the SFC is also evident (H6 boost).**

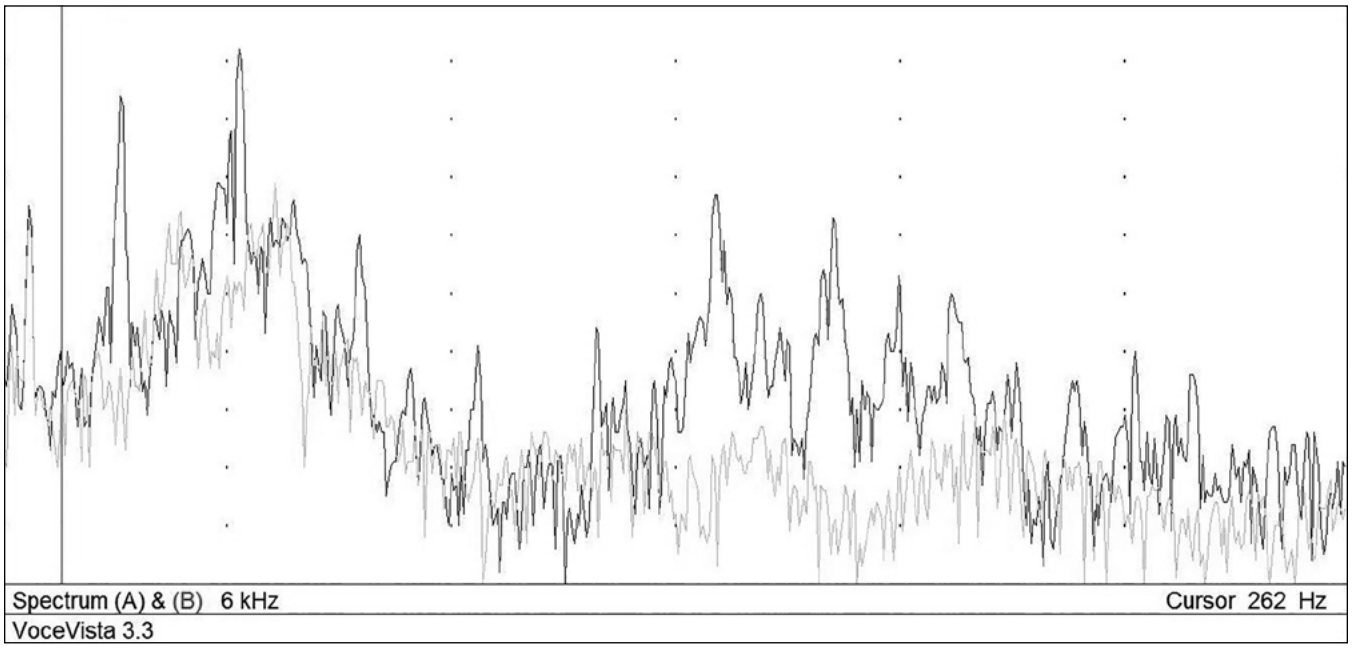

Figure 12. **A and B in overlay (male audio and fry), harmonics in black, formants in gray. F1 and F2 displaying a clustering effect with H2 between them and near fundamental.**

TAD, reduced range, tendency toward fatigue, lack of dynamic control, and limitations in timbre. Stephen Austin points out that this situation can also make the chest voice less agile, because of compensatory strategies that involve more glottal adduction and elevated breath pressure.[11] Vocal fatigue and possible vocal health consequences from tension or excess pressure could once again decrease the longevity of the singing voice.

THE OLD AND THE NEW: PHILOSOPHIES OF THE MIXED VOICE

The most widely recognized use of TAD, with women in classical singing, has been when it is applied below and through the *primo passaggio*. But historically, it has also been used for the advantage of its influence on CTD. Mathilde Marchesi (who specialized in the female voice) asserted in 1901 that cultivating the chest register is necessary for complete development of the vocal instrument, and that others who think it could undermine progress in the head register are mistaken.[12] Later, Vennard shared the view that when a female singer finds her chest voice she will often then uncover resonance in her whole instrument.[13] Austin reports, that chest development in women can bring improvements in the head voice, like greater compass, freedom, tone quality, and dynamic range.[14] From the time of Garcia, pedagogues have focused on training the firm vocal fold closure that is associated with TAD. Now we know that this type of phonation is advantageous because of the robust series of harmonics generated by it. But from the beginning, teachers have had fears about teaching chest mixture to women.

