Functioning of the Voice, Acoustics and Microphones

Vocal Pedagogy II | Jeanne Gofii-Fynn

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Unless there is a critical condition of a vocal disorder or dysfunction, there are very few people who don't use their voices during the day. We produce sound even when we yawn or sigh, or as we react to things. People often hum tunes when brushing their teeth, or in the shower. Our voices are usually the way we communicate things with ourselves, our surroundings and the people around us. However, if you go out on the street and ask where one's vocal cords are, or how they function, they most likely don't know much about it. They may have an approximate idea, however, probably not as well as our other body parts. Although this is a personal assumption, compared to vocal anatomy and physiology, I am guessing that more people know where their kidneys are located and what they are for, as it is often taught in science classes growing up, and people tend to take kidney health more seriously. Yet, the voice is as important, and how it functions should be a more accessible information to the general population.

Many professionals use their voices in different settings. Teachers, musicians, CEO's, dance instructors and more. They may be giving a speech through a microphone, or cuing dance moves with their bare voices. Regardless of the job, if people understand how their voice functions, and how the acoustical factors affect it, they can use it in a more efficient way. Microphones are a big part of today's technology, and is an additional layer added to how acoustics affect our sound, which I am interested in investigating further for my next research paper.

Thus, the purpose of this paper is to summarize how we produce sound, and discuss some very general acoustical circumstances that may alter our sound. It is crucial to understand how the voice functions and a step into vocal acoustics before we can understand how microphones alter our sound as well.

So, how does our voice function? How do we produce the sounds that we do? There are three main components that play a role in our vocal system, each with its own sub-details as well. These are : **power source, sound source, and sound modifiers.**

Power Source

The power source, in this case, is our lungs. Our respiratory system is the first step we should explore. "Breath is integral to voice production; vocal folds cannot vibrate without it" (Devore, Cookman 2009). After our brain signals our diaphragm to contract, it lowers, creating an increase in volume in our lungs, and decreasing the pressure, which is also sometimes referred to as Boyle's Law. "The lungs supply a constant stream of air that passes between the vocal folds and provides power for voice production, which is especially important for singing" (Sataloff, 2006). There are a bunch of muscles we use for breathing during the inhalation and exhalation process. For inhalation, for instance, lungs don't breathe on their own. The essential and primary muscles we should know are the diaphragm and our extrinsic intercostals (ribs). During exhalation (which is when the act of speaking and singing happens), we use our intrinsic intercostals and abdominal muscles such as the transverse (horizontal muscles), internal/external obliques, and the rectus which can be seen as the “six pack” muscles.. In more practical terms, singers and other professionals who use their voices should be aware of the role breathing plays in the efficiency of our sound. Understanding all muscles involved when producing sound may help with leaning on better support rather than putting all the pressure on our throats.

Working on the balancing of the airflow and air pressure, as well as maintaining a healthy level of subglottal resistance, and understanding how to control it better is crucial. Subglottal pressure is the air that builds below the vocal cords, and the glottal resistance could be explained as the term used to describe the resistance against airflow at the vocal fold level. As Cotrell (2010) explains: “Increasing the airflow yields to no result if there is insufficient resistance to increase the subglottal pressure. In order to manage subglottal pressure and airflow, singers must learn to manipulate both expiratory and glottal resistance”.

There’s still quite a lot of debate when it comes to what type of breathing serves the singers best. However, Peckham (2010) claims that “there are three main ways singers tend to breathe, but only one of them is considered to be effective.” The three kinds mentioned in her book are: chest breathing, rib breathing and rib/abdominal breathing(which is the accepted one that brings the most efficient support to a singer. When we can coordinate airflow with air pressure, we can control things better, such as amplitude, pitch, registry etc. For practical reasons, it is important to understand different kinds of breathing, and make the “support system” that is constantly mentioned, more accessible to the student/singer. Onsets of a singer or speaker are great clues as to how one’s vocal cords may be functioning, and how they are balancing airflow with air pressure. This is important in teaching singing. Unless intentional and stylistic, we can detect underuse or overuse of the resistance system. Singer/speaker may sound breathy, or too tense.

