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Module 1 Assignment
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Exploring acoustic boosters in the soprano voice, with focus on tongue and jaw

There are those teachers who feel that applying science to an art is quackery, but I believe that our only safeguard against the charlatan is general knowledge of the most accurate information available - Vennard (1967, p. iii).

I am a soprano and my interest in voice pedagogy and acoustics began in my recent years as a teacher and performer. I began a doctorate investigating the influence of language on voice production in classical singing. Due to the lack of resources and limited knowledge in the subject, I went back to basics and instead began an MA in Voice Pedagogy to acquire a scientifically based understanding of pedagogy.

A good singer does not always make a good teacher. At the start of my vocal training, I was instructed by good singers who became teachers, to find resonance by “putting the sound in the head/nose”, “ignore the tongue”, “let it be/float” etc. Today we know that the feeling of placing the voice in the head is a byproduct of vibrations being felt, and rarely works when students try to search for the “placement” (Vennard, 1987; Miller, 2000; Chipman, 2008) potentially resulting in several vocal issues (Coffin, 1980). A good teacher knows what to do and why, and I wish to be able to be confident in teaching vocal resonance, hence this study.

The Critical Evaluation discusses acoustic boosting in lyric sopranos, and includes a strategy that has been devised for preparation of a recent performance of Musetta. At the age of 23 I sang Musetta in a staged production of *La Bohème* Act II with orchestra. Grateful for the opportunity, a combination of learning the role quickly and (needlessly) worrying about projecting over an orchestra resulted in my developing a wide vibrato tongue root tension that would plague me for the rest of my career.

Exercises were adapted from my training and what I have learned in the process of writing this essay. Having listened back to the performance, I can attest that the exercises have successfully helped me overcome old muscular habits, so I can recommend the strategy to fellow singers and teachers wanting to work on overcoming muscular habits and boosting acoustic energy in the soprano range.

CRITICAL EVALUATION

What is an Acoustic Boost in Opera Singing?

An increase in singer's formant level of 6 DB exhibits the presence of the singer's formant, a strategy used by opera singers to boost their sound and be heard above an orchestra (Sundberg, 2001). Barnes *et al*. (2004) investigated the existence of a singer's formant in sopranos in which the authors concluded that the skill of boosting energy in the high range is likely necessary for top-ranking operatic sopranos.

Chapman, who formed part of the Barnes *et al*. study, asserts that resonance "equates to loudness" (Chapman, 2017, p. 98). According to Chipman (2008) resonance should not be confused with power but is the result of "an open and free vocal tract coupled with sufficient breath energy", with singers achieving perfect balance between bright ("ring" or singer's formant") and "dark" – the so-called chiaroscuro (Chipman, 2008 p. 46; Miller, 2000).

Certain select terms refer to an acoustic boost, and will be used interchangeably throughout the essay. Amplitude is defined as a "spatial correlative of intensity", while intensity is the "energy of a sound wave", volume is "loudness" (Vennard, 1967. p. 234). Loudness is "the perceptual feature relating to the physical concept of intensity…intensity (power)…of a sound…usually measured in…decibals [dB]" (Laver, 1994, p. 501). In theatre terms, the word projection is often used, referring to their ability to carry the voice (Dayme, 1993), while Vennard calls it ring (1967).

Most of the literature suggests that loudness is a by-product of good singing, developed over time by singers as they learn to use their resonances correctly. According to Miller, "the singer should not strive for a bigger voice but for a complete sound based on proper airflow, acoustic definition, and vocal-fold freedom" (Miller, 2004, p. 172).

What is Resonance?

Resonance is defined as "sympathetic vibration of bodies capable of producing sounds as soon as a pitch similar to that of the body or one of its overtones is heard" (Kennedy and Joyce Bourne Kennedy, 1996, p. 602). Resonance is reinforced by a resonator, which is an acoustic tool shaped with a hollow, so the sound waves can be transmitted through the air (Apel, 1950).

Resonator: The Vocal Tract

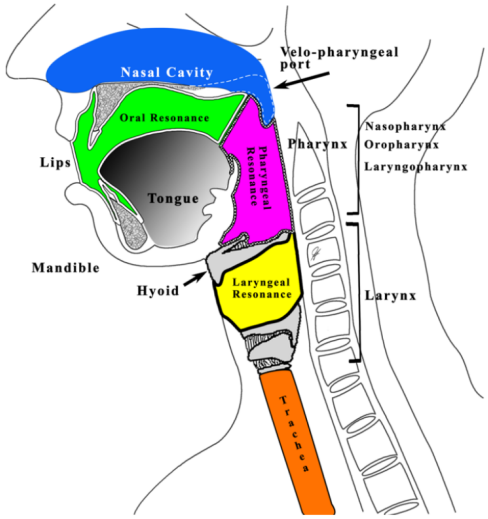


Figure 1. Side view of various resonance cavities (Nair, 2021, p. 79)

A resonator is a "secondary vibrator; specifically, that part of an instrument which reinforces the primary vibration" (Vennard, 1967, p. 237), which in this case, is the voice source produced by the vocal folds in the larynx. The resonator used to increase quality and loudness in vocal production is the vocal tract (Dayme, 1993). The vocal tract (Figure 1) with its areas of resonances and main articulators, is "a system of cavities, from the vocal folds to the lips, potentially including a nasal branch. It is a typical acoustic filter" since sound is generated at the vocal folds and sent towards the mouth and possibly the nose (Herbst and Švec, 2016, p. 76).

During speaking and singing, the vocal tract has three different resonance frequencies reacting with one another: pitch (fundamental frequency) and its harmonic resonances which are produced by the voice source; vocal tract resonances (natural resonances created by the shape of the vocal tract, which can be manipulated to an extent by the singer); and formants, which are selected resonance peaks in the vocal tract (Bozeman, 2013).

When air is passed through the vocal tract and pitch is produced, its harmonic (fundamental/overtone) is boosted as it comes nearer to a formant, resulting in an overall boosted resonance (D. G. Miller, 1987). Among the infinite number of formants, the most significant are the lower formant frequencies. F1 and F2 tune and shape vowels via the articulators including the jaw, tongue body/tip and lips. The jaw is particularly responsible for the F1, which raises with increased opening (Figure 2a and 2b); the shape of the body of the tongue largely influences F2; the tip of the tongue effects F3 (Sundberg, 1977). F1 determines "depth or fullness of timbre [and] warmth or roundness"; F2 determines vowel clarity and definition (Bozeman, 2013, p. 12).

By aligning formants with pitch, singers create acoustic boosts at c. 2-4 kHz, an area which the human ear is highly sensitive to. Since instruments lack frequency spectrum energy in this region, singers can carry their voice over orchestras in large halls, leading them to acquire significant vocal efficiency (Sundberg, 1977; Bozeman, 2013, 2017). This is often referred to as resonance tuning strategy (Irene and Harris, 2024). Resonance tuning strategies differ between low and high voices, particularly with increased frequencies into the high soprano range, suggesting this may have implications for pedagogical training (Herbst and Story, 2022). According to Schutte and Miller (1985), Rothenberg (1985), and Frant and Qi-guang (1985): when sopranos tune the first formant to a frequency slightly above the fundamental, it allows for more efficient breath use (Sundberg, 1987).