> Because one can approach the study of this register [TAD] only with the help of profound knowledge, under the threat of ruining the student's voice, and because the blending of this register with that of the falsetto [CTD] can be secured only by a long and ably directed labor. It has therefore been judged simpler and more natural to free oneself from the difficulty of studying it.[15]

The history of head mix in men is perhaps more obscure. Writings on *voce faringea*, or "pharyngeal voice," describe a male falsetto with greater intensity.[16] There are early tenor arias, with pitches above C_5, that required a technique beyond the limits of today's classical male upper extension.[17] Historical sources, describing singers who could produce *voce faringea*, claim that these pitches were sung flexibly, securely, and with dynamic variety.[18] *Voce faringea* is not to be confused with *mezza voce* or "half voice," which refers to TAD at a soft dynamic level.[19] Viennese tenor and countertenor, Alexander Mayr, was able to show in his 2017 study that the acoustic intensity in the range of the classical SFC was stronger in his imitation of *voce faringea* technique than in his falsetto.[20] Also in his investigation, the electroglottograph (EGG) showed a higher percentage of time the glottis is closed (or closed quotient, CQ) for *voce faringea* (.61) than falsetto (.45), which was not as high as chest (.70) but was even higher than *mezza voce* (.58).[21] Mixed voices make it difficult to create CQ percentage ranges that definitively reflect either register (in this case, CTD has a greater CQ than .5). Mayr believes that in *voce faringea* the adductive strength of the lateral cricoarytenoid muscles and the interarytenoid muscles are important.[22] His findings correspond with other studies, confirming that pharyngeal narrowing raises F2 and that aryepiglottic constriction can increase acoustic energy near formants 3, 4, and 5.[23]

While the idea of mix has been used for centuries, it has become more relevant as high belt expectations have gone further up the scale in music theater (MT) and CCM styles. Sometimes the language can seem to imply the mixing of registers. It is difficult to talk about mixing registers as they are currently labeled and defined. If one muscle group is "dominant," it has the most control or influence. Either the TA muscles or CT muscles can be dominant in a particular moment, but they cannot share dominance. Donald Miller asserts,

> Simultaneous activation of "chest" and "falsetto" modes of vibration of the vocal folds, while experimentally feasible, is not applicable in singing, . . . the skillful blending of registers . . . is effected by other means than a percentagewise blending of the "chest" and "falsetto" voice source.[24]

A recent study of laryngeal adjustments in both female *passaggi* disputes these conclusions, and claims that the progressive modifications evident when crossing registers, support the theory that registers can be mixed or blended.[25] It is important to note that this study was done ascending the scale, but not descending.[26] More importantly, most experts do not believe that the male extension can be taught by simply adding weight to falsetto (CTD); neither do most teachers think that a singer can go into belt from head voice (CTD). Mary Saunders, who trained many elite female belters, declares that it is never successful to try to force belt production from the head voice.[27] It is not currently possible to measure the degree of muscle involvement directly, but we can measure indicators of muscle involvement.

These characteristics can be adjusted by a trained singer to resemble the other muscular dominance. Ultimately, expert singers and teachers are usually quite confident about which register they are actually hearing or utilizing. The muscle group that is dominant is apparent.

The two physiological registers have characteristics that can be identified in EGG. The asymmetrical profile of the EGG is connected to the greater glottal contact of TAD (Figure 13). In TAD, since the vocal folds are thicker and have a loose cover, there is a vertical phase difference (the folds open gradually from bottom to top). It takes them longer to open in TAD, which is evident in the EGG. The CTD profile is more symmetrical and the opening phase of comparatively shorter duration, when the folds are thin and the vertical phase difference is insignificant. Also, in CTD, the harmonic spectrum tends to decline more quickly than it does in TAD. Mayr shows that the EGG for *voce faringea* more closely resembles the EGG for chest, which indicates the glottal closure is more similar to chest, even though the singer is in falsetto.[28] Since glottal adduction impacts the shape of the EGG, it may not always be possible to determine register in mixed voices (at least for men in CTD) by that indicator alone.

The variable of glottal closure, going back again to Garcia, seems to be part of the explanation in looking at the phenomenon of mix. Teachers have long followed Garcia's lead in using strong glottal adduction (in CTD) to smooth register transition.[29] Researchers have discovered that even if the extent of closure changes, the register can remain the same.[30] Trained singers seem able to consciously modify phonation type, like breathy, flow, or pressed phonation, which have varying degrees of glottal adduction.[31] One possible, scientifically accurate way to describe mix is to say that it occurs when borrowing at least one physical element of the other register, which results in also sharing some of its quality.

PEDAGOGUE RESPONSE: A BEGINNING

There are valuable aspects from these trends in contemporary music that should remain. One must look at what these trends help the singer to accomplish, and why audiences respond to them. We often think of different adjectives to describe register traits. Registration is one effective tool available for interpretation. According

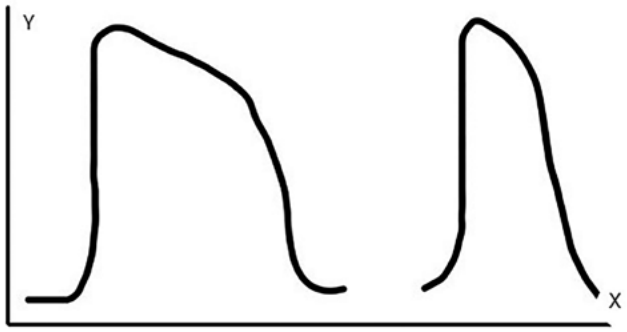

Figure 13. Sketch of typical EGG wave forms for TAD (left) and CTD (right), x axis = time, y axis = glottal closure.

to the rules of MT and CCM, communication that is authentic is the highest priority.[32] Communication, therefore, comes before technique and even before vocal health. This reordering of priorities has brought about some of these vocal trends, and is what draws students to imitate them. As singers become more advanced, they have more efficient tools available for transmitting emotions in their sound. However, the desire and willingness to connect with the audience at this level of honesty, is one thing teachers should avoid training out of their students.

