At the Beginning of Phonation:

Creation of Vocal Colours through
Glottal Configuration and Vocal Tract Filtering

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Each singer's voice offers unique characteristics that distinguish their sound from other singers' articulative properties. Although *vocal timbre*, or the colours of the voice, may be particular to each singer, the quality of their singing is very much dependent on how they use their instrument to convey emotions. In her book *Functional Unity of the Singing* Voice, Barbara Doscher stated that "the quality and focus of the vocal sound are determined in large measure by how efficiently the resonance components of the instruments are used."[1] The modern vocal pedagogue should understand the mechanism of these components, what takes place at the glottal source and the resonator/vocal tract before even producing sound if they hope to use their instruments optimally and employ a variety of colours to make performance emotionally appealing to the audience. In this paper, I will address how vocal colours are produced at the glottal source and how different vocal qualities are made in the adduction of the vocal folds, with special focus on the role of the membranous and cartilaginous adductions. I will also address how sound is filtered in the vocal tract for resonation. Ultimately, I will explore how the glottis and vocal tract function in relation to each other to create various vocal colours. My hope is that this paper will contribute to further discussions around the creation of vocal colours through glottal configuration and vocal tract filtering to better understand and define emotive singing and better design and implement curricula for vocal students in their endeavour to improve their performances.

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[1] Barbara M. Doscher, *The Functional Unity of the Singing Voice*, 2nd ed. (Metuchen, N.J: Scarecrow Press, 1994), 98.

Creation of Vocal Colours at the Glottal Source

At the glottal source, the quality of sound is determined by how the arytenoids join together, which informs the type of glottal closure on the onset of tone. Manuel Garcia ll, known as the "father of modern voice science," made direct observations of firm glottal closure and was the first to study systematically the relationship between tone quality and glottal setting, laryngeal position and the effects of the resonating tube.[2] Garcia was the first to differentiate between the glottal source and the adjustments of that sound by the vocal tract.[3] His theory of *coup de la glotte* emphasizes the importance of establishing firm glottal closure in order to achieve a ringing quality, or *voix éclatant*. By contrast, loose glottal closure will result in a veiled/ dull sound, or *voix sourde*.[4] Garcia stated that "when one very vigorously pinches the arytenoids together, the glottis is represented only by a narrow or elliptical slit, through which the air driven out by the lungs must escape. Here each molecule of air is subjected to the laws of vibration, and the voice takes on a very pronounced brilliance."[5] Regarding this quote, Herbst, Howard, and Švec articulated in their article "The Sound Source in Singing" that "Garcia describes how voice timbre can be influenced by controlling a physiologic parameter-the adduction of the arytenoids. In addition, Garcia hints at the inverse relation between glottal adduction and airflow rates, and the fact that the maximum phonation duration is dependent on the degree of glottal adduction."[6] Firm glottal closure results in a coordinated onset with a more potent, sting-

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2 Points made by Professor Torin Chiles in Vocal Pedagogy 9510, UWO, 2022.

3 James A. Stark, *Bel Canto: A History of Vocal Pedagogy* (Toronto: University of Toronto Press, 1999), 36.

3 Ibid, 55.

4 Ibid, 36.

5 Ibid, 11.

6 Christian T. Herbst, David M. Howard, and Jan G. Švec, "The Sound Source in Singing: Basic Principles and Muscular Adjustments for Fine-tuning Vocal Timbre," in *The Oxford Handbook of Singing*, Ed. Graham F. Welch, David M. Howard, and John Nix (Oxford: Oxford University Press), 118.

like tone, while loose glottal closure lends to a more diffused and breathier onset. Airflow and glottal closure are what take place in the mechanism before a singer can filter the sound through the vocal tract to convey emotions, and in the Bel Canto tradition it is crucial to have firm glottal closure in order to produce a well-balanced tone.

The quality of sound is dependent on the breath the singer takes. Doscher expressed that "subglottic pressure is the pressure just below the vocal folds and is the result of a complex system of breathing and phonatory factors."[7] In this complex system of breathing, balanced release of air is essential to consistency in subglottic air pressure and subsequently phonation. In his book *The Comparative Anatomy and Physiology of the Larynx*, Negus stated that:

> "The movements at the glottis are under the control of the respiratory center… Dilatation of the glottis is of sudden onset, preceding expansion of thorax and descent of the diaphragm; the movement is of brief duration, where no direct relation in time or duration to that of the diaphragm. Narrowing occurs as the first event in expiration; it is also sudden and brief."[8]

Appoggio, or the "lean" in the voice, is what Richard Miller described as "pacing of breath."[9] Stark defined this term as "a complex coordination of all the muscles of singing, and it is rooted in the equilibrium between breath pressure and controlled phonation."[10] Also

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7 Doscher, *Functional Unity of the Singing Voice*, 62.

