The Efficacy of Mental Practice for Motor Skill Enhancement in Singing

Nicholas J. Klein

A dissertation

submitted in partial fulfillment of the

requirements for the degree of

Doctor of Musical Arts

University of Washington

2021

Reading Committee:

Thomas Harper, chair

Mark Rodgers

Carrie Shaw

Program Authorized to Offer Degree:

Music

© Copyright 2021

Nicholas J. Klein

University of Washington

Abstract

The Efficacy of Mental Practice for Motor Skill Enhancement in Singing

Nicholas J. Klein

Chair of the Supervisory Committee:

Thomas Harper, School of Music

This document collects and evaluates scientific evidence to support the use of mental practice to enhance motor skills in singing and in teaching singing. It provides detailed information about the various brain regions and processes involved in motor sequencing and how these regions interact with one another to facilitate motor function. This document synthesizes research on mental practice from sports medicine, physical therapy and rehabilitation, surgery, and instrumental music in order to apply similar strategies to vocal-motor functions involved in singing. This document provides exercises for successful mental practice to enhance motor function in all five systems of singing, including respiration, phonation, registration, articulation, and resonance. It also provides exercises for successful mental practice to enhance memory of repertoire and roles, as well as for the development of character and other performance aspects.

Acknowledgements

I would like to thank my committee members for their immense support and guidance through all phases of researching and writing this dissertation. Thank you to Thomas Harper for your encouragement and guidance not just to acquire information, but to synthesize it in a way that will be beneficial for my own teaching and for the rest of our field. You have been one of the most supportive educators I've come across in my education, and I truly appreciate your constant encouragement and leadership. Thank you to Dr. Carrie Shaw for your interest in all of my general exam topics, and for asking many insightful questions that challenged me to become a better researcher, musician, and teacher. Your assistance in finding resources and in connecting me with leading scholars in the field was invaluable, and I am so grateful for that. To Dr. Mark Rodgers, I thank you for pushing me to always think more deeply and for your extremely generous critiques and feedback on how to improve my scholarly writing. This document and research would not be what it is today without your knowledge and support.

Thank you to my incredible friends, family, and former teachers who have all inspired me and constantly encouraged me to pursue my passion and dreams of singing: Megan Consolo for showing me how much joy can be found in music and Jacqueline Barlow-Ware for guiding and supporting me in all of my crazy repertoire choices and for teaching me how to sing beautifully and emote sincerely. Thank you to my parents and sister for their unwavering love and support. Thank you to my colleagues in the graduate voice program at the University of Washington (Athena, Ryan, Katrina, and Vivianna) for being amazing listeners, collaborators, and more importantly, lifelong friends. Lastly, I would like to thank my partner, Evan. I would not be who I am or where I am today without your support, encouragement, and guidance. You have joined

me on this journey of life while I pursued my passion and dreams, and I will be forever grateful that I have you in my life.