Acoustic efficiency increases size of voice by acquiring "proper spectral balance" (Miller, 2004, p. 172) and ensures the singer "avoids many of the muscular problems of hyperfunction and hypofunction [which] may result in stiffness of parts of the vocal tract, hoarseness, register problems, limitations of range, colour, poor vibrato, malfunction, and disfunction" (Coffin, 1980, p. xii). Furthermore, Dromey *et al*. (2009) suggest that the relationship between harmonic and formant resonances contributes towards an evenly produced vibrato with better amplitude (Patinka and Nix, 2020). Moreover, efficient resonation allows the singer to sing for hours without tiring the voice (Dimon, 2011) which, considering the average opera performance lasts almost three hours, and often follows an intensive rehearsal schedule, is important.

Acoustic Boosting in the Soprano Voice

Sundberg made huge strides in our understanding of soprano voice acoustics studying their resonance tuning strategies (Vos, 2018). As sopranos ascend into higher pitches, they match their first formant frequency to the fundamental (Figure 2a, 2b), increasing amplitude and generating a near effortless power boost (up to 30dB increase of sound pressure level) without vocal strain. Some sopranos further raise their first frequency formant by shortening their vocal tract via lip spreading (Sundberg, 1977). Miller explains of the "loud soprano top: when the F_o [fundamental frequency] (which is also the strongest harmonic of the voice source) is resonated by the F_1 [first formant] (the strongest, as well as the lowest, resonance of the vocal tract), conditions are right for the most efficient production of loud sounds." (Miller, 1987, p. 12).

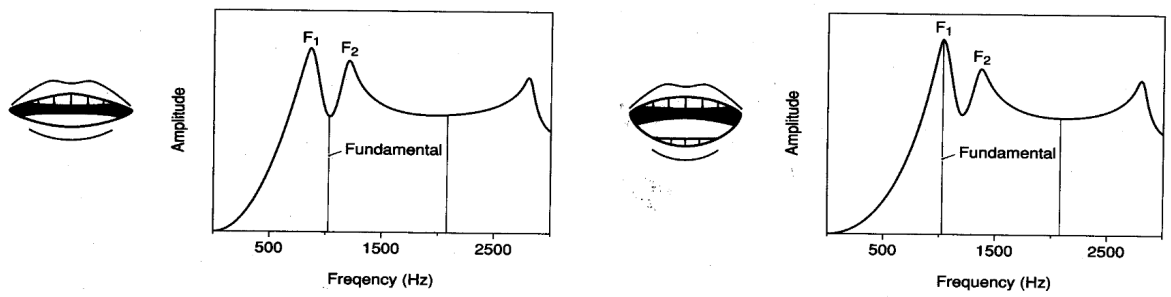


Figure 2a and 2b. Formant Tuning in Sopranos

Figure 2a depicts jaw with narrow opening, Figure 2b depicts jaw with wider opening, raising F1 to match F0. (slideplayer.com, 2011)

Sopranos typically have three formants that fall within audible range, and the Singer's Formant Cluster is sometimes adopted in middle and lower registers, whereby the F_1, F_2, and F_3 are matched to create a power boost thereby increasing amplification. This is achieved by lowering the larynx, opening the throat, and narrowing the epilarynx (ary-epiglottic muscle/sphincter) exit. According to Weiss *et al*., "the exact location of the singer's formant may vary depending on individual voice types and ranges, the vowels attempted, the pitch and amplitude produced, and individual physiology" (2001, p. 458) (Figure 3).

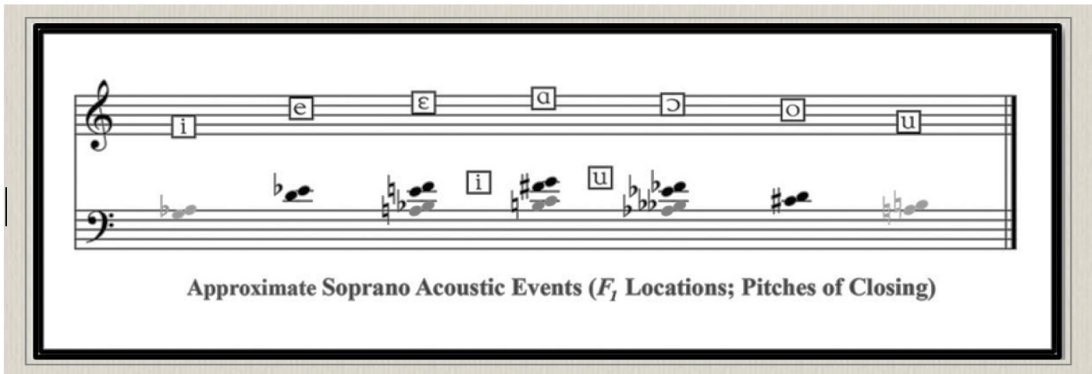


Figure 3. Approximate soprano acoustic events (Bozeman, 2021, p. 68).

Weiss *et al*. (2001) found little evidence in their study proving the presence of a singer's formant in sopranos, including in very high frequencies analysis, which is in line with research presented by Sundberg. It was suggested that sopranos do not need a singing formant since "much of the spectral energy produced by the voice at high pitch levels is already high-frequency energy of the fundamental and harmonics and becomes increasingly higher as the pitch is extended" (2001, p. 459; Bozeman, 2021). However, Weiss *et al*. assumed that the "tested voices would likely carry well in a concert setting" (2001, p. 467), sparking doubts regarding the subjects' level of professionalism.

By contrast, Barnes *et al*. (2004) subjects were national and internationally regarded operatic sopranos, including one superstar subject, defined as having a career performing at absolute top opera house levels as a soloist with large orchestral accompaniment, consistently, for over a period of 10 years. The presence of their singer's formant on the /a/ and /o/ back vowels was confirmed, with a link to the high range (2-4kHz) energy. Interestingly, although the star soprano was not perceived as loud by the researchers, the energy in her singer's formant frequency suggested high levels of projection suitable for the purposes of her work on operatic stages.

Articulatory Tools

Tongue, and the Importance of Tongue Shape

The tongue is a veritable stumbling block in the path of the singer
– Luisa Tetrazzini (Tetrazzini and Caruso, 1975)

Singers lack of self-awareness when it comes to tongue position and shape, since the proprioreceptors (nerve endings receiving stimuli from the body, particularly in response to position and movement) decreases towards the back of the tongue (Nair, Nair and Reishofer, 2016, Cambridge Dictionary, 2023). According to Kier & Smith (1985), the tongue is a muscular hydrostat, it retains its volume no matter what position it takes; while it is one of the most flexible organs in the body, the position of the tongue is very much influenced by movements of the jaw, which connects to its extrinsic muscles, thus influencing vowel and resonance. This requires that singers learn to "significantly rehabituate the use of the tongue [to be] far more active on the vertical plane". When combined with significant jaw opening, a technique that takes many years to achieve, it successfully increases intensity and diction clarity (Nair, 2021, p. 53).