There is another beneficial element from students imitating popular vocal trends that should stay. Singers can be excellent imitators. Many teachers use this strength in the studio, with modeling and listening. Intuitively copying registers, vowels, and intensity levels, is not an inherently negative ability. Teachers can view mimicking as a positive trait when students enter the studio. A beginner who can copy CCM styles well can probably also imitate other vocal techniques.

Some teachers may speculate about whether there is a best way to begin, considering the inherent, register imbalances, and if there are any consistent rules for guidance. One might claim that to incorporate an element from one register, the student must first be familiar and proficient, to a certain degree, in that register. However, teachers do have differing opinions on this subject.

Speech-language pathologists Wendy LeBorgne and Marci Rosenberg apply their expertise in muscle function to voice science. They relate the fact that muscles occur in agonist/antagonist partners to the TA and CT muscles and their associated singing registers.[33] When one muscle pair is contracted, the other is relaxed, which

is also called reciprocal inhibition (an interesting truth when considering muscular dominance). LeBorgne and Rosenberg also correlate the principles of exercise physiology to voice training. They emphasize that when training singers to belt, for example, muscle groups should be alternated, so those that have been overloaded can recover.[34] LeBorgne and Rosenberg advocate cross-training voice registers to create equilibrium in the mechanism, and to prevent the difficulties that can result from lack of balance.[35] This practice also may apply to falsetto. James McKinney cautions that the intense stretching of the folds in falsetto, over time, can permanently alter them, to the point that they cannot rebound to their original state.[36] Laryngologists refer to folds with this type of damage as "bowed."[37] It would be interesting to discover whether this principle of cross-training could also benefit male singers who frequently use CTD. While order is not specifically addressed, these principles all serve to underscore the potential value in training an underdeveloped, natural register, at least to a certain level, before cultivating advanced use of a secondary one.

Many instructors begin with male and female voices by finding balance in the middle range from which to move outward. Saunders does address training order. She admonishes that teachers would be unwise to introduce belt to a female singer until she has a developed head voice, with some indicators like healthy vibrato and sustained, legato phrasing.[38] She even cautions that for young singers, one can't exaggerate the importance of strengthening this head register.[39] Saunders says, without this, a singer is operating with an incomplete instrument, unable to access all of the timbres available for expression.[40] She further declares, that if a voice is weak in the upper range, developing chest won't bring a good result, because the mechanism will be imbalanced.[41]

Austin, writing about utilizing the chest register in female voice training, relates that women are not the only ones who can sing with an underdeveloped chest voice—men can too.[42] He maintains this can cause problems when a teacher attempts to categorize the voice.[43] Finding the comfortable range, tessitura, size, and points of transition in a voice, is possible only if the primary register is accessible, at least to a certain level. Austin adds that teachers need the information gathered from cultivating the chest register in the male singer in order to select appropriate repertoire.[44] The development of TAD in men could also benefit falsetto (CTD), just as the development of TAD in women is beneficial for CTD. Men are able to produce falsetto in three different ways that are not equally desirable.[45] In the least efficient type, a portion of the glottis does not close (the mutational chink), and only a fraction of the folds vibrate, which results in weak sound.[46] In another type, a portion of the folds is "damped" and the remaining length vibrates.[47] In the third type, the full length of the folds vibrate.[48] One could reason that learning to sing in TAD, using the entire fold, could have some potential to improve an inefficient falsetto (CTD) mechanism. (How this relates to advanced techniques used by countertenors, and the methods used by their teachers, would be an interesting comparison but is beyond the scope of this investigation.)

PEDAGOGUE RESPONSE: CATEGORIES AND SOLUTIONS IN COMMON

Occasionally the question arises about whether or not traditional breathing techniques are necessary in CCM styles of singing. Again, it begins with Garcia, who observed that singers cannot sustain pitches in head as long as they can in chest.[49] TAD is considered the more efficient phonation since it has greater intensity with reduced airflow. According to Ingo Titze, this is because the thicker vocal folds require less lung pressure to begin and maintain phonation.[50] One might then conclude that a balanced combination of thoracic and abdominal breathing may not be necessary for certain vocal tasks. Saunders advocates breath that is low and free of tension most of the time, and in the chest only some of the time.[51] LeBorgne and Rosenberg also address the benefit of developing breathing muscles for any singing that is taxing physically or vocally.[52] They express that singers should be able to reduce the amount of burden on the larynx if they can optimize the muscles of the respiratory system.[53] In addition, glottal resistance is a function of breath pressure (torso compression) and airflow.[54] So to vary glottal adduction, one may also benefit from some degree of control over exhalation. While none of these contributors specify order, one could propose that learning how to manage the breath might be a useful prerequisite to studying any styles that are vocally strenuous or require the ability to control glottal closure.