The Efficacy of Mental Practice for Motor Skill Enhancement in Singing

Nicholas J. Klein, DMA Candidate in Voice Performance

Table of Contents

Title Page……………………………………………………………………………...…………..i

Abstract……………………………………………………………………………...……...iii

Acknowledgements………………………………………………………………………………iv

List of Figures…………………………………………………………………...……………vii

I. Chapter One: Introduction……………………………………………………......………1

II. Chapter Two: What is Learning?...13

III. Chapter Three: Mental Practice……………………………………………….……………35

IV. Chapter Four: Mental Practice for Respiration……………………………….…………48

V. Chapter Five: Mental Practice for Phonation…………………………………………………64

VI. Chapter Six: Mental Practice for Registration.………………………………………………78

VII. Chapter Seven: Mental Practice for Articulation……………………………………………103

VIII. Chapter Eight: Mental Practice for Resonance……………………………………………...134

IX. Chapter Nine: Mental Practice for Memorization…………………………………………...157

X. Chapter Ten: Mental Practice for Character/Performance…………………………………..163

XI. Conclusions………………………………………………………………………………….168

XII. Appendices…………………………………………………………………………………..170

XIII. Bibliography…………………………………………………………………………………185

List of Figures

Figure 1: Image of the cerebrum, brain stem, and cerebellum……………………………………3
Figure 2: Image of the four lobes of the brain…………………………………………………….3
Figure 3: The lobes of the Cerebrum……………………………………………………………...4
Figure 4: The Three Stages of Learning…………………………………………………………14
Figure 5: Working memory model for singing……………………………………………..…22
Figure 6: The lobes of the Cerebrum……………………………………………………………26
Figure 7: Motor cortex……………………………………………………………………………...27
Figure 8: The expanded closed-loop model for movement control……………………………...28
Figure 9: The primary muscles of inhalation and exhalation……………………………………49
Figure 10: The primary muscles of inhalation and exhalation……………………………………..52
Figure 11: Muscles of respiration………………………………………………………………..54
Figure 12: Muscles of respiration………………………………………………………………..54
Figure 13: Muscles of respiration………………………………………………………………..54
Figure 14: Muscles of respiration………………………………………………………………..54
Figure 15: Muscles of respiration………………………………………………………………..54
Figure 16: Muscles of respiration………………………………………………………………..54
Figure 17: The primary muscles of inhalation and exhalation……………………………………..55
Figure 18: Front and side views of diaphragm and its movements during breathing…………....56
Figure 19: Action of the diaphragm in relation to rib movement……………………….………56
Figure 20: Vocalis and thyroarytenoid muscles, as viewed from above……………………...…68
Figure 21: Action of the posterior cricoarytenoid muscles, the openers………………………...68
Figure 22: Action of the lateral cricoarytenoid muscles, which close the glottis………………..69
Figure 23: The cricothyroid, a stretching muscle………………………………………………..70
Figure 24: Stretching of the vocal folds………………………………………………………....70
Figure 25: Adduction and Abduction……………………………………………………………71
Figure 26: Steps in vocal fold oscillation………………………………………………………..72
Figure 27: Wave action of the vocal folds……………………………………………………….73
Figure 28: Top view of the larynx showing the intrinsic laryngeal muscles…………………….86
Figure 29: Vertical addiction of the vocal folds…………………………………………………87
Figure 30: Vocal folds in chest voice……………………………………………………………88
Figure 31: Mode 1 cycle of vibration showing vertical phase difference at glottis……………..89
Figure 32: Vocal folds in falsetto………………………………………………………………..90
Figure 33: Mode 2 vibration showing little or no vertical phase difference……………………91
Figure 34: Incomplete glottal closure during flageolet or falsetto production…………………..92
Figure 35: Image of two slide rules……………………………………………………………...94
Figure 36: Articulator Interconnections………………………………………………………...105
Figure 37: Head Anatomy………………………………………………………………………115
Figure 38: The position of the tongue determines the kind of vowels produced……………….116
Figure 39: High front [i]………………………………………………………………………..117
Figure 40: High front [I]………………………………………………………………………..118
Figure 41: Mid front [e]………………………………………………………………………...118
Figure 42: Mid front [ɛ]………………………………………………………………………...119
Figure 43: Low front [æ]……………………………………………………………………….119
Figure 44: High back – lip rounded [u]………………………………………………………...120

Figure 45: High back – lip rounded [ʊ]…………………………………………..…………...120
Figure 46: Mid back – lip rounded [o] ………………………………………………...……121
Figure 47: Side view of the head and neck showing cavities important to resonance…...…….139
Figure 48: Free resonators of the vocal tract……………………………………………...140
Figure 49: Laryngopharynx……………………………………………………………….141
Figure 50: Endoscopic view of the larynx and surrounding structures………………………...143
Figure 51: The mask……………………………………………………………………145

Chapter One:

Introduction

Singers of all styles hone their craft and artistry for many years through extensive study and practice. For many, this process requires hours of time in a practice room singing scales, vocal exercises focused on building specific skills, and repertoire. Their efforts are comparable to those of high-level athletes who spend hours in the gym or on the field, or surgeons who seemingly live in a skills-lab for the majority of their residencies to become proficient in performing a variety of life-saving procedures. However, surgeons and athletes have an additional component of their practice regime that hasn't been thoroughly studied in musicians, specifically singers, and that is the use of *mental practice* in addition to physical practice.