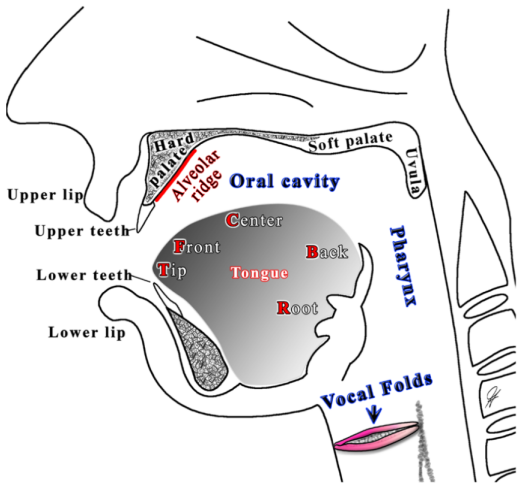


Figure 4. Left midsagittal image showing the articulators (Nair, 2021, p. 80).

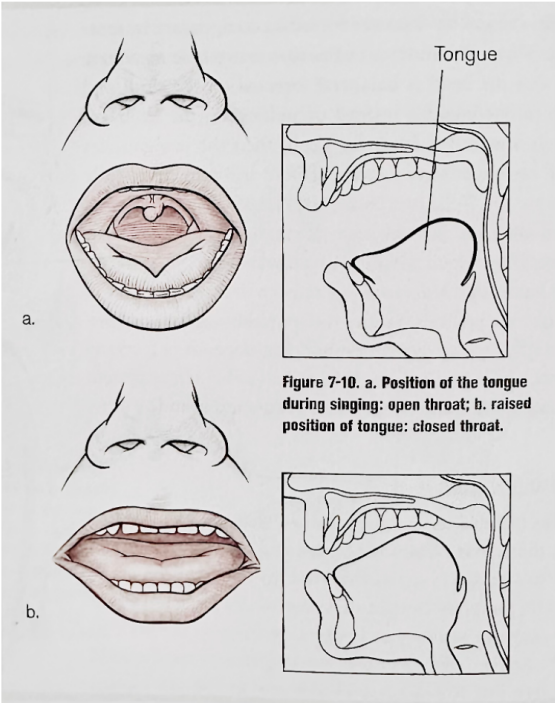


Figure 5. Tongue position showing open throat (a) and closed throat (b) (Dimon, 2011, p. 86).

The tongue is “one of the most versatile and mobile organs of speech” (Laver, 1994, p. 121). It has the most important role when it comes to adapting the size of the resonating chambers and forming vowels with its articulators to optimise resonances (Vennard, 1967) (Figure 4). During rest, the body of the tongue rests at the roof of the mouth against the hard palate, with the tip of the tongue behind the lower front teeth. During singing, the tongue drops with the jaw as the jaw opens, flattening and forming a slight groove” (Dimon, 2011, p.86) (Figure 5). Dimon (2011) uses the word “flattening”, and Vennard (1967) believes in allowing the tongue to be as low in the mouth as possible.

The idea of a low tongue could be misleading, and modern pedagogy would suggest caution in encouraging this notion, as it may cause tongue root tension resulting in a swallowed sound (Chapman, 2017). Since the tongue is connected to the soft palate, allowing depressed tongue root also encourages the palatoglossus muscle to pull down the velum (soft palate). Most pedagogues believe that raising the soft palate greatly aids in producing more “ring” in the tone by allowing increased resonance space and therefore increased volume, prevents extra air from escaping, and reduces nasality (Chapman, 2017, p. 95; Dayme, 2005; Vennard, 1967). Some studies (Figure 6) have shown that there could be some benefit to allowing a small narrowing to occur (Sundberg *et al*., 2007; Brian P. Gill *et al*., 2018). Birch *et al.* (2002) analysed VPO (velopharyngeal opening) in 17 professional operatic singers (including 6 sopranos), and while they found difficulty in determining resonance advantage with VPO presence, they suggested that VPO does not necessarily cause a nasal quality, and controlling the degree of opening may influence timbre colour and improve singer’s formant presence.

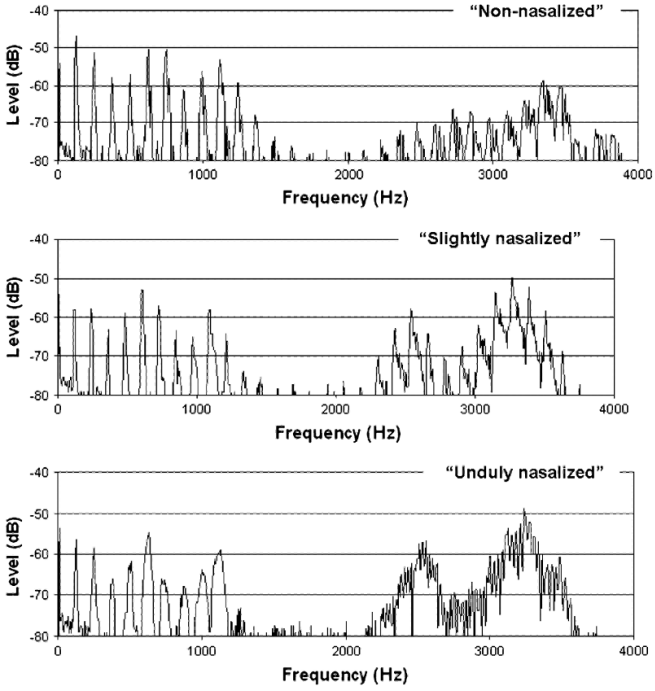


Figure 6. Graph depicts frequency and decibels on non-nasal, slight nasal, and unduly nasal qualities sung on /a/ vowel (Sundberg *et al*., 2018, p. 128).

Dimon (2011) highlights the importance of the tongue contributing towards the highly sought after "megaphone shape", that is "higher in back and sloping downward to create a fairly large opening for the mouth" for a neutral /a/ vowel, however raising the tongue produces a "more strident or pinched tone" (Dimon, 2011, p. 86). Much of the literature leans towards encouraging the tongue to be free and in a relaxed position. Tongue tension seems to be blamed for many vocal issues, including "articulation, resonance, and efficiency of phonation", and allowing the tongue "to have a thick, full presence in the mouth" is only the initial stage of vocal development, prior to learning how to use it efficiently (LeFevre, 2011, p. 157). Obert (2022) asserts that the tongue should not be ignored, and the singer should learn to use it.