Sound Source

Next up is our sound source: our vocal folds. They are most well known to create sound by vibrating. Vocal cords are located in our larynx and it is a V-shaped muscular system that has five layers to it. These layers are:

- Epithelium
- Lamina Propria
    - Superficial
    - Intermediate
    - Deep
- Vocalis Muscle

Each of these layers have a different purpose and function for/of the vocal folds. The epithelium and superficial layer of the lamina propria are often considered the *cover* of the fold, the intermediate and deep layers of the lamina propria are thought to be a *transition* while the vocalis muscle is the *body* of the vocal fold[1]. What's useful to know practically, beyond the functionality is that "...this layered structure of the vocal folds is not present at birth, but rather begins developing at around the age of 7 or 8 years and is not completed until the end of adolescence." (Sataloff, Chapter 10, 2017). When we are kids, we don't have as many protective layers which is why children are more prone to vocal injuries. Furthermore, as we age, we lose

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[1] Mucosa and Muscles. (n.d.). Retrieved from https://www.yorku.ca/earmstro/journey/larynx2.html.

the elasticity in the lamina propria. If we have singers who smoke, understanding which layers are affected by it etc can also be important. Epithelium, which is the outer layer of the folds can be seriously inflamed due to smoking. Additionally, there are gender differences too, which is a notable fact to be aware of. "Chan et al found the differences in physical properties between male and female vocal ligaments and adjacent lamina propria" (Klepacek, I., Jirak, D., Smrckova, M. D., Janouskova, O., & Vampola, T. , 2016)

The size of the vocal cords and our larynxes change depending on gender and age, as well. For men, vocal folds are approximately as big as a US quarter, and for women about the size of a US dime.

The vocal folds use different sets of muscles to achieve different sounds. Some sounds as an example may be lighter mechanism, such as the head voice/falsetto or a heavier mechanism such as chest or speaking voice. The sound that comes out depends on many factors such as the length and mass of the vocal folds, as well as how we adjust our breathing pressure. Through a more scientific lense, The National Center for Voice and Speech, on their website, explain it as:

> "The differences between the various registers are created by many factors, including the balance between the activity of the CT (cricothyroid) and TA (thyroarytenoid) muscles, the balance between adduction and abduction (closing/opening) of the vocal folds, the amount of the vocal folds that is in vibration, and the shape of the vocal tract"[2]

For instance, when singing in our head voice, the CT muscle is more predominant, and folds are lengthened, thinned and stretched. On the other hand, chest voice primarily uses the TA muscle

[2] http://www.ncvs.org/ncvs/tutorials/voiceprod/tutorial/voluntary.html

and folds are shorter, often producing lower pitches. We could even sing the same pitch, and manipulate the registry using different sets of muscles.

Chapman (2017) wrote that the vocal folds vibrate by being blown apart and getting sucked back together, and the movement is continuous during the act of phonation. Phonation happens when the vocal cords are in “closed” or adducted position. Herbs, Hess, Muller, Svec and Sundberg (2015) also said that:

> Vocal fold adduction in the posterior (cartilaginous) portion of the glottis is mainly achieved by the lateral cricoarytenoid (LCA) and the interarytenoid muscles.8 Insufficient vocal fold adduction leads to incomplete glottal closure and thus the absence of a closed phase during the glottal cycle. Glottal adduction may vary within the phonatory adductory range.

Furthermore, “Research into vocal fold vibration continues, but we now acknowledge that the myoelastic/aerodynamic theory of voice as the most valid” (Chapman, 2017). Myoelastic-aerodynamic theory looks into vocal folds, muscles and airflow. It states that our vocal folds get sucked back together and oscillate on that movement. It suggests for us to think of voice as a wind instrument that works with airflow rather than as strings that vibrate or just as a mass of muscles. The Bernoulli effect, which is a part of this theory, claims that: When air moves a shorter distance it goes faster. Our vocal folds are sucked together due to the air that is passing through: due to changing pressure and velocity creates a vacuum-like effect. And according to this theory, due to elasticity they want to go back to their original position and oscillate on that movement. It closes bottom to top and the process repeats- its basically a return force. In practicality this can help us understand that we don’t need to squeeze any muscles in our throat to induce vocal fold adduction, rather, it is the adequate speed of air that is creating a vacuum and sucking them back together, acquiring vocal fold closure. The speed of airflow is also increased during the lighter mechanism[3].

Resonance/Acoustics/Sound Modifiers

Final main step to add to how the voice functions is our resonance system and acoustics. In some ways, we probably have the most control in this step. Acoustics is a very broad topic: from the cavities in our teeth, our facial structure, to our geographical and physical location, our sound, and how we perceive the sound differentiates. Even the weather conditions can change the way sound travels. A few fundamental things we should know about vocal acoustics are formants and frequencies.