8 Victor Negus, *The Comparative Anatomy and Physiology of the Larynx* (New York: Hafner Pub. Co, 1962), 72.

9 Richard Miller, *The Structure of Singing: System and Art in Vocal Technique* (New York: Schirmer Books, 1996), 38.

10 Stark, *Bel Canto*, 120.

known as “singing on the gesture of inhalation,”[11] *appoggio* is essential in the Bel Canto tradition to efficiently producing a balanced tone using only as much air as the singer needs. However, an unsuccessful execution on this type of breathing will result in either a “pressed” or “diffused” tone. Ware described “pressed tone” as “the result of high subglottal pressure combined with a strong adductory force of the vocal folds.” The reduced airflow due to excessive adduction of the vocal cords will result in a “cackly” tone.[12] As well, Ware described “diffused” or “aspirate” tone as “excessive airflow at the onset of tone,” and “the result of variable airflow combined with a weak adductory force of the vocal folds.”[13] During the execution of such tone, there is air leakage through the glottis, and this increase in airflow hinders harmonics in “getting excited,” and the lack of “excitation” of the lower frequencies and concentration of energy at the fundamental frequency will cause the tone to be breathy and “flute-like.”[14] Finding the balance between air supply and glottal closure is one factor that makes Bel Canto singing considerably challenging for the aspiring student. Supplying the vocal folds with too much air and a lack of glottal closure will lead to a diffused and breathy onset, while insufficient airflow and excessively pinching the arytenoids against that air will result in a “pressed” tone.

The coordinated onset not only results in a better sound but is also optimal for the singer’s vocal health. Miller stated that “the coordinated onset, which results from dynamic equilibrium of the participating musculature and of subglottic pressure, produces healthy

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11 Richard Miller, *Solutions for Singers: Tools for Performers and Teachers* (Oxford: Oxford University Press, 2004), 13-14.

12 Ware, *Basics of Vocal Pedagogy*, 106.

13 Ibid, 107.

14 Ibid, 106.

vocalism."[15] Unless the singer increases their breath support to what is called for in the music being sung, all the other aspects of singing that are successful would have been achieved in vain.[16] Lamperti cautioned against "overblowing" the vocal folds with excessive air: "By singing appoggiata, is meant that all notes, from the lowest to the highest, are produced by a column of air over which the singer has perfect command, by holding back the breath, and not permitting more air than is absolutely necessary for the formation of the note to escape from the lungs."[17] According to Doscher, "there must be efficient breath management to bring about firm glottal closure and the right kind of resistance to the positioning via use of the extrinsic musculature."[18] Ultimately, part of the singer's endeavour is to find the right amount of air supply from the lungs, and balance that airflow with firm glottal closure, to achieve the optimal core sound that will then enter the Vocal Tract for amplification and resonation.

Subglottal air pressure affects timbre through the level of intensity the singer uses to draw the arytenoids together. More intensity in singing is connected to increased subglottal air pressure.[19] Before a colour is produced via the resonation tract and articulators of the mouth, the quality of tone is determined at the glottal source through increased airflow and greater glottal resistance. Doscher described subglottic air pressure as "the result of the flow of air against the resistance of the vocal folds, and it is a major regulator of the

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15 Richard Miller, *The Structure of Singing: System and Art in Vocal Technique* (New York: Schirmer Books, 1996), 8.

16 Richard Miller, *On the Art of Singing* (New York: Oxford University Press, 1996), 56.

17 Ware, *Basics of Vocal Pedagogy*, 101.

18 Doscher, *Functional Unity of the Singing Voice*, 142-143.

19 Ibid, 20.

intensity of tone."[20] Garcia observed that higher levels of tonal intensity required greater glottal pressure. He stated that "It is necessary to pinch the glottis in proportion to the amount of pressure one gives the air."[21] The balance between airflow and subglottic pressure may differ from one singer to another, but universally it is most optimal when breath release is easy and steady.[22] Doscher explained the importance of balancing the glottis to achieve optimal sound in the Bel Canto tradition: "the vocal folds must resist the breath stream strongly enough to produce a long glottal closure and consequently a richer tone. Richer means a larger number of overtones, reaching to higher frequencies, and with sufficient intensity."[23] Referring to the singer's formant, this "richer" quality is the "opera singer sound" that cuts through an orchestra in a larger theatre and is part of what differentiates each singer.

Membranous and Cartilaginous Glottis

The glottis can be divided into two parts: 1)the membranous glottis, which includes the part of the vocal folds from the anterior commissure (the cricoarytenoid synovial joint) to the tip of the vocal process (anterior base of the arytenoid cartilage); and 2) the cartilaginous glottis, which includes the most posterior part of the glottis and is made up of the arytenoid and cartilages and their processes. Both parts are maintained by the cricoarytenoid muscles.[24]

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20 Ibid, 19-20.
21 Stark, *Bel Canto*, 238.
22 Doscher, *Functional Unity of the Singing Voice*, 20.
23 Ibid, 144-145.
24 Christian T. Herbst, David M. Howard, and Jan G. Švec, "The Sound Source in Singing: Basic Principles and Muscular Adjustments for Fine-tuning Vocal Timbre," in *The Oxford Handbook of Singing*, Ed. Graham F. Welch, David M. Howard, and John Nix (Oxford: Oxford University Press), 129.