Before defining mental practice and discussing what it entails, it is important to introduce some very specific information about cognition, brain mapping, and brain functions. Cognition is "the mental process of knowing, thinking, learning, memory, knowledge formation, reasoning, problem-solving, judging, decision making, comprehension, and production of language through thought and the senses."[1] Without knowing it, singers are constantly processing various types of information and forming cognitive and kinesthetic responses to it. Cognitive Bodily-Kinesthetic Awareness in singing is the process in which a person's mental abilities coordinate with their own bodily movements.[2] In other words, Cognitive Bodily-Kinesthetic Awareness in singing is the ability to stay aware of the ease and fluidity of vocal processes while singing.

1 "Cognition," Biology Online, October 27, 2019, https://www.biologyonline.com/dictionary/cognition.
2 Karen Leigh-Post, "Mind-Body Awareness for Singers: Unleashing Optimal Performance," in *Mind-Body Awareness for Singers: Unleashing Optimal Performance* (San Diego, CA: Plural Publishing, 2014), xv.

The Nervous System

The *Nervous System* is divided into the *central nervous system (CNS)* and the *peripheral nervous system (PNS).* The central nervous system (CNS) is located within skeletal structures of the skull and skeletal spine. The peripheral nervous system is outside of these skeletal structures and includes the cranial nerves, spinal nerves, and sensory receptor organs. The CNS is made up of three main components: the motor system, the sensory system, and higher brain functions.[3] The functional unit of the nervous system is a *neuron*. Neurons can be further classified as motor neurons, sensory neurons, or interneurons, which transmit information between neurons within the CNS. All neurons have *dendrites* and *axons*. Dendrites bring information to the body of the cell and axons take information away from the body of the cell. Neurons communicate by sending information in the form of electrochemical messages, and these messages are carried along the axon and across synapses, or the spaces between cells, from one cell to another.

The Brain

The brain is the central component in cognition. Brain mapping is a way to identify the various locations of the different cortical structures or areas of the brain. Essentially, brain mapping is the study of anatomy and physiology of the brain. The brain can be divided into three major regions: the *cerebrum, cerebellum*, and *brain stem*. The cerebrum comprises about 83% of the brain and is made up of cerebral hemispheres.[4] The cerebellum lies at the back of the hemispheres. It is the second largest region of the brain, at about 10% of the brain's volume, but

3 Ibid., xxi.
4 Kenneth S. Saladin, "The Brain and Cranial Nerves," in *Anatomy and Physiology: the Unity of Form and Function*, 7th ed. (New York, NY: McGraw-Hill, 2015), 508–510.

it contains nearly 50% of its neurons.[5] The brain stem is the remaining portion of the brain, according to Saladin, although definitions vary amongst researchers.