Jaw and Mouth Opening, their effect on resonance, and the Lower Mandible Maneuver

Most authors agree that a certain degree of mouth opening is necessary, but how much seems to be the debating factor. Miller asserts that there is no steadfast rule for jaw and mouth position, and its opening depends on "the vowel, the consonant, the tessitura, and the intensity level" (Miller, 2000, p. 83). Titze (2012) agrees that mouth opening increases power. However, according to Chapman (2017), when singing teachers teach their students to open their mouth wide to increase loudness, it can have a negative effect on the pharynx by making it smaller. Applying forceful movement can jam and tense the temporomandibular joint (TMJ) (Vennard,

1967; Miller, 1996; Dimon, 2011; Nair, 2021). While Chapman suggests to “drop the jaw back and down rather than jutting it forward” (Chapman, 2017, p. 94), Dimon goes on to suggest that due to the tendency to retract the jaw, it is best to first open slowly and allow the jaw to hang – it “not only hinges but glide” forward, preventing the TM joint jam and allowing the jaw to open more fully. A pocket just in front of the lower ear should be felt (Dimon, 2011, p. 84). Vennard (1967) suggests feeling as though the jaw “hangs down of its own weight”, and to avoid compression of the larynx, the head needs to be a little forward. While some singers barely need to open the jaw, the preference is for significant opening of the lower jaw. Miller asserts that a “hung jaw” does not necessarily mean the jaw is free of tension and may result in rigidity; rather, encouragement of free organic movement with text is suggested (1996, p. 268).

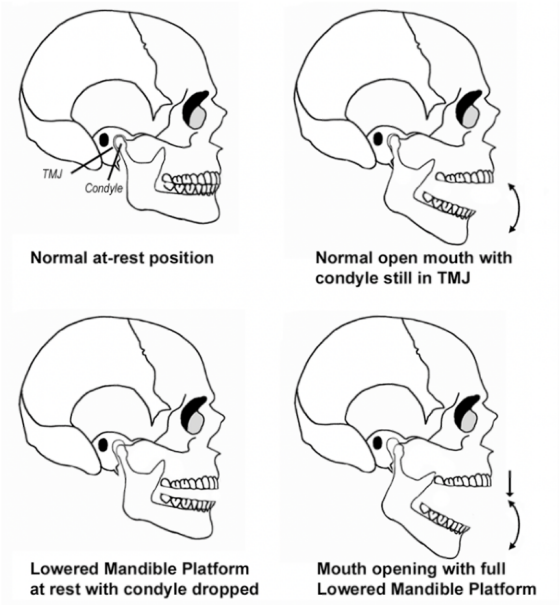


Figure 7. Top skulls show jaw at rest, bottom skulls show low mandible maneuver with condyle dropped (Nair *et al*., 2016, p. 128.e17)

A study was carried out where measurements of the Lower Mandible Manoeuvre (LMM) were obtained by analysis of elite singers via video material (Nair *et al*., 2015). The LMM refers to the opening acquired in the “first 10% of the yawn sequence in which the entire mandible platform drops” via rotation of the condyle (Figure 7), creating significant increase of oral space, together with an increase in pharyngeal space, since the hyoid bone and larynx drop, contributing towards a lengthening of the pharynx (Nair et. al, 2015, p. 128e16). The study observed that a high percentage of elite singers opened their mouth more than those of lesser rank, with a clearly lowered “posterior mandible (the angle of the ramus)”. Nair *et al*. believe that this manoeuvre contributes towards the tonal success of elite singers. For this reason, Nair *et al*. believe that using the yawn analogy could be a useful tool in helping the singer achieve the correct motion (2015).

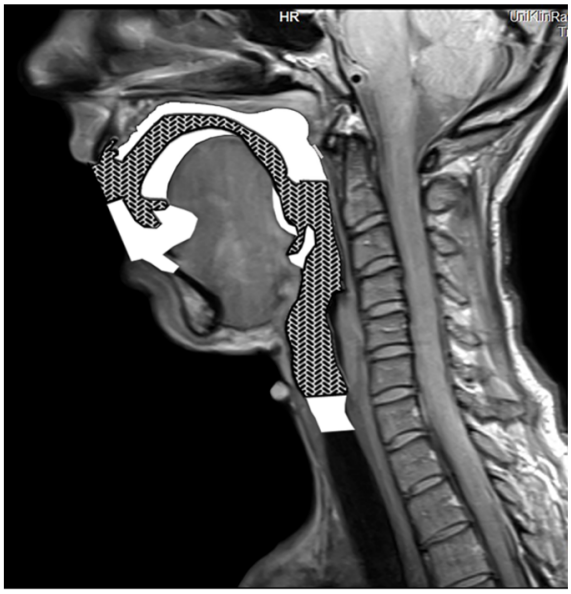


Figure 8. LMM showing increase in vocal resonance. The darkly shaded area shows a sung /i/ without LMM, the white area shows the increased resonance spaces with the LMM (Nair *et al*., 2016, p. 128.e.23)

Nair (2021, p. 49) asserts that there are two LMM strategies:

1. "The drop of the entire jaw platform; and
2. The drop of the posterior part of the mandible"

In both strategies, the first harmonics, the singer's formant, and the intensity are increased, thus providing useful acoustic boost (Figure 8).

Acoustic Boosting: A Devised Strategy

"*The teacher's goal is not to enlarge the voice but to free it,*
so that its full dimensions can be heard" ~ Miller (2004, p. 172)

We have seen that movement and flexibility in the tongue and jaw are of utmost importance in finding freedom and optimal boosting within shapes, which positively impacts resonance. A strategy has been devised to help achieve this, consisting of basic stretching exercises which encourage release of tension, allow for free and maximum opening, resulting in boosted formants. For a fully comprehensive warm up strategy, please refer to Appendix A.

Tongue Stretches

Start your warmup with some tongue stretches (LeFevre, 2017; Nair 2021). Please refer directly to the authors for more detailed exercises in releasing tongue tension.

- Waggle the tongue from side to side, from one corner to the other.
- Waggle the tongue up and down. As your turn it up and towards the back of the mouth, bite the underside of the tongue.
- Keep tip of the tongue behind upper teeth (alveolar ridge) while opening and closing the jaw.
- Pull the tongue out of the mouth (a) while holding the tip (b) root of tongue (Figure 9).