The membranous glottis is adducted chiefly through the contractions of the thyroarytenoid (TA), causing the vocal folds to bulge medially, which reduces the width of the glottis anteriorly.[25] Vocal timbre modification at the laryngeal level (the sound source in Miller's tripartite system) can be altered through the adduction of the posterior (cartilaginous) glottis, which is controlled when the tone quality is changed between "breathy" and "pressed".[26]

Figure 1[27]

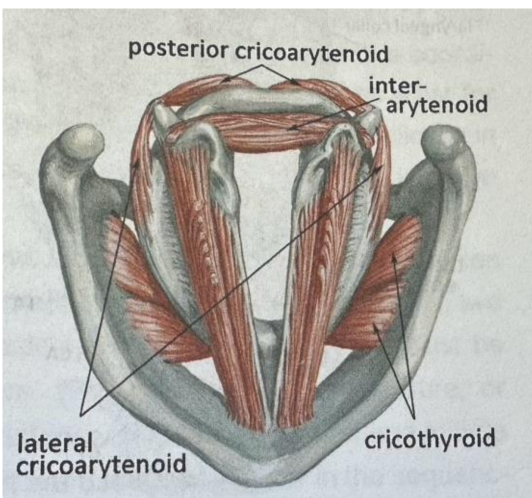
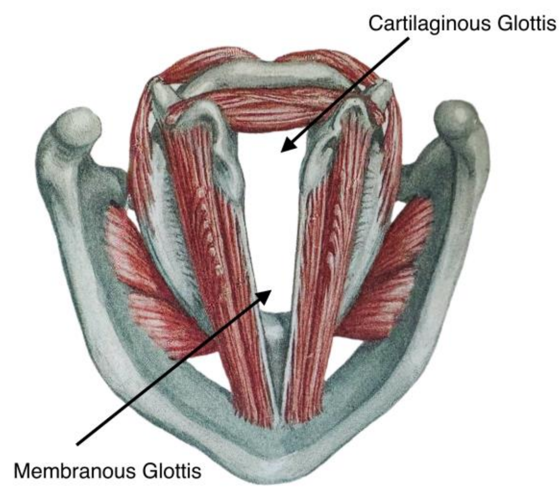


Figure 2[28]



25 Ibid.

26 Christian T. Herbst and Jan G Svec, "Adjustment of Glottal Configurations in Singing," in *Journal of Singing*, 301.

27 Scott Jeffrey McCoy, *Your Voice: An Inside View 3, Voice Science and Pedagogy*, 3rd ed. (Gahanna, OH: Inside View Press, 2019), 165.

28 Image taken from Image taken from McCoy, *Your Voice: An Inside View 3*, 165; Labels made from Herbst and Svec, "Adjustment of Glottal Configuration" diagram, 302.

Examination of the two glottal adjustments can reveal so much information, including 1) the singer's intended sound quality, 2) muscular adjustments made in the larynx, 3) their impact on glottal adduction (membranous and/or cartilaginous glottis), 4) vibratory properties of the vocal folds and their effect on glottal airflow, and 5) the actual sound that is produced.[29] The "breathy" and "pressed" voice qualities are enabled by the adductors- the lateral cricoarytenoid (LCA) and interarytenoid (IA) muscles- and an abductor: the posterior cricoarytenoid muscle.[30]

To begin phonation, the glottis closes through the adduction of the vocal folds, which is accomplished through the movements of the LCA and IA muscles. The lateral cricoarytenoid (LCA) muscle originates from the lateral surface of the cricoid cartilage and inserts into the muscular processes of the arytenoids. Upon contraction, they rotate the arytenoids and bring the vocal processes together to close the posterior part of the glottis. However, their contraction alone does not completely bring about glottal closure, as a considerable amount of air will pass through the open gap. The interarytenoid (IA) muscles between the two arytenoid cartilages aid in completely closing this space in the glottis. The IA muscles are made up of two parts: *the transverse interarytenoid* which slides the two arytenoids together along the surface of the cricoid cartilage, and the *oblique interarytenoid* which criss-crosses behind the transverse part of the muscle and goes into the aryepiglottic fold.[31]

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29 Herbst and Svec, "Adjustments of Glottal Configuration," 301-302.
30 Ibid, 301-303.
31 McCoy, *Your Voice: An Inside View* 3, 165.