For belt techniques, it is often assumed that the larynx is high—and indeed, as the pitch rises, the vocal tract has to adapt to maintain the H2/F1 bond. Teachers can acknowledge several truths related to the position of the larynx. Constriction in the tongue and pharynx can occur with an elevated laryngeal postion.[55] A raised larynx creates challenges for articulation because it reduces space for the tongue, jaw, and hyoid bone.[56] The vocal register can change without altering the height of the larynx.[57] Falsetto in men can be produced with a high or low larynx. Observations by researchers (including Jeannette LoVetri) of trained, professional MT singers revealed an unexpected result. Most had a laryngeal position that, although higher than "legit," was lower in belt than it was in mix (most likely CTD mix).[58] This outcome may indicate that the singers were achieving head mix with some pharyngeal constriction rather than using traditional middle voice methods. Teachers can certainly concede that an awareness of laryngeal position is necessary, along with some knowledge of how to exercise control over that position.

All of the subjects for this inquiry had what is perceived as straight tone, in the sample that was analyzed. Studies have identified that vibrato can actually be produced in two ways.[59] The first, most frequently encountered type is believed to result naturally, when the action of the CTs on the vocal folds and the breath are in balance[60] John Nix clarifies that current scientific studies are needed to document how specific vibrato characteristics respond to airflow and subglottal pressure.[61] Tone with vibrato was shown in an earlier study to have about 10% greater air flow than straight tone,[62] and greater airflow is currently associated with reduced glottal closure.[63] The second, less common type of vibrato, over which singers can exert a degree of direct manipulation, results through abdominal action that varies subglottal pressure.[64] Nix points out that vibrato has been observed to subside at the outer limits of the vocal compass.[65] He relates this to the fact that at the lowest end of the range, TA muscle involvement is the strongest, as is the CT on the highest end of the range.[66] Elite belters utilize vibrato. One could suggest that using vibrato may be a beneficial part of voice instruction, regardless of repertoire, for building healthy flow phonation, and also as a tool for lightening vocal fold adduction during demanding TAD usage. However, the greater airflow that accompanies vibrato may eliminate it as a choice, when breath pressures are high enough that airflow should also be reduced.[67]

Many instructors teach that when singers listen to their own voices the sound is not entirely accurate, because some of the vibrations inside the body (from bone conduction, for example) cannot be heard by anyone else. For some purposes, students must learn to turn their ears "off," and redirect attention to the kinesthetic experience. Kinesthetic awareness is a valuable tool for improving resonance; students can describe the locations where they perceive vibrations and teachers can use that information to help singers repeat successful vocal tract shapes. Kenneth Bozeman affirms that there are some sufficiently consistent perceptions that may be pedagogically useful.[68] Some brief summaries of these are: sensations of vertical height and space, vibrations near the nasopharynx (but without an open nasal port), and sensations traversing the hard palate due to the second formant for each vowel.[69] Students can also perceive the phenomenon Barbara Doscher describes as the "mirror image": when pitches ascend, vowel timbres below the physiological register transition migrate from open to close, and vowel timbres above the transition migrate from close to open.[70] The reverse occurs on the descent. In their respective primary registers, men experience the migration below the shift, while women experience the migration above it. Kinesthetic awareness is also a valuable means to protect vocal health. In most of the athletic realm, a certain degree of discomfort and fatigue is seen as desirable. Students, regardless of repertoire choices, must retrain to view these symptoms in the singing voice as warning signs.

In our culture, when individuals are doing their best, they are giving 100% effort. In singing, at the laryngeal level, 100% effort is too taxing and would probably be classified as pressed phonation. For singers, high degrees of effort can be appropriate in areas like communicating emotion, mental focus, and even breath management for certain phrases. However, at the level of the larynx, students should be cautious of effort that is too high and begin to decrease elements like volume, breath pressure, and vocal fold adduction.[71] Percentages of effort can be classified only by the singer; however, when pressures are getting too high, a teacher can ask a student what his or her perception is, and then tell the student to stay under

that number.[72] This strategy applies to male and female singers, especially those ascending the scale in TAD.

The simple tool of using dynamics in the studio is probably underutilized. Dynamics are helpful in addressing many issues, including registration. Softer sound can lighten the mechanism to transition to head and louder sound can add weight to the mechanism to transition to chest.[73] Garcia's *messa di voce* exercise was originally intended to use crescendo and decrescendo to transition in an out of registers (in the approximate octave of pitches, where both registers are an option). With beginning singers, softer sound can also be used to aid with pressed phonation and louder sound with breathy phonation.

PEDAGOGUE RESPONSE: ADVANCED AND SPECIAL CASES

There are some benefits to the falsetto trend, when teaching male singers range expansion and the upper extension. Teachers have long used falsetto for its influence on TAD. According to McKinney, falsetto can help a singer have less anxiety on high pitches and free vocalis muscle tension.[74] Another author suggests that the male upper extension emerges, after men experience the effortlessness of high notes in the falsetto register.[75] Matthew Edwards instructs male students to hold a pitch in falsetto for fifteen seconds, for the purpose of stretching the muscle fibers and bands in the elongated vocal folds.[76] McCoy uses the fluidity of falsetto glides into chest to confirm if the larynx is in a relaxed and lowered position.[77] More wisdom from Vennard underscores the usefulness of cross-training men in their auxiliary register, something that the Italian School had been doing with women from the beginning (female language added).