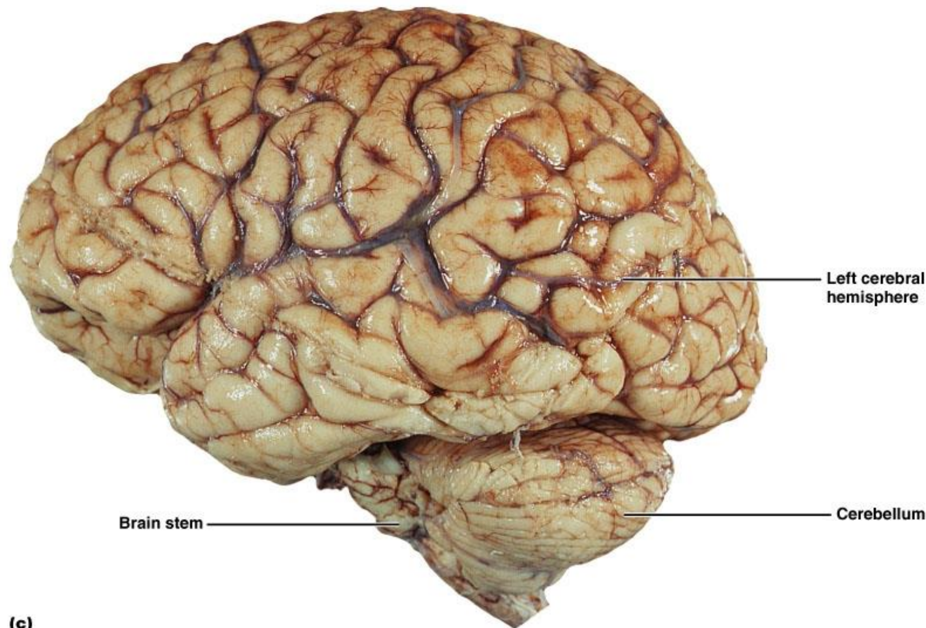


Figure 1: Image of the cerebrum, brain stem, and cerebellum, digital image, APSU Biology, accessed July 12, 2021, https://www.apsubiology.org/anatomy/2010/2010_Exam_Reviews/Exam_4_Review/CH_12_Gross_Anatomy_of_the_Brain.htm

The cerebrum is the home of sensory perception, memory, thought, judgement, and voluntary motor action. The components of the cerebrum are the *frontal lobe*, the *parietal lobe*, the *occipital lobe*, the *temporal lobe*, and the *insular lobe*.

Figure 2: Image of the four lobes of the brain, digital image, University of Washington, accessed July 12, 2021, https://faculty.washington.edu/chudler/lobe.html

5 Ibid.

The *cerebellum* consists of two hemispheres (right and left) connected by a bridge called the *vermis*. The cerebellum also has a surface cortex of gray matter and a deep layer of white matter. The cerebellum is connected to the brain stem by three pairs of stalks made up of thick bundles of nerve fibers, called *cerebellar peduncles*. The brain stem is located at the base of the cerebrum, connecting the brain to the spinal cord. It consists of three main parts: the *pons*, the *midbrain*, and the *medulla oblongata*. Located in white matter between the brain stem and the cerebrum are subcortical structures – the *thalamus*, the *hypothalamus*, the *basal ganglia*, and the *limbic structures (hippocampus and amygdala).* The *cerebral cortex*, which is the outermost layer of the cerebrum, consists of various cortices including the *frontal cortex* and *posterior cortex.*

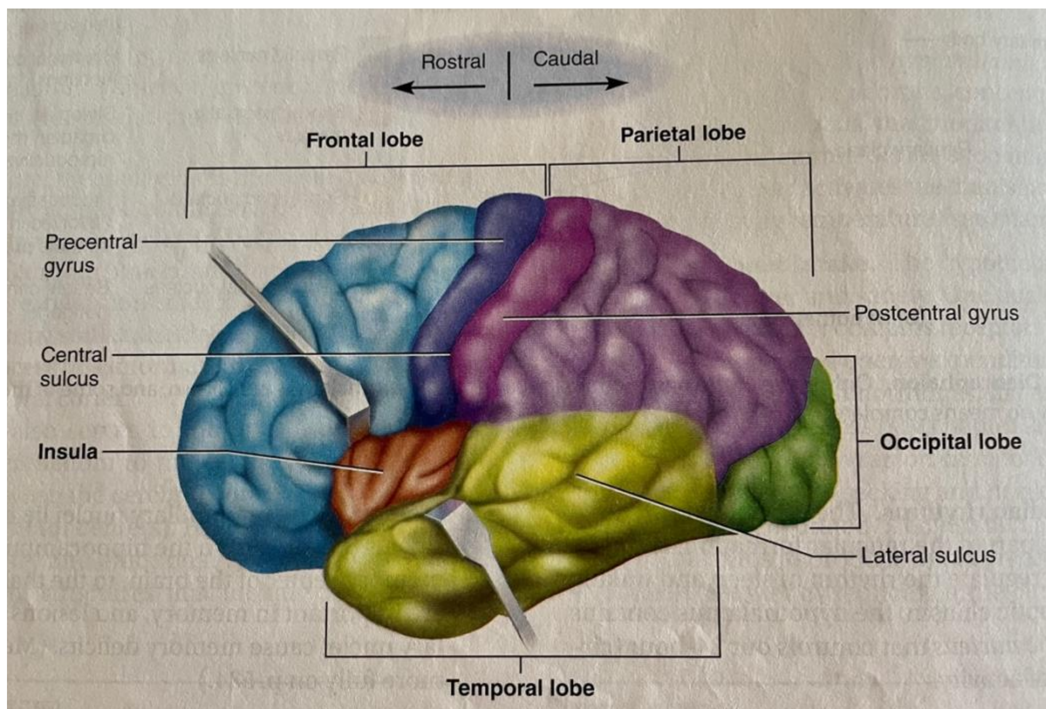


Figure 3: The lobes of the Cerebrum. Image reproduced from Kenneth Saladin, *Anatomy and Physiology: The Unity of Form and Function*, (New York, NY: McGraw Hill Education, 2015): 526.