The main function of the LCA and IA muscles is to adduct the cartilaginous glottis through the positioning of the arytenoid cartilages. This movement is prompted by the combined action of the LCA and IA, hence the term "cartilaginous adduction." These muscles can be fully adducted, or there can be a posterior glottal chink (PGC), which varies in sizes. In the case of the glottal chink, contact of the vocal folds during the glottal cycle is minimized or even non-existent, resulting in a steady airflow during the closed phase, which introduces "noise" into the voice source. As a side effect, cartilaginous adduction can also influence the configuration of the membranous glottis through the effect of the LCA activity on the superior part of the membranous vocal fold portion.[32]

The LCA adducts the vocal processes (the superior membranous portion of the vocal folds), while the IA muscle seals the posterior part of the cartilaginous glottis for cartilaginous adduction. As a ripple effect, cartilaginous adduction influences the membranous glottis through the effect of the LCA on the superior part of the membranous vocal fold portion. Because the folds end posteriorly at the vocal processes of the arytenoid cartilages, any adjustment of the cartilaginous glottis is, to an extent, transmitted to the membranous glottis. A higher degree of cartilaginous adduction will result in a longer closed phase, causing stronger high frequencies in the sound.[33] When a sound is made with a substantial posterior glottal chink, it is made with a less adducted cartilaginous glottis in breathy phonation compared to in the balanced phonation.[34]

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32 Herbst and Svec, "Adjustments of Glottal Configuration," 303.
33 Ibid.
34 Ibid, 304.

Vocal Tract Filtering

The sound produced at the larynx is the result of what Miller called "airflow and vocal fold approximation," and is modified by the vocal tract, the mechanism's "acoustic filter." Benade expressed that "the vocal tract… has the duty of transforming the rather simple airflow spectrum provided by the vocal cords into the recognizable acoustical patterns needed for speech and music."[35] Negus described the role of the resonators in creating vocal timbre in relation to the sound source: "the sound produced at the larynx is of itself feeble and of poor quality; it is by the resonators that amplification and modification are carried out, giving volume and character to the voice."[36] Indeed, these two systems are interdependent: alone, the resonation tract cannot produce any type of tone; it relies on the sound it is provided with from the larynx. Although the larynx is "the sound source" as per Miller's tripartite system, alone its sound is certainly of "feeble and poor quality." The singer's core timbre/unique vocal characteristics are reliant on both these aspects for the creation of sound, as well as its amplification and resonation.

Negus explained the process of phonation, from the sound source to the resonators: "the sounds produced in the larynx are amplified and selected in the pharynx, mouth and nose, and in the cavities some of the overtones can be strengthened while others are subdued or suppressed."[37] The shape and size of the tract determines the nature of the sound being produced. Singing requires a different type of control over the source and filter, the vocal

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35 Arthur H. Benade, *Fundamentals of Musical Acoustics* (New York: Oxford University Press, 1976), 369.
36 Negus, *The Comparative Anatomy and Physiology of the Larynx*, 144.
37 Ibid, 199.

tract, than speech.[38] In speech, the resonator does not need to be as expansive to create sound, because often in spoken communication the speaker does not need to project further than 1-2 meters ahead of them. In comparison, singing in the Bel Canto tradition requires projecting sound to fill a hall for the singer to portray a character and present their story. Furthermore, the opera singers' sound must also be able to cut through an orchestra before reaching the audience. In this case, it is crucial for the singer to know their voice and understand how to utilize their instrument efficiently to give an effective performance.

According to Miller, "by skillfully combining the resonating cavities, vocal timbre can be controlled."[39] Herbst and Svec defined voice timbre control through sound modifiers as "articulation by introducing changes into the vocal tract shape."[40] Each singer's natural vocal colour is influenced by their physiological build, including body structure, size of the vocal folds and their configuration, and supraglottal resonance characteristics.[41] In his book *Structure of Singing*, Miller acknowledged that the characteristics of each singer's voice differs, and each resonator is constantly varying in shape:

> "The timbre of vocal sound produced by the singer obviously varies. Differences in timbre have corresponding locations of resonance sensation. (Singers generally mean vocal timbre when they speak of "resonance.") The relative dimensions of the resonators of the vocal tract constantly change in response to phonetic articulation. Flexible adjustment of a resonator is more important than the resonator's absolute dimension."[42]

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38 Miller, *The Structure of Singing*, 48.
39 Ibid.
40 Herbst and Svec, "Adjustment of Glottal Configurations in Singing," 301.
41 Doscher, *Functional Unity of the Singing Voice*, 125.
42 Miller, *The Structure of Singing*, 57.

In the resonating tract, suppleness is also crucial because it is what allows the singer to make necessary adjustments for vowel integrity and intelligibility in the text.

A. G. Bell's description of the vocal tract in his book, *The Mechanism of Speech*, explains the connection between the creation of resonance in the vocal tract and timbre: "The upper part of the larynx, together with the pharynx… and mouth, constitutes a passage-way, or tube, of variable size and shape, through which the vibrating current air has passed. It is here that the voice is moulded, so to speak, on its way to the ear, and the quality or timbre of the voice."[43] According to Doscher , "the quality and focus of the vocal sound are determined in large measure by how efficiently the resonance components of the instruments are used."[44] The raw sound from the larynx is filtered in the vocal tract for resonance. In the vocal tract, the raw, buzzy sound from the sound source (larynx) is refined to produce the ringing, vibrant tone that fills performance halls. To recognize a student's core timbre, the pedagogue must understand the anatomy of the Vocal Tract and how to make adjustments to create space in the resonator and produce a vibrant tone.