Our vocal tract has resonators and articulators; how we shape our throat, mouth, lip and tongue changes how the sound comes out. As Johan Sundberg describes in the Vocal Health and Pedagogy book, "in the case of the vocal tract resonator, the resonances are called "formants". Each have their frequencies, which alter our vocal timbre"(Sataloff, 2017, p.353). There's about five formants. "The two lowest formants determine vowel quality; where-as the higher formants determine how much of the personal voice characteristics, including voice classification."(Sataloff , 2017, p.381)

The frequencies of these formants change depending on whether the person is speaking or singing. It also varies depending on the length of the vocal tract and varies with loudness of phonation.

[3] Adapted version of my answer to the Take Home Assessment from our Vocal Ped class last semester.

Howard and Murphy (2008), in their book called Voice Science Acoustics and Recording, cover an extensive amount of information about human voice, how sound travels, and more.

> The acoustic characteristics of a soundwill be modified by the spaces through which it passes in much the same way as the sound of the voice varies in different rooms and buildings. In the case of speech and singing, the sound modifiers are the spaces through which the soundsource passes to emerge from between the lips and/or nostrils of the speaker or singer. It is the shape of these spaces that serves to modify acoustically the output from the sound source.

Our sound travels through space, starting in our nasal and oral cavity. It is then shaped by our throat, mouth and tongue. The most practical example of this is vowels. Vowels are sound modifiers. As Karyn O'Connor writes:

> "Each vowel has its own distribution of acoustic energy that distinguishes it from all other vowels. Vowels will almost always have four or more distinguishable formants. However, the first two formants are the most important in determining vowel quality and in differentiating it from other vowels."

Next Step : Microphones, Acoustics and Pedagogy

Last but not least, something extremely popular and can not be overlooked at in music and singing these days is microphones. Microphones manipulate sound immediately and have their various acoustical characteristics depending on which kind we are using. Different microphones have different capabilities in how they capture and reflect sound and frequencies.

Beyond our vocal box structure and our physical location, it is an added layer to the discussion. As voice teachers and performers, it is probably time to understand this aspect better.

For my final project, I am hoping to explore microphones and how it affects the way we sing. Does it take off the pressure? Do we modify our vowels differently when singing into a microphone? How much does amplification change the way sound travels directly from the mouth vs a speaker? Before understanding how sound is manipulated, we must understand how it is produced and therefore explaining the basics of how the voice functions is related to my next project. I am excited to look at microphones in relation to all of the vocal pedagogical aspects that were captured in this paper.

Citations and Resources

Chapman, J. L. (2017). *Singing and teaching singing: a holistic approach to classical voice*. San Diego, CA: Plural Publishing.

Cottrell, D. (2010). On the voice: Support or resistance? examining breathing techniques in choral singing. *Choral Journal, 50*(9), 53-59. Retrieved from http://ezproxy.cul.columbia.edu/login?url=https://search.proquest.com/docview/753557087?accountid=10226

DEVORE, K. A. T. E. (2020). *Voice Book: caring for, protecting, and improving your voice*. S.l.: CHICAGO REVIEW.

Herbst, C. T., Hess, M., Müller, F., Švec, J. G., & Sundberg, J. (2015). Glottal Adduction and Subglottal Pressure in Singing. *Journal of Voice*, *29*(4), 391–402. doi: 10.1016/j.jvoice.2014.08.009

Howard, D. M., & Murphy, D. (2008). *Voice science, acoustics and recording*. San Diegon CA: Plural Pub.

Klepacek, I., Jirak, D., Smrckova, M. D., Janouskova, O., & Vampola, T. (2016). The Human Vocal Fold Layers. Their Delineation Inside Vocal Fold as a Background to Create 3D Digital and Synthetic Glottal Model. *Journal of Voice*, *30*(5), 529–537. doi: 10.1016/j.jvoice.2015.08.004

Mucosa and Muscles. (n.d.). Retrieved from https://www.yorku.ca/earmstro/journey/larynx2.html.

Mix it up Monday: Singing is not ALL about the breath. (2018, March 19). Retrieved from https://edwardsvoice.wordpress.com/2018/03/19/mix-it-up-monday-singing-is-not-all-about-the-breath/

O'Connor, K. (n.d.). Vowels, Vowel Formants and Vowel Modification. Retrieved October 8, 2019, from http://www.singwise.com/cgi-bin/main.pl?section=articles&doc=VowelsFormantsAndModifications&page=2.

Peckham, A. (2010). *The contemporary singer: elements of vocal technique*. Boston, MA, USA: Berklee Press.

Sataloff, R. T. (2006). *Vocal health and pedagogy*. San Diego, Calif.: Plural Publ.

Sataloff, R. T. (2017). *Vocal health and pedagogy science, assessment, and treatment*. San Diego, CA: Plural.