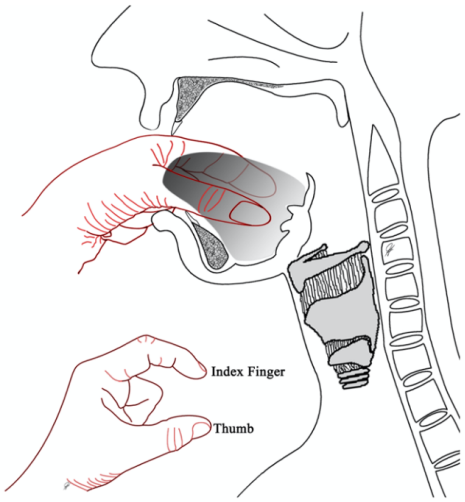


Figure 9. Tongue root pull (Nair, 2021, p. 62)

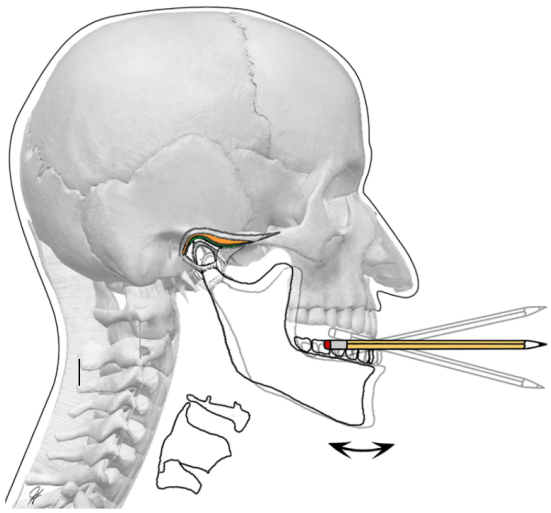


Figure 10. Pencil exercise to help drop back of the jaw (Nair, 2021, p. 51)

Jaw Stretch and Opening

Some strategies can help find/correct jaw opening (Chapmen, 2017; Nair, 2021). Choose from one of the following as part of your daily routine to find comfortable jaw position and best starting sound.

- Press the teeth together, place fingers externally on the back of the teeth. Gently open the back teeth with your fingers, as comfortable far as they can go, while externally massage the TMJ.
- Place a pencil behind your front teeth (Figure 10). Feel the condyle bulging and gliding forward as you slowly move the jaw back and forward. This should cause larynx to drop, with elongation in / opening of the pharynx and posterior oral cavity. Sing a comfortable pitched note to see if you can feel a more resonant sound, while recording it, can you hear the difference?

Conclusion

Table 1 seeks to present the complex nature of acoustics in a simple format as an alternative for those struggling to understand acoustics and use of acoustic boosting tools, with information that has been gathered from various sources that were used in the writing of this essay. I have yet come across anything of the sort, and as my research progresses, I will continue to develop and expand it.

Articulatory Tool	Position	Movement	Formant Result
Jaw Opening	Narrow	Closes Vowel	Maintains Low F1
	Wide	Opens Vowel	Raises F1
Lips	Round	Lengthens Lateral Cavity	Lowers both Formants, especially F1
	Spread	Shortens Lateral Cavity	Raises both formants, especially F1
Tongue	Low	Opens Vowel	Raises F1
	High	Closes Vowel	Lowers F1
	Back	Lengthens Lateral Cavity via Large Frontal Space and Small Back Space	Raises F1 / Lowers F2
	Front	Shortens Lateral Cavity via Small Front Space and Large Back Space	Lowers F1 / Raises F2

Table 1. Articulatory tools showing jaw opening, lips, and tongue position, and its effect on formants.

We have investigated how shaping the vocal tract, in particular the tongue and jaw, positively/negatively affects resonance and acoustic boost, and that sopranos open their jaw to increase their first formant and maintain a frequency at/just above that of their fundamental (Sundberg, 1975). This study has reaffirmed and increased confidence in my understanding of tongue position and required jaw space to facilitate acoustic boost. It has also helped me develop and refine exercises to increase acoustic boost.

CRITICAL REFLECTION

Following submission of the Formative Assignment, I needed a mental break given the dense content regarding acoustics. I struggled to read alongside performance audition preparations, so I considered changing topic, but no other subject drew my interest as much as soprano acoustics. Discussing topic conundrum with my tutor was a turning point for me; the suggestion that I approach the assignment from a pedagogical aspect was extremely helpful and allowed for my mind to begin mentally reframing the essay structure. I began asking questions and taking various notes during my own practice, processing the work mentally. During the Critical Reflection group session, the reflective model by Ghaye (2010) immediately stood out for me. Since I tend to fall into negative thought patterns, common in individuals with ADHD (Onebright, 2023), the creative, therapeutic, and optimistic elements of this approach felt appropriate.

As per my tutor's feedback on the Formative Assignment, I read almost cover to cover, three dense sources by Sundberg (1977), Vennard (1967) and others. I also began Coffin's *Overtones of Bel Canto* (1995), a hugely complex book, containing concepts I look forward to grasping. As I reflect on this process, I noticed how much I enjoyed having print books and highlighting (rather than reading from my laptop or iPad). I took notes on my laptop, and iPad while reading and watching VSC lectures.

Throughout the reading process, I constantly reflected upon my own singing and teaching, and how I relay information to students. Having an active career makes it is necessary to keep up my own training. I mentioned earlier on that I was preparing for the role of Musetta which was partly full of old habits. One coach commented on the different sound I was producing in Act II, without knowing that I had sung it many years ago. I therefore made it my mission to test out what I was learning and reading by applying it to my role preparation. In this way, the process by which I created the devised strategy and used what I was learning in my role preparation was very much reflection-in-action:

> *When a practitioner sees a new situation as some element of his repertoire, he gets a new way of seeing it and a new possibility for action in it, but the adequacy and utility of his new view must still be discovered in action. Reflection-in-action necessarily involves experiment*.
>
> - Schön (1992, p. 141)

I was particularly vindicated on three occasions: First, my coach of several years suggested that the MA is helping me on my own singing path; second, as is customary to discuss everything singing in productions, my colleagues said I have good vocal placement, vowels, open sound, and a loud voice; thirdly, I received an excellent review in a well-respected Italian magazine by an Italian critic, following the performance.

Unfortunately, having ADHD makes it difficult to find a moment of focus and increases anxiety (NHS, 20210). While I had every intention of working on the essay long before the deadline, health and family troubles made it difficult to find the emotional and mental space to focus on scientific aspects of such a complex subject. This was all happening alongside preparing to debut as Musetta on my home turf, where I felt I was being given the chance to prove myself. I was having persistently anxious thoughts to give up the course; I kept recalling the anxiety of starting and stopping my PhD, but also the regret that came with it. I wanted to give myself the space to continue, so I requested a deadline extension.

The more I read, the more I am fascinated, and the more I am convinced that I need to find a better way to cope to give myself the best chance of completing the course, which I am determined to do. I have put together a Personal Development Plan which includes steps to help make this journey more manageable, providing more enjoyment in the process. I take great satisfaction in the knowledge that I am pursuing a course that is providing me with great insight into my own singing as a performer, helping me to explore areas such as acoustic boosting, whilst also putting me on a long-term trajectory to be a good voice pedagogue.