Vocal tract resonance is determined by its length and shape. The vocal tract is a tube with the buccal cavity (mouth) as the opening on the open end and the glottis as the opening on the closed end.[45] In Bel Canto singing, almost everything in the mechanism widens, lengthens or expands: the embouchure is opened more than in speaking, the soft palate is

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43 Brad Story, "The Vocal Tract in Singing," in *The Oxford Handbook of Singing*, Ed. Graham F. Welch, David M. Howard, and John Nix (Oxford Library of Psychology: Oxford Academic, 2014), 146.

44 Doscher, *Functional Unity of the Singing Voice*, 98.

45 Ware, *Basics of Vocal Pedagogy*, 136.

raised in order to expand the back of the mouth, the pharynx is widened, and the larynx is lowered to lengthen the airway above the vocal cords (supraglottis).[46] Ware explained that "together, the laryngopharynx and oropharynx form the largest resonating cavity and have the greatest effect on tonal quality. The laryngopharynx extends from the base of the cricoid cartilage to the top of the epiglottis and includes the laryngeal collar, or epilaryngeal area. The larger oropharynx extends from the top of the epiglottis to the soft palate."[47] Titze compared these expansions for producing a fuller, richer sound to what wild animals do to make themselves bigger to protect themselves, as for example how lions and tigers lower their larynx 20-30cm and lengthen their supraglottal airways to make a roar.[48] Miller stated that "the supraglottic resonator system is a phonetic instrument that permits vowel definition, consonant formation, and general language perception. These functions are as necessary in singing as in speaking, and the same basic acoustic factors apply in song and speech."[49]

Acoustic adjustments are made through the relevant positions of the tongue, mandible, larynx, embouchure and velum and how they contribute to the overall shape of the airspace that goes from the vocal folds to the lips.[50] The vocal tract is the airspace that generates the "acoustic characteristics" of the sound pressure made by the singer. Control over vocal tract configuration is essential to creating the ideal acoustic characteristics of singing, as the acoustic properties and resonances produced influence clarity of vowels and sound

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46 Ingo R. Titze, "Space in the Throat and Associated Vocal Qualities," from *Journal of Singing 61* (2005), 499.

47 Ware, *Basics of Vocal Pedagogy*, 141.

48 Ibid.

49 Miller, *On the Art of Singing*, 50-51.

50 Story, "The Vocal Tract in Singing," 146.

quality (timbre).[51] There are various ways to position the vocal tract, including lowering the larynx and expanding the pharynx by raising the soft palate/velum and widening the sides of the pharynx. The singer can change the position of the articulators (tongue, lips and jaw), which are in charge of vowel formation.[52] The most important adjustment of the vocal tract is the position of the larynx (vertical), which significantly affects vocal colour.[53] Laryngeal positioning predisposes the quality of sound that is eventually filtered through the vocal tract. For example, if the singer employs a diffused onset, this quality of sound will result in a "hollow" tone as it is filtered through the resonator/vocal tract.

Vowels are produced by the combination of a sound source: the signal is the airflow pulses made by the opening and closing of the space between the vocal cords: the glottis, glottal flow and sound filter (the vocal tract, which is made up of the epilaryngeal, pharyngeal and oral cavities). Vocal tract shape creates a pattern of "acoustic resonances," which enhances some harmonics and suppresses others, as the source signal/wave advances through the vocal tract. With all of this in mind, the sound quality of a singer is a result of the interactions from the source to the filter.[54] Vocal tract configuration is heavily influenced by how the lips and tongue are positioned by the singer to create different vowels (see Appendix 1 at the end of the paper). In his book *Structure of Singing*, Miller explains the connection between vowels and the subsequent configuration of the vocal tract:

> "Specific vocal tract configurations, therefore, can be directly associated with vowel differentiation… These include the posture of the hump of the tongue in the vocal tract; the extent of constriction

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[51] Ibid.
[52] Stark, *Bel Canto*, 38.
[53] Ibid, 39.
[54] Story, "The Vocal Tract in Singing," 149.

between the tongue and the velum; length of the tongue in regard to constriction at certain points in the vocal tract; lip separation; lip rounding, jaw separation; velopharyngeal posture; and tongue constrictions which occur in some phonetic posture, as in the retroflex [ɝ] and [ɚ]. These variables can be joined, as, for example, in the extent of lip separation or rounding related to tongue or palate constrictions."[55]

Various vowels occur in different regions of the buccal cavity, configurating the Vocal Tract and drawing out various components of Garcia's four "tints," as described earlier in the paper. Some vowels take place at the front of the mouth, such as [i], [e], [ɛ] and [æ], utilize formants that naturally produce a brilliant sound with "ring." In contrast, back vowels, like [ɑ], [ɔ], [o] and [u], have lower formants and less brilliancy. (See Figure 2)[56] Consonants can be formed with the lips, the teeth, and the tongue. Such sounds are produced at the glottis and modified by the resonators.[57] Stark stated that "the vocal tract is indeed tractable. Adjustments to the vertical laryngeal position, the pharynx, the tongue, the jaw, and the lips can be coordinated with degrees of glottal closure to produce what Garcia called 'all the tints of the voice.'"[58]