> The development of the "unused" register produces two good results. It builds muscular strength . . . The laryngeal musculature is given a special kind of exercise in one extreme register which the opposite extreme will not provide, but which would be generally beneficial. Second, this practice gives the singer a "feel" of something that he [she] should be doing but which he [she] probably does not when he [she] uses only the other mechanism.[78]

Experts claim there are variations of belt that are healthier (have lower CQ values and put a lighter load on the vocal folds) compared to those that are potentially more taxing. A study (including Johan Sundberg) comparing female belt types (in one singer) labeled the categories of belt as "heavy," "speech-like," "nasal," "brassy," and "ringy."[79] Subglottal pressure in the ringy type of belt was the lowest (and similar to classical singing), but was the highest in the heavy belt.[80] The CQ values were .5 for heavy belt, .25 for (CTD) classical singing, and .3 for ringy belt.[81] The fact that ringy belt was still in chest was confirmed by a panel of experts and by the singer subject (Lisa Popeil) herself.[82] EGG profiles, for particularly the ringy belt category (not provided in the results of this study), would be informative. There appear to be types of belt that are more vocally demanding than others. When the goal is for vocal production to sound difficult for interpretive reasons, the belt could be a heavier type. Ringy belt requires singers to be highly skilled in strategies that mitigate extreme pressure levels. Most expert belters and their teachers would agree that methods to reduce pressure in high belt require specialized training.

The irony that "cover" in traditional pedagogy, and belt in CCM pedagogy, share some similarities has not gone unnoticed. Both productions extend TAD up the scale, resulting in high subglottal pressures, with larger CQs. Cover and belt productions differ in the ways they reduce this laryngeal load. In the upper extension, men use what Bozeman describes as "close timbre," a range of acoustic similarity, which predictably occurs at different turning points on the scale for each voice type, depending on the vowel.[83] During close timbre, the "yell" pairing of formant and harmonic (H2/F1, consistently found in belt) is released and another pairing maximized with F2. This is possible because of the greater length of the vocal tract. Belt and cover both have acoustic energy in the upper frequencies, but how this is accomplished differs. In classical techniques, men are using the SFC, which always has depth component (due to the laryngeal position). When there is some degree of pharyngeal constriction and the larynx is not lowered, depth no longer plays a part. However, belt and cover (and *voce faringea*, too) share the narrowed aryepiglottic sphincter, which creates ring (or twang) timbre.[84] In mix, instead of the bright/dark quality of classical *chiaroscuro* timbre, Bozeman describes a bright/bright or *chiarochiaro* quality.[85] It is important to note that when using cover

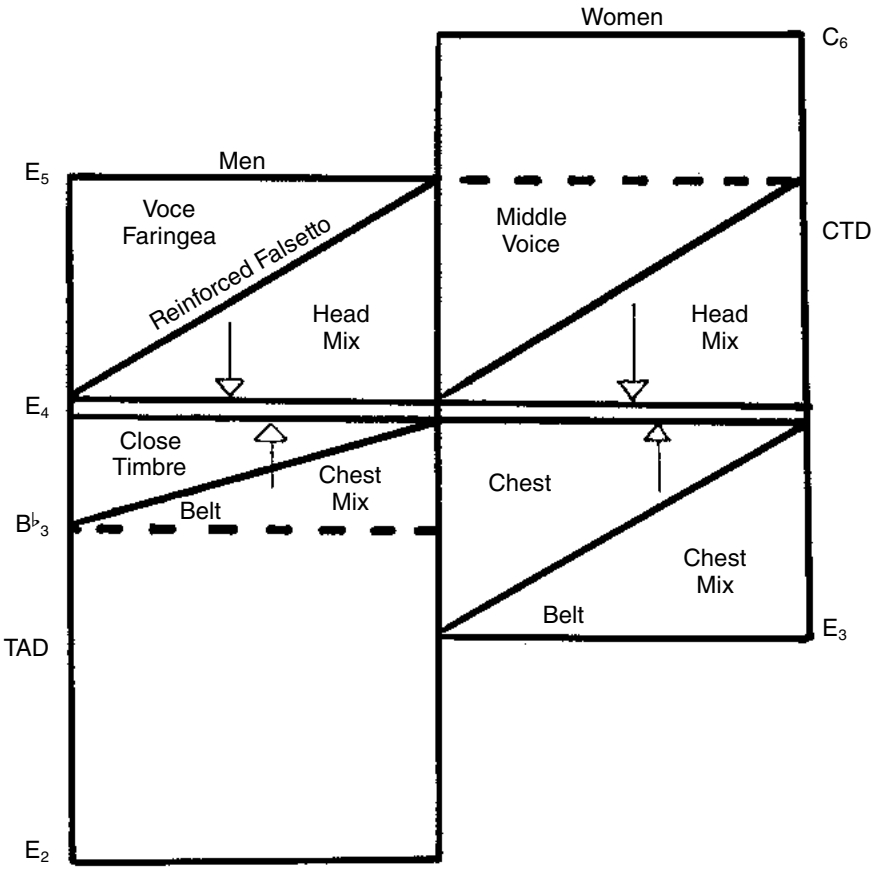

Figure 14. Approximate primary, secondary and acoustic registers, including mixed voices for men and women, to be adjusted for voice type (April D. Young, 2018)

Key: double line=physiological register shift, this is mobile and can slide up or down, crossing this changes the register
dotted line=acoustic register (women's below dotted line and men's above)
diagonal line=traditional/CCM division for secondary registers and acoustic registers within primary registers
arrow=pushing the physiological register boundary, these can *overlap* in range.

techniques, the male singer is still utilizing his primary, physiological register, TAD, whereas in belt, the female singer is utilizing her secondary register (since her primary one is CTD).