Personal Development Plan

Overall goal	Development opportunity to meet overall goal	Specific actions taken to achieve goal	Resources and support needed	What would success look like	Target date for completion
Cover the basics of pedagogy without further procrastination	Become a better teacher	Construct plan for watching VSC videos, both relevant to my research, and those of interest as a pedagogue to help in my teaching	Ask VSC for help with structured plan to build up foundation pedagogy	Have a structure in place; watched planned VSC videos	December 2024
Achieve more knowledge in acoustics, vowels, and consonants	Will make my research better	Plan books and papers to read/understand, including: -D.G. Miller's *Resonance in Singing* -B. Coffin's *Overtones of Bel Canto* -Howell's work	Library Resources; own resources and purchases	Having read all the most important literature	April 2025
Network	Will help my own research; build visibility within the community	Reach out to / Communicate with researchers in the singing science community	Ask VSC to make introductions; reach out via ResearchGate; check out their research and websites	Having developed a list of people potentially interested in collaboration	August 2025
Private Teaching	Increasing my visibility as a private teacher	Promote myself on SM platforms and teaching websites	Reaching out/Word of mouth	Increased requests for singing lessons and increased number of students.	December 2025

References

Apel, W. (1950). *The Harvard Dictionary of Music*. Cambridge, Massachusetts: Harvard University Press.

Birch, P., Gümoes, B., Stavad, H., Prytz, S., Björkner, E. and Sundberg, J. (2002). Velum Behavior in Professional Classic Operatic Singing. *Journal of Voice*, 16(1), pp.61–71. doi: https://doi.org/10.1016/s0892-1997(02)00073-5.

Barnes, J.J., Davis, P., Oates, J. and Chapman, J. (2004). The relationship between professional operatic soprano voice and high range spectral energy. *The Journal of the Acoustical Society of America*, 116(1), pp.530–538. doi: https://doi.org/10.1121/1.1710505.

Bozeman, K. (2013). *Practical vocal acoustics: pedagogic applications for teachers and singers*. Hillsdale, NY: Pendragon Press.

Bozeman, K. (2017) VOICE PEDAGOGY The Pedagogic Use of Absolute Spectral Tone Color Theory. *Journal of Singing*, 74(2), pp. 179–183. Available at: https://www.nats.org/_Library/JOS_On_Point/JOS-074-2-2017-179_-_Kenneth_Bozeman_-_Voice_Pedagogy.pdf (Accessed: 18 January 2024).

Bozeman, K. (2021). *Kinesthetic voice pedagogy 2 : motivating acoustic efficiency*. Gahanna, Oh: Inside View Press.

Cambridge Dictionary (2023). *Cambridge English Dictionary: Meanings & Definitions*. Cambridge.org. Available at: https://dictionary.cambridge.org/dictionary/english/ (Accessed: 10 April 2024).

Caruso, E. and Tetrazzini, L. (1975). *Caruso and Tetrazzini On the Art of Singing*. Dover Publications, Inc.

Chapman, J.L. and Morris, R. (2017). *Singing and teaching singing : a holistic approach to classical voice*. 3rd ed. San Diego, Ca: Plural Publishing.

Chipman, BJ (2008) *Singing with Mind, Body, and Soul: A Practical Guide for Singers and Teachers of Singing*. Tucson, Arizona: Wheatmark, Inc.

Coffin, B. (1995). *Coffin's Overtones of Bel Canto*. Scarecrow Press.

Dayme, Meribeth Bunch (1993). *Dynamics of the singing voice*. 2nd, revised ed. Wien ; New York: Springer.

Dimon, T. (2011). *Your Body, Your Voice*. North Atlantic Books.

Ghaye, T. (2010). Teaching and Learning through Reflective Practice: A Practical Guide for Positive Action (2nd ed.). Routledge. doi: https://doi.org/10.4324/9780203833322.

Gill, B.P., Lee, J., Lã, F.M.B. and Sundberg, J. (2020). Spectrum Effects of a Velopharyngeal Opening in Singing. *Journal of Voice*, 34(3), pp.346–351. doi: https://doi.org/10.1016/j.jvoice.2018.11.014

Graf, S., Schwiebacher, J., Richter, L., Buchberger, M., Adachi, S., Mastnak, W. and Hoyer, P. (2020). Adjustment of Vocal Tract Shape via Biofeedback: Influence on Vowels. *Journal of Voice*, 34(3), pp.335–345. doi: https://doi.org/10.1016/j.jvoice.2018.10.007.

Herbst, C.T. and Story, B.H. (2022). Computer simulation of vocal tract resonance tuning strategies with respect to fundamental frequency and voice source spectral slope in singing. *Journal of the Acoustical Society of America*, 152(6), pp.3548–3561. doi: https://doi.org/10.1121/10.0014421.

Herbst, C.T. and Švec, J. (2016) 'Basics of Voice Acoustics – A Tutorial', in R.T. Sataloff and M.S. Benninger, (eds) *Sataloff's Comprehensive Textbook of Otolaryngology: Head & Neck Surgery (Laryngology) - Volume 4*. New York: Jaypee Brothers Medical Publishers, pp. 63–80. doi: https://doi.org/10.5005/jp/books/12711_7.

Kennedy, M. and Joyce Bourne Kennedy (1996). *The Concise Oxford Dictionary of Music*. Oxford ; New York: Oxford University Press.

Irene, L. and Harris, D. (2024). *Acoustic Strategies*. VoiceScienceWorks. Available at: https://www.voicescienceworks.org/acoustic-strategies.html (Accessed: 5 May 2024).

Laver, J. (1994). *Principles of phonetics*. Cambridge: Cambridge University Press.

LeFevre, C. (2011) 'Tongue Management', *Journal of Singing*, 68(2), pp. 157–162. Available at: https://search-ebscohost-com.ezproxy.uwtsd.ac.uk/login.aspx?direct=true&db=eue&AN=525580784&site=ehost-live (Accessed: 10 April 2024).

LeFevre, C. and McCoy, S. (2017) 'Tongue Management, Part 2', *Journal of Singing*, 74(1), 51-55. Available at: https://link.gale.com/apps/doc/A624031675/HRCA?u=anon~b626e1e&sid=googleScholar&xid=2c90cfb3 (Accessed 22 April 2024).

Miller, D. G. (1987) Some observations on the soprano voice. *Nature*. 43. 12-15. Available at: https://www.researchgate.net/publication/285460125_Some_observations_on_the_soprano_voice (Accessed: 17 January 2024).

Miller, R. (1996). *On the Art of Singing*. Oxford University Press. doi: https://doi.org/10.1093/acprof:osobl/9780195098259.001.0001.

Miller, R. (2000). *Training soprano voices*. New York: Oxford University Press.

Miller, R. (2004). *Solutions for singers : tools for performers and teachers*. Oxford ; New York: Oxford University Press.

Nair, A. (2021) *The tongue as a gateway to voice, resonance, style, and intelligibility*. San Diego, CA: Plural Publishing.

Nair, A., Nair, G. and Reishofer, G. (2016). The Low Mandible Maneuver and Its Resonential Implications for Elite Singers. *Journal of Voice*, 30(1), pp.128.e13–128.e32. doi: https://doi.org/10.1016/j.jvoice.2015.03.010.

NHS (2021). *Symptoms - Attention Deficit Hyperactivity Disorder (ADHD)*. NHS. Available at: https://www.nhs.uk/conditions/attention-deficit-hyperactivity-disorder-adhd/symptoms/ (Accessed: 7 May 2024).