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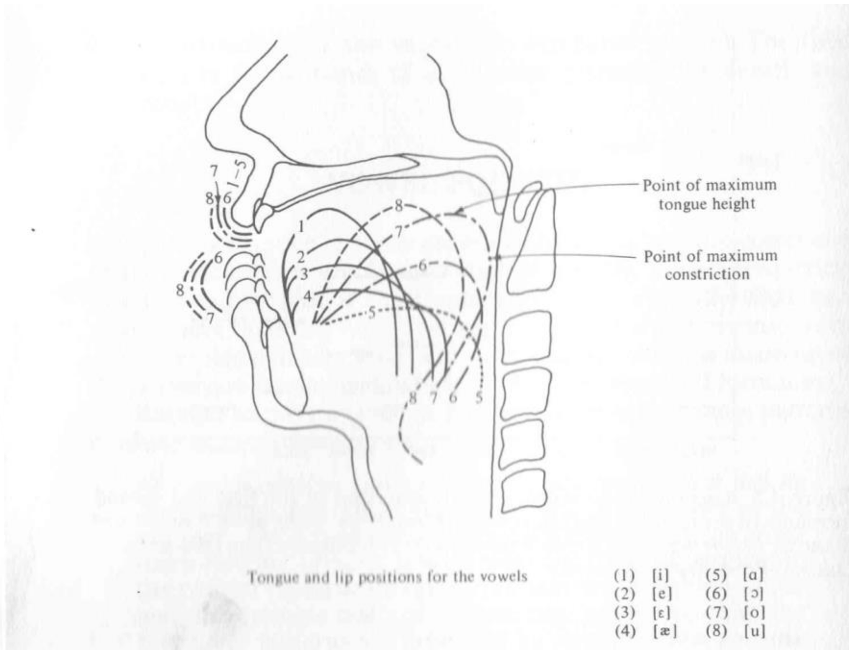
55 Miller, *The Structure of Singing*, 51.
56 Ibid, 150.
57 Negus, *The Comparative Anatomy and Physiology of the Larynx*, 117.
58 Stark, *Bel Canto*, 55-56.

Figure 3: Various positions of the tongue for different vowels[59]



Suggestions from voice teachers often used for establishing vocal tract alignment include imagining and imitating: 1) drinking water/drinking in the sound, 2) smelling a rose/fragrant scent, 3) suppressing a smile, 4) starting to sneeze, 5) pleasantly surprised sighing, saying "aw." These suggestions are images that portray "reflexive actions" and assist in aligning the musculature and organs of the vocal tract through subconscious rising of the soft palate, stretching of the anterior-posterior faucial pillars, and lowering of the larynx.[60]

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59 Negus, *The Comparative Anatomy and Physiology of the Larynx*, 117.
60 Ware, *Basics of Vocal Pedagogy*, 151.

Relation between Glottis and Vocal Tract

According to Miller, “the way to maintain good resonance balance is to properly adjust breath energy to mounting pitch so that there is an exact cooperation between air emission and vocal-fold closure. As pitch ascends, the elongation of the vocal folds and the diminution of the vocal-fold mass create greater resistance to the exit of breath. This constantly altering energy must be taken into account on all dynamic levels.”[61] A stabilized larynx that remains consistent and that does not move along with the pitch is what Miller called a “universal mark of good singing.” Successful singing is dependent on laryngeal action and the shapes of the resonating tract in response to that action.[62]

As mentioned earlier in the paper, Negus stated that although sound begins at the larynx, it is of weak quality until it passes through the vocal tract for resonation.[63] Ware defined tone quality as “a product of the glottal source spectrum modulated by the resonance in the vocal tract, which means that a singer’s vocal color is dependent on the unique vibratory patterns of the vocal folds combined with the distinctive properties of the vocal tract.”[64] He asserted that “beautiful vocal tone is the combined result of vocal-fold vibration and the way the glottal tone is shaped as it travels through the vocal tract.” The more harmonics are created by the instrument, the richer the tone. With resonance, stronger harmonics result in a fuller tone.[65] Miller spoke to the roles of the larynx, glottal source and vocal tract in creating vocal quality:

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61 Richard Miller, “Sotto Voce: Vocal Timbre in Piano Dynamic” in *Journal of Singing* (1996), 23

62 Miller, *On the Art of Singing*, 26.

63 Negus, *The Comparative Anatomy and Physiology of the Larynx*, 144.

64 Ware, *Basics of Vocal Pedagogy*, 189.

65 Ibid, 135.

> "The quality of voicing is dependent on what happens at the larynx (the vibrator), subglottically (below the larynx) with regard to pressure and airflow (the motor), and within supraglottic vocal tract filter (the resonator). No state relationship should exist between these contributors, not do the necessary changes among them occur in a state of muscle relaxation. A dynamic muscle balance ensures flexibility, and is dependent on an alert ready-for-action condition in the body."[66]