Some other interesting comparisons can be made when observing shared characteristics across mixed voices (Figure 14). For example, in reinforced falsetto and female middle voice acoustic strategies, where CTD is brought down from above, there are again different methods for increasing acoustic energy. A traditional understanding of the female head mix is that it results from vowel and timbre modifications, which in turn impact the folds (non-linear source theory). This technique allows the singer to reduce airflow and increase glottal adduction without squeezing the glottis.[86] *Voce faringea*, on the other hand, seems to place more importance on a form of constriction to vary glottal adduction, rather than vowel and timbre modifications. Both men and women are able to increase harmonic boosts in the acoustic registers, which occur within their respective primary registers, via timbre and vowel modifications (men in TAD in the upper extension, and women in CTD in the middle voice). Both are also able to maintain a low larynx with this strategy. Both men and women (at least some of the time) seem to rely on a degree of pharyngeal constriction, to achieve upper harmonic

intensity in the acoustic registers, which occurs within their respective secondary registers (men in CTD in reinforced falsetto, and women in TAD in belt).

Some studies (again one including LoVetri) have suggested that register transition for young voices is a third higher than it is for the adult female voice (approximately G_4 instead of about E_4, which varies slightly for voice type).[87] This conclusion was drawn from a change in the progression of closed quotient (CQ) values in ascending pitch, which dropped until about G_4 and then increased (for both MT and classical styles).[88] The CQ values for classical style were lower than the values for MT style, implying register but otherwise dominance is not clarified.[89] This potential *passaggio* shift raises many questions for the current discussion regarding mixed voices in young singers. (The ages and stages of adolescent hormonal change are beyond the scope of this inquiry.) With this in mind, is an untrained child able healthily to go higher in TAD than an untrained adult? When in CTD, does the untrained child have to use a chest mix sooner on the descent? Child singers are imitating what they hear in popular music, including mixed voices. This author is suggesting the possibility, that a higher transition could allow untrained girls to imitate some of the popular sounds they hear (like women singing primarily in TAD) more easily than untrained adults. What would this mean for young women after voice change? Young female singers using primarily CTD, can usually negotiate voice change without significant vocal health consequences, but what about a girl who is imitating heavy belt production? What happens (in the short term) if she attempts to sing in the same key (without guidance), if her *primo passaggio* drops a third? Boys, if they were imitating men singing in falsetto, and after voice change suddenly have a large, unfamiliar TAD voice, might choose to sing in the more familiar CTD register. These are important ideas to explore for teachers of young voices and for all teachers, since many students may have developed habits as children that influence their vocal instruments as adults.

CONCLUSION

At the beginning of this investigation, a 1967 quote from Vennard related that the chest register in women and the falsetto register in men were "unused."[90] Just twenty-five years later, that situation had changed for young women, and in 1994, Doscher maintained, "Among today's young female singers, the head register often is underused and sometimes rejected entirely. Much of the popular music is written in low keys, and chest register is carried up well beyond F^4[*sic*]."[91] This tendency continues, and twenty-four years later, in 2018, we have a new reality to add to this trajectory of change, this time for young men. Using Doscher's wording, one could say: Among today's young male singers, the chest register often is underused. It might not even be an exaggeration to say that it is sometimes rejected entirely.

The popularity of rock musicals has significantly changed the demands being made on singers, and the skills teachers must help them to develop. Directors no longer ask for ability in only one type of singing. Female singers need to be adept in both legit and belt styles. Male singers are being asked to sing in wide ranges. Since in MT cover is not often a viable option, men are belting too and mixing in falsetto.

There is a need for trained specialists to teach vocalists outside of the traditional realm. Most teachers, even if they do not feel equipped to teach CCM singers, would agree that all students (including children) deserve, at the very least, to learn techniques that protect vocal health. Otherwise, traditional teachers are contributing to the increasingly large gap in the market that leaves room for vocal coaches with very little education, who can be more damaging than helpful. At no time in history has it been more important for the voice teacher to be a master of the subject of registration.

One thing that has not changed is the need for teacher expertise in evaluating the voice. When using an element of one register to influence the other, cross-training for vocal health, or teaching advanced registration techniques, the teacher's honed, diagnostic ear remains his or her greatest asset. With each unique student, the teacher watches for the same warning signs. Does the student tire more easily? Is progress in one area causing a setback in another? How the student responds will inform voice classification and repertoire direction, just as it always has.