Nix, J. (2016) 'Closing your mouth to "open" your sound', *Journal of Singing*, 73(1), pp. 35–41. Available at: https://link.gale.com/apps/doc/A464354556/HRCA?u=anon~e3271b2&sid=googleScholar&xid=22b1a0c6 (Accessed 22 April 2024).

Obert, K. (2022). *A Tonguecentric Conversation About This Important Structure With Kerrie Obert*. *Voice Study Centre*. Available at: https://voicestudycentre.instructure.com/ (Accessed 5 April 2024).

Onebright (2023). *Adult ADHD: Overthinking and Intrusive Thoughts*. Onebright. Available at: https://onebright.com/advice-hub/news/adult-adhd-overthinking-and-intrusive-thoughts/ (Accessed 7 May 2024).

Patinka, P.M. and Nix, J. (2020) 'changes in vibrato rate, vibrato extent, and vibrato jitter in soprano voices in response to changes in mouth opening: a pilot study', *Journal of Singing*, 77(2), pp. 213–218. Available at: https://search-ebscohost-com.ezproxy.uwtsd.ac.uk/login.aspx?direct=true&db=eue&AN=146962765&site=ehost-live (Accessed: 18 January 2024).

Schön, D.A. (1992). The Reflective Practitioner: How Professionals Think in Action (1st ed.). Routledge. doi: https://doi.org/10.4324/9781315237473.

Sundberg, J. (1975). Formant Technique in a Professional Female Singer. *Acta Acustica united with Acustica*, 32(2), pp.89–96. Available at: https://www.ingentaconnect.com/content/dav/aaua/1975/00000032/00000002/art00006# (Accessed 7 May 2024).

Sundberg, J. (1977). The Acoustics of the Singing Voice. *Scientific American*, 236(3), pp.82–91. Available at: https://www.jstor.org/stable/24953939 (Accessed: 26 January 2023).

Sundberg, J. (1987). *The science of the singing voice*. DeKalb, Illinois: Northern Illinois University Press.

Sundberg, J. (2001). Level and Center Frequency of the Singer's Formant. *Journal of Voice*, 15(2), pp.176–186. doi: https://doi.org/10.1016/s0892-1997(01)00019-4.

Sundberg, J., Birch, P., Gümoes, B., Stavad, H., Prytz, S. and Karle, A. (2007). Experimental Findings on the Nasal Tract Resonator in Singing. *Journal of Voice*, 21(2), pp.127–137. doi: https://doi.org/10.1016/j.jvoice.2005.11.005.

Titze, I. (2012). "Why Do Classically Trained Singers Widen Their Throat?" *Journal of singing*, 69(2). doi: https://doi.org/info:doi/.

Vennard, W. (1967). *Singing : the mechanism and the technic*. New York: Carl Fischer.

Weiss, R., Brown, W.S. and Moris, J. (2001) Singer's formant in sopranos: fact or fiction? *Journal of Voice*, 15(4), pp. 457–468. doi: https://doi.org/10.1016/s0892-1997(01)00046-7.

APPENDIX A

A comprehensive warm up prior to boosting resonance in the upper register

This warmup strategy consists of articulatory exercises which focus on releasing tension in preparation for conscious use in vowel and consonant production, starting with the lower and middle registers, then moving into the upper registers. These exercises have been developed via my own training over the years, through lessons (as a teacher and student), and are supported by existing research. Credit is given where it is due. It is best to practise in front of a mirror to monitor any potential additional tension arising from performing the exercises.

Step 1: Tongue Stretches (as seen in essay strategy)

Start your warmup with some tongue stretches (LeFevre, 2017; Nair 2021). Please refer directly to the authors for more detailed exercises in releasing tongue tension.

- Waggle the tongue from side to side, from one corner to the other.
- Waggle the tongue up and down. As your turn it up and towards the back of the mouth, bite the underside of the tongue.
- Keep tip of the tongue behind upper teeth (alveolar ridge) while opening and closing the jaw.
- Pull the tongue out of the mouth (a) while holding the tip (b) root of tongue (Figure 9).

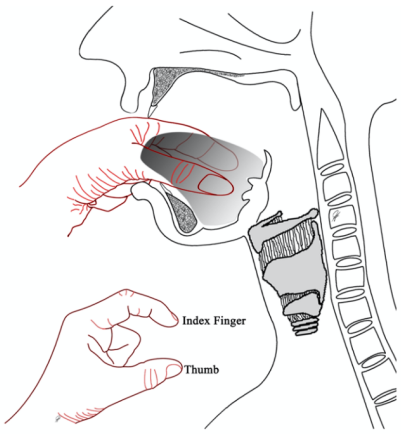
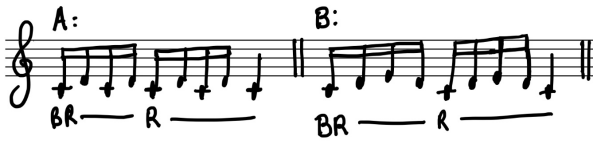


Figure 9. Tongue root pull (Nair, 2021, p. 62)

Step 2: SOVT Exercises

Please refer to Nix (2016) for benefits of SOVT exercises, which are known to help in coordinating breath energy with high spectral frequency, resulting in acoustic boosts. A table outlining categories of SOVT Exercises have also been provided in Appendix B.

- The Raspberry. First unvoiced, then voiced, into a siren.
- Lip Trill (i.e. Lip Buzz / BRR). First unvoiced, then voiced.
- Tongue Trill (Rolled R). Voiced, siren.
- Lip Trill following by a Tongue Trill first on two note (A), then on three note (B) sequence, ascending and descending, covering lower and middle registers. If the singer is a young high soprano, start on E flat, E, or F, as the low register will take time to develop.



Step 3: Jaw Stretch and Opening (as seen in essay strategy)

Some strategies can help find/correct jaw opening (Chapmen, 2017; Nair, 2021). Choose from one of the following as part of your daily routine to find comfortable jaw position and best starting sound.

- Press the teeth together, place fingers externally on the back of the teeth. Gently open the back teeth with your fingers, as comfortable far as they can go, while externally massage the TMJ.
- Place a pencil behind your front teeth (Figure 10). Feel the condyle bulging and gliding forward as you slowly move the jaw back and forward. This should cause larynx to drop, with elongation in / opening of the pharynx and posterior oral cavity. Sing a comfortable pitched note to see if you can feel a more resonant sound, while recording it, can you hear the difference?