Indeed, Garcia observed a physical and acoustic phenomenon. These two systems are interdependent and are crucial to achieving flexibility in the vocal mechanism for a healty, vibrant tone. The relationship between the glottal source and the resonation tract must be consistently dynamic. As soon as the energy from the air supply drops, the vocal fold vibration cycle becomes more effortful and arduous, and consequently the resonation will lack vibrancy and become "dull," to use Garcia's words. Miller affirmed that "singing on the gesture of inhalation" (*appoggio*) is essential to efficiently producing a balanced tone.[67] Ware cautioned that insufficient air supply against excessive glottal closure will lend towards a "pressed" sound, whereas excessive airflow against insufficient glottal closure will result in a more "diffused" sound.[68] The quality of the breath and glottal closure will affect the sound that passes through the vocal tract, therefore *appoggio* is necessary to produce the balanced onset for the singer's vocal health.

The body must remain ready and available for the following phrase, rather than getting "stuck" or even collapsing. This state is necessary in order to achieve buoyancy and flexibility in the breathing mechanism for the most optimal released sound.[69] In Stark's

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66 Miller, *On the Art of Singing*, 253.
67 Miller, *Solutions for Singers*, 13-14.
68 Ware, *Basics of Vocal Pedagogy*, 107.
69 Miller, *On the Art of Singing*, 253.

words, “Garcia noted that as the larynx descends below the position of rest, the entire pharynx changes its conformation: the soft palate rises, the tongue flattens and becomes hollow along the mid-line toward the posterior part, the pillars of the fauces separate at their base, and the soft tissues of the pharynx gain greater tonus.”[70] Firm glottal pressure, a stabilized larynx, elevated soft palate and long resonating tube are the best combination for a balanced vocal quality. Garcia reiterated the need for balance in the singing mechanism:

> “The student should thoroughly understand that the ring or dulness [sic] of sound is, in effect and mechanism, completely distinct from the open and closed timbres. The ringing and dulness are produced in the interior of the larynx, independently of the position, high or low, of this organ, while the open or closed qualities of the voice require the bodily movement of the larynx, and of its antagonist the soft palate. Hence, any timbre may be bright or dull. This observation is most important for the expressive qualities of the voice.” (Garcia 1894, 12, from Hints on Singing)[71]

Garcia noted that, together with the theory of vocal timbres and breath management, proper glottal closure makes all the “tints” of the voice available to the singer and puts the singer in position for producing the optimal sound.[72] Stark observed “the crux of Garcia’s vocal method is found in the numerous ways the glottal source and the vocal tract interact in creating the ‘tints’ of the voice. In his Traité, he asserted that ‘the dullness of the voice is corrected by pinching the glottis vigorously.”[73]

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70 Stark, *Bel Canto*, 39.
71 Ibid, 37.
72 Ibid, 38.
73 Ibid.

Garcia expressed that the qualities of the four tints (éclatant/bright, soured/dull, clair/bright and sombre/dark) can be mixed together to produce a variety of vocal colours.[74] He observed that, while students were ascending the scale in chest voice with timbre claire, the larynx begins in a position that is a little lower than at rest, and when the pitches rise, so does the larynx, making the tone "thin and strangled." However, when singing in chest voice with *timbre sombre*, the larynx consistently stays below the position of rest. When the singer makes sound in the head register, the larynx rises again very quickly. Garcia explained that the clear and dark timbres can borrow from each other, leading to many possible vocal colours.[75] Combinations of these four "tints" would not only balance the quality of the tone, but also prevent unhealthy tendencies such as raising the larynx in ascending pitches.

To position for the best sound, voice teachers work to help students "optimize" their resonance and align their resonator. In order to achieve this, they identify the successful spectrum of vowels, balancing beauty of tone with vowel intelligibility. They ensure that the vowels track consistently at all pitches, discovering the core timbre in the student and finding the singer's formant.[76] It is the vocal teacher's responsibility to recognize their students' vocal core timbre as well as tendencies, to better discern how to "track" their vowels consistently, ensuring that the quality of their core sound stays consistent through their vocal range. With the voice teacher's role in mind, it is important to know which tools can be utilized to help students reach optimal resonance and understand the sensations of

74 Ibid, 36-37.
75 Ibid.
76 Points made by Professor Torin Chiles in Vocal Pedagogy 9510, UWO, 2022.

successful resonation. Such tools include breathing through a drinking straw before phonation, which helps widen the space in the vocal tract and lower the larynx for more potency in the singer's formant.