This exploration points to several areas where additional research would be beneficial. For example, inquiry into the results of TAD cross-training in men using frequent falsetto production in CCM (for the purposes

of preventing injury and encouraging longevity) would be useful. Whether or not the volitional type of vibrato could be pedagogically utilized in advanced register usage needs further examination. There are many questions about mixed voices in young singers. More study is also needed into strategies to increase energy in the upper frequencies (pharyngeal constriction and narrowing of the aryepiglottic space) in especially male head and chest mix and female head mix. EGG with CQ values are needed for the mixed voices that have had less analysis (like head mix in both men and women). Also, evaluating laryngeal positions (impacted by the acoustic strategy employed) in *voce faringea* and male and female head mix would be helpful. Largely unaddressed in this inquiry are the adjustments between breath pressure and airflow, which are the variables involved in fine tuning glottal adduction. In general, where glottal adduction needs to increase (as in CTD mix), based on the phonation equation of breath pressure/airflow = glottal adduction,[92] one could expect a reduction in airflow or an increase in breath pressure or both. Conversely where breath pressure needs to decrease, as in belt,[93] the equation could also read, breath pressure = glottal adduction x (times) airflow, so either adduction, airflow or both, can be diminished. However, these relationships warrant further investigation, as potential elements of mixing register characteristics, which singers appear to be able to consciously control.

This discussion reveals several encouraging conclusions. While the two trends are completely different, some of the problems they can cause in the untrained voice are similar, and there are solutions in common that can be utilized effectively. With the right tools, there are many silver linings to the challenges created by vocal trends in popular music. When teachers encounter these challenges in the studio, they can turn them into great opportunities. Maybe teaching students with voices that are "mixed up and upside down" is not so bad after all.

Permissions

NOTES

1. William Vennard, *Singing: The Mechanism and the Technic,* rev. ed. (New York: Carl Fischer, 1967), 76.
2. Kenneth Bozeman, *Kinesthetic Voice Pedagogy: Motivating Acoustic Efficiency* (Gahanna, OH: Inside View Press, 2017), 79.
3. Norman Spivey, "Teaching Music Theater Singing: One Teacher's Journey," *Journal of Singing* 62, no. 2 (November/December 2005): 199.
4. Donald Gray Miller, *Resonance in Singing: Voice Building through Acoustic Feedback* (Princeton: Inside View Press, 2008), 66.
5. Ibid., 93.
6. Kenneth W. Bozeman, *Practical Vocal Acoustics: Pedagogic Applications for Teachers and Singers* (Hillsdale, NY: Pendragon Press, 2013), 7.
7. Scott McCoy, *Your Voice: an Inside View*, 2nd ed. (Delaware, OH: Inside View Press, 2012), 62.
8. Miller, 66.
9. Scott McCoy, "Falsetto and the Male High Voice," *Journal of Singing* 59, no 5 (May/June 2003): 406.
10. Bozeman, *Practical Vocal Acoustics*, 34.
11. Stephen F. Austin, "Treasure 'Chest'—A Physiological and Pedagogical Review of the Low Mechanism," *Journal of Singing* 61, no. 3 (January/February 2005): 250.

12. Mathilde Marchesi, *Ten Singing Lessons* (New York: Harper & Brothers, 1901), 31, 106.
13. Vennard, 121.
14. Austin, 245.
15. Manuel Garcia II, *Memoire on the Human Voice,* in *A Complete Treatise on the Art of Singing: Part One,* the editions of 1841 and 1872, collated, ed., and trans. Donald V. Paschke (New York: Da Capo Press, 1984), 50.
16. Alexander Mayr, "Investigating the Voce Faringea: Physiological and Acoustic Characteristics of the Bel Canto Tenor's Forgotten Singing Practice," *Journal of Voice* 31, no. 2 (March 2017): 255.e13.
17. Ibid., 255.e13.
18. Ibid., 255.e14.
19. Ibid., 255.e15.
20. Ibid., 225.e16.
21. Ibid., 255.e19.
22. Ibid.
23. Ibid., 255.e21.
24. Donald G. Miller, *Singing Technique,* quoted in James Stark, *Bel Canto: A History of Vocal Pedagogy* (Toronto: University of Toronto Press, 2008), 87.
25. Matthias Echternach et al., "Laryngeal Evidence for the First and Second Passaggio in Professionally Trained Sopranos," *Plos One* 12, no. 5 (May 3, 2017): 11.
26. Ibid., 12.
27. Mary Saunders, *Bel Canto Can Belto: Teaching Women to Sing Musical Theater,* DVD-ROM (University Park, PA: Penn State Media Sales, 2007).
28. Mayr, 255.e17.
29. Stark, 72.
30. Christian T. Herbst et al., "Glottal Adduction and Subglottal Pressure in Singing," *Journal of Voice* 29, no. 4 (July 2015): 399.
31. Ibid., 392.
32. Spivey, 201.
33. Wendy DeLeo LeBorgne and Marci Daniels Rosenberg, *The Vocal Athlete* (San Diego: Plural Publishing, 2014), eBook Academic Collection (EBSCOhost), 249.
34. Ibid., 249.
35. Ibid.
36. James C. McKinney, *The Diagnosis and Correction of Vocal Faults: A Manual for Teachers of Singing and for Choir Directors* (Long Grove, IL: Waveland Press, 2005), 104.
37. Ibid.
38. Saunders.
39. Ibid.
40. Ibid.
41. Ibid.
42. Austin, 246.
43. Ibid.
44. Ibid.
45. McKinney, 100.
46. Ibid.
47. Ibid.
48. Ibid.
49. Stark, 69.
50. Ingo Titze, "Phonation Threshold Pressure," *Journal of Singing* 47, no. 4 (March/April 1991): 23.
51. Saunders.
52. LeBorgne and Rosenberg, 247.
53. Ibid.
54. Bozeman, *Practical Vocal Acoustics,* 5.
55. Carla LeFevre, "Techniques for Maintaining a Low Larynx and Open Throat in Classical Singing," *Journal of Singing* 71, no. 4 (March/April 2015): 459.
56. Ingo R. Titze, "Belting and a High Larynx Position," *Journal of Singing* 63, no. 5 (May/June 2007): 558.
57. Jeannette Lovetri, Susan Lesh, and Peak Woo, "Preliminary Study on the Ability of Trained Singers to Control the Intrinsic and Extrinsic Laryngeal Musculature," *Journal of Voice* 13, no. 2 (June 1999): 225.
58. Ibid., 224–225.
59. John Nix, "Shaken, Not Stirred: Practical Ideas for Addressing Vibrato and Nonvibrato Singing in the Studio and the Choral Rehearsal," *Journal of Singing* 70, no. 4 (March/April 2014): 412.
60. Thomas Shipp, E. Thomas Doherty, and Stig Haglund, "Physiologic Factors in Vocal Vibrato Production," *Journal of Voice* 4, no. 4 (1990): 303.
61. Nix, 414.
62. Shigenobu Iwata and John Large, "Aerodynamic Study of Vibrato and Voluntary 'Straight Tone' Pairs in Singing," *Journal of the Acoustical Society of America* 49, no. 1A (1971): 137.
63. Bozeman, *Practical Vocal Acoustics*, 5.
64. Shipp, Doherty, and Haglund, 303.
65. Randi Wooding and John Nix, "Perception of Non-Vibrato Sung Tones: A Pilot Study," *Journal of Voice* 30, no. 6 (November 2016): 762.e20.
66. Ibid.