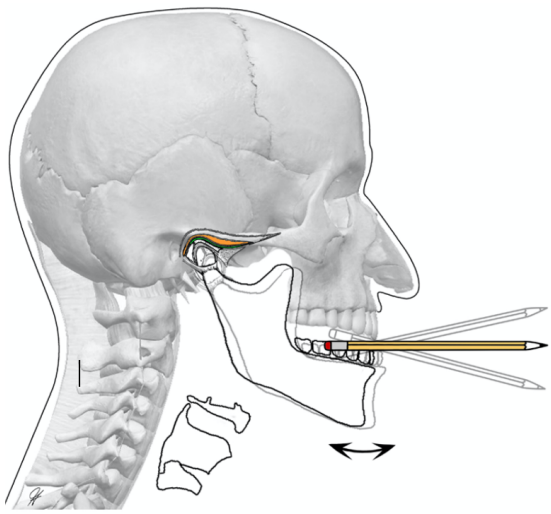


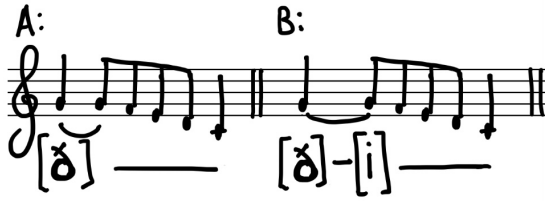
Figure 10. Pencil exercise to help drop back of the jaw (Nair, 2021, p. 51)

Step 4: SOVT + Vowels

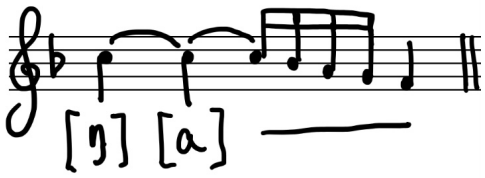
Now introduce vowels with the SOVT exercises:

- Lip Trill, Tongue Trill, and into /i/ vowel, on 5 note scale sequence ascending and descending. Feel the jaw slowly drop as you go from Tongue Trill into /i/ vowel. Bite tongue during Lip Trill. (Exercise courtesy of Nelly Miricioiu's Studio).

- Five note descending scale on /ð/ (A); then starting on /ð/ and releasing into /i/ (B). (Exercise from Yvonne Kenny's Studio).

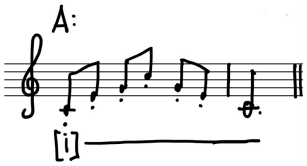


- Five note descending scale on /ŋ/, dropping the jaw as much as you need for the /a/, feeling the vibration sensations filling into the backspace (Chipman, 2008, p. 49).

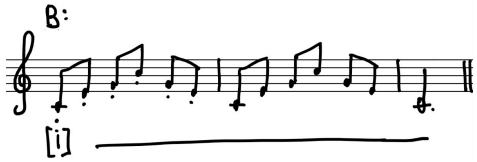


Step 5: Arpeggio into the Upper Range

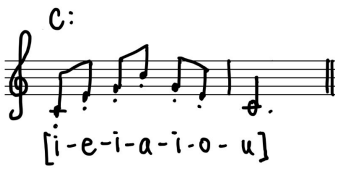
- Arpeggios should start from the lower range, extending into the high range, and back down again, ideally flowing continuously without rest in between. Arpeggio A is the most basic in staccato form. The jaw will naturally start to open the higher into the tessitura the singer goes, and the vowel /i/ will begin to modify and take more of an /E-a/ colour. Once the higher register has been approached, and it is time to turn back down towards the middle and lower registers, without being uncomfortable, try to retain the jaw opening (within reason), making sure not to tense, and making sure that the tongue does not drop on the way down.



- For an additional challenge, add the legato sequence (B).

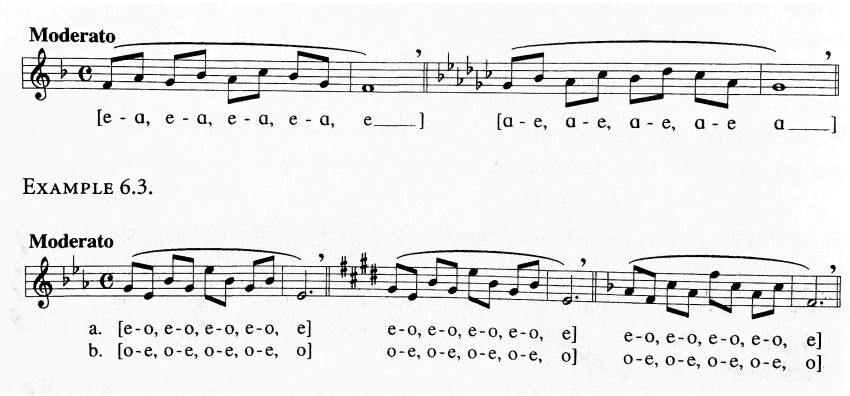


- Once the vowels feel comfortably confident, the next stage of this exercise is to introduce the other vowels (C). I slot in the /i/ between each of them to keep the rest of the vowels lined up, resonating, and flexible. This exercise I have developed myself.



Step 6: Vowel Tracking on Legato

- Front to back to front vowel sequence /i-e-a-e-i/ sung on the same note. Miller suggests using combinations of lateral and rounded vowels: /ɛ-ɔ/; /ɛ-o/; /e-u/; /ɑ-o/; ɑ- ɔ/; /ɑ-u/; /i-ɑ/; /i-o/; /i-u/. Vowels must retain resonance and definition when changing pitch pattern (Miller, 2000, p. 85-86).



- /i-e-a-o-u/ vowels can be sung on just one note. If the vowels still feel like they are not properly lined up, they can be done in the sequence of /i-e-i-a-i-o-i-u/. The natural mouth position (therefore slight lip rounding for the round vowels) should be followed.
- Following that, the exercise can be done in the sequence of /a-e-i-o-u/. Allow the other vowels to readjust their space into the /a/ position, which should naturally feel a bit louder and freer, and allow the jaw to drop. Place fingers on back jaw muscles as a reminder of the correct jaw opening.

Step 7

Gentle messa di voce (crescendo to decrescendo) on the /a/ vowel. If /a/ is not comfortable, start with /ng/ which helps raise the back tongue position.

Step 8

For the final exercise, sing octave scales on variation of vowels, extending into the upper registers again.

APPENDIX B

Type of semiocclusion	Definition	Examples
Sustained semiocclusion	Semioccluded postures that can be maintained consistently for several seconds without any appreciable change in vocal tract shape.	(a) singing vowels into a straw or tube (b) sustained phonation of voiced fricative consonants, such as /v/, /z/, /ʒ/, /ð/ (c) sustained phonation of nasal consonants, such as /m/, /n/, /ŋ/, or the Coffin "Standing Wave" exercise (phonating a vowel with one's hand completely over the mouth)
Oscillatory semiocclusion	Postures where a regular cycle of pressures are built up behind an occlusion, then released; the cycle of pressure changes is not unlike that which takes place at the glottal level, although at a much lower frequency than occurs at the vocal folds.	(d) lip buzz (e) raspberry (f) rolled /r/ (g) phonating into a straw that is partially immersed under water
Transitory semiocclusion or occlusion	Postures that are very short in duration; can feature a brief complete occlusion of the vocal tract.	(h) semi-vowels /j/ and /w/ (i) voiced plosive consonants /b/, /g/, /d/