In their study examining various semi-occluded vocal tract (SOVT) methods, Guzman, Laukkanen, Krupa, Horáček, Švec, and Geneid, used a resonance tube and a much smaller opening, the stirring straw, to examine the vocal tract and glottal function during and after phonation. In this study, a classically trained male singer spoke the vowel [a], phonated with the same vowel into the resonance tube, and then repeated [a] after the exercise. Computerized tomography (CT) was performed throughout the study. After a fifteen-minute period of silence, the same exercise was repeated with a stirring straw. Information taken from the CT midsagittal and transversal images included anatomic distances and area measures, as well as acoustic, perceptual, electoglottographic (EGG), and subglottic pressure measures.

This study determined that, during and after phonation into the tube and straw, the velum closed the nasal passage more effectively, the laryngeal position was lowered, and the hypopharynx area widened. Furthermore, the ratio between the inlet of the lower pharynx and the outlet of the epilaryngeal tube was higher during and after tube and straw phonation. Acoustically, there was an improvement in vocal quality following the tube and straw exercises, as the singer's formant was more prominent. Subglottic pressure increased during straw phonation, and was maintained after the exercise. The researchers concluded that vocal exercises with "vocal tract impedance" give rise to "vocal efficiency and economy." These researchers noted increased prominence of the singer's formant. In addition, they observed that vocal tract and glottal modifications were more prominent during and after straw phonation, compared to tube phonation.[77] With these goals and useful tools in mind, it is crucial for the singing teacher to utilize vocalises to help students put into practice these concepts.

To understand how sound is filtered, the modern vocal pedagogue must understand the intricacies of vocal fold closure with appropriate subglottic pressure/transglottal flow. Knowledge of how different vocal qualities are produced at the glottal source and how different vocal qualities are made in the adduction of the vocal folds and filtered in the vocal tract for resonation are central to training aspiring singers. Ultimately, the voice student's progress is very much dependent on the experience, expertise, and discernment of the voice teacher, who can see what their talent naturally lends itself to. Although the student may be very diligent in their endeavours, without proper guidance all their efforts will be for naught. Raw talent alone is insufficient. The voice teacher's responsibility is to help students better understand the instrument they inherited and use it optimally to give a compelling performance in the healthiest way possible.

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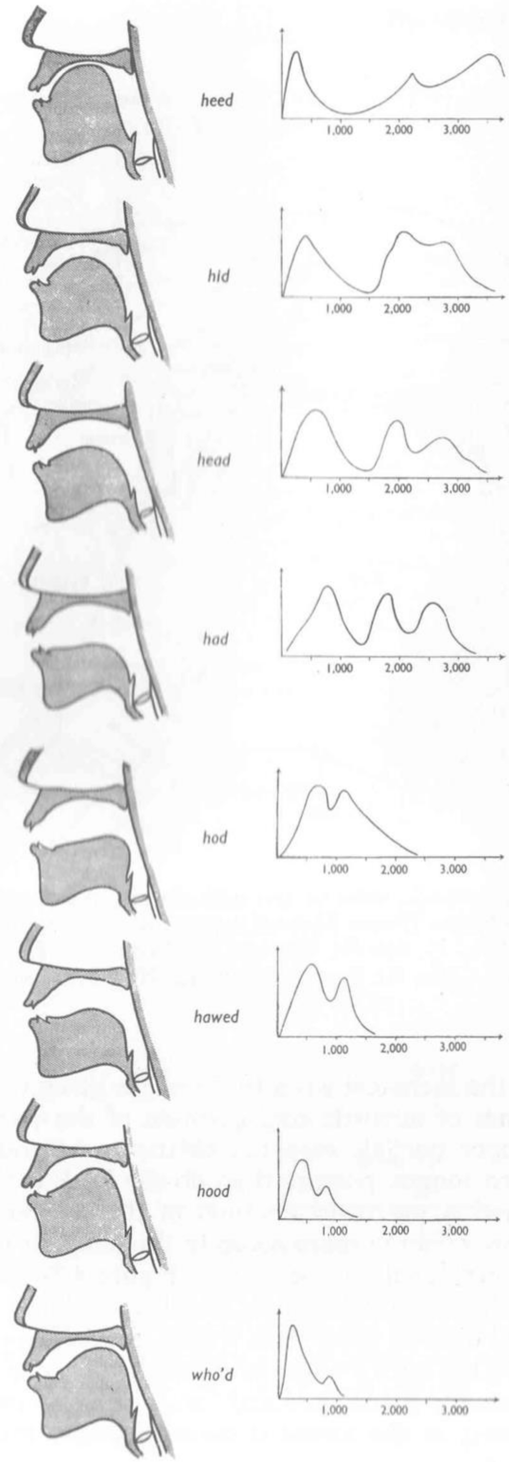
77 Marco Guzman, Anne-Maria Laukkanen, Petr Krupa, Jaromir Horáček, Jan G Švec, and Ahmed Geneid, "Vocal Tract and Glottal Function During and After Vocal Exercising With Resonance Tube and Straw," in *Journal of Voice 27*, ed. Robert Thayer Sataloff (Amsterdam: Elsevier Inc, 2013) 19.

Appendix 1:[78]



78 Miller, *Structure of Singing*, 54.

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