67. Bozeman, *Practical Vocal Acoustics*, 5.
68. Bozeman, *Kinesthetic Voice Pedagogy*, 46.
69. Ibid., 15, 54, 55.
70. Barbara M. Doscher, *The Functional Unity of the Singing Voice,* 2nd ed. (Lanham, MD: Scarecrow Press, 1994), 160–162.
71. Matthew Edwards, "Teaching Mix and Belt" (Lecture at the CCM Vocal Pedagogy Institute, Session I, Shenandoah University, Winchester, VA, July 17, 2017).
72. Marci Daniels Rosenberg and Wendy D. Leborgne, *The Vocal Athlete: Application and Technique for the Hybrid Singer* (San Diego, CA: Plural Publishing, 2014), 11–12.
73. Edwards.
74. McKinney,105.
75. D. A. Clippinger, *The Head Voice and Other Problems: Practical Talks on Singing* (Boston: Oliver Ditson, 1917), 26.
76. Matt Edwards, "The Benefits of Using Falsetto When Teaching Men," *Mix It Up Monday* (blog), May 22, 2017; https://edwardsvoice.wordpress.com/2017/05/22/mix-it-up-monday-the-benefits-of-using-falsetto-when-teaching-men/ (accessed March 13, 2018).
77. McCoy, "Falsetto," 405.
78. Vennard, 76.
79. Johan Sundberg, Margareta Thalén, and Lisa Popeil, "Substyles of Belting: Phonatory and Resonatory Characteristics," *Journal of Voice* 26, no. 1 (January 2012): 44.
80. Ibid., 49.
81. Ibid.
82. Ibid.
83. Bozeman, *Practical Vocal Acoustics*, 23, 126.
84. Ibid. 70.
85. Ibid.
86. Ibid., 43.
87. Christopher Barlow and Jeannette LoVetri, "Closed Quotient and Spectral Measures of Female Adolescent Singers in Different Singing Styles," *Journal of Voice* 24, no. 3 (May 2010): 316, Science Direct.
88. Ibid.
89. Ibid.
90. Vennard, 76.
91. Doscher, 181–182.
92. Bozeman, *Practical Vocal Acoustics*, 5.
93. Ibid., 70.

April D. Young, soprano, is on the voice faculties of Holy Names Music Center in Spokane, WA and The Oaks Conservatory of the Creative and Performing Arts in Spokane Valley, WA. In both locations she teaches classical and CCM techniques and literature, and also works with young voices. Ms. Young maintains a private studio. She holds a Bachelor of Arts degree in Music with a Voice Performance emphasis from Westmont College in Santa Barbara, CA, and a Master of Voice Pedagogy degree from Westminster Choir College in Princeton, NJ. Ms. Young studied voice with the late Sister Marietta Coyle. Ms. Young is a group voice clinician for area high school choirs. She directed children's, youth, and adult choirs. Ms. Young served as a cantor in several parishes around the Spokane diocese for twenty-three years. Her solo performing credits include recital, oratorio, and music theater. Ms. Young's studio credits include the vocals for a computer game in the Myst series.