The frontal cortex (or lobe) includes the *prefrontal cortex* and *motor cortices*. The posterior cortex (or lobe) includes the occipital lobe, parietal lobe, and temporal lobe. The parietal lobe includes the *somatosensory cortex* and the *posterior parietal cortex*. Each area of the brain has its own unique set of functions.

Within the cerebral cortex, the following areas are involved in the planning and execution of most motor functions. The *primary motor cortex, supplementary motor area (SMA), and the pre-SMA* are primarily involved in the selection of voluntary movements. The posterior parietal cortex is involved in guiding voluntary movements in space, such as moving one's arm or leg. The *dorsolateral prefrontal cortex* is involved in selection and sequencing of voluntary movements according to willed intentions (knowing or deliberately choosing to act). The *medial prefrontal cortex* is associated with intuitive behaviors initiated according to "rule sets" rather than conscious reasoning.[6] In addition to the areas of cerebral cortex, the following areas are also involved in motor planning and execution. The *hippocampus and amygdala (limbic structures)* quickly assess sensory information, trigger motor responses, and assist in the formation of memory. The *basal ganglia* and *cerebellum* are influential in the formation of motor programs for speech, as well as moderating reproducible movements such as walking, laughing, and sustained phonation. The brain stem structures are responsible for vital life support functions such as breathing and sensory and motor information processing, among a multitude of other things. The *laryngeal motor cortex (LMC)* is located within the primary motor cortex. The LMC sends electrochemical messages from the primary motor cortex to the brain stem, which houses motoneurons that innervate the laryngeal muscles.[7] When stimulated, these motoneurons signal

6 Karen Leigh-Post, "Mind-Body Awareness for Singers: Unleashing Optimal Performance," in *Mind-Body Awareness for Singers: Unleashing Optimal Performance* (San Diego, CA: Plural Publishing, 2014), xxiv.
7 Kristina Simonyan, "The Laryngeal Motor Cortex: Its Organization and Connectivity," *Curr Opin Neurobiol* (2014): 1.

the muscles of the larynx to adduct (close) the vocal folds and raise or lower the height of the larynx.

The Auditory and Vestibular Systems

Other important components of the nervous system of particular importance to singers are the auditory system and the vestibular system. The auditory system is a very basic transmission pathway leading from where sounds are first received at the outer ear to the auditory cortex. External auditory stimuli are received at the outer ear and then carried through the ear canal and middle ear to the inner ear where the auditory and vestibular organs reside. Vibrational stimuli are sent directly to the receptors in the inner ear. Once in the inner ear (for both auditory and vibrational stimuli), "the information is transduced into neural signals when hair cells (a type of mechanoreceptor) are moved by the fluid in the cochlea and are in turn transmitted via the vestibulocochlear nerve (CN VIII) to the brain where…they are projected to the auditory cortex where they can be heard or perceived as song."[8] The auditory system also includes projections to the cerebellum, basal ganglia, and motor cortices. The same vibrations that are processed by the auditory system are processed in the vestibular system as motion. The vestibular system is responsible for receiving, processing, and projecting both sensory and motor information that "informs our knowledge of motion and space, effects head and eye movements that facilitate receptivity, and…signals corrective postural and autonomic reflexes in response to changes in our orientation to gravity."[9] The vestibular system also contains the vestibulo-spinal system, which is a collection of fibers of the medial vestibulo-spinal tract that control the muscles of the head and neck.

---

8 Leigh-Post, *Mind-Body Awareness for Singers*, xxxi.
9 Ibid., 35.

Expertise

When actively training cortical functions, the ultimate goal is to develop expertise in a skill or subject area. What is expertise? The Merriam-Webster Dictionary defines expertise as "the skill of an expert."[10] The Cambridge Dictionary offers a slightly different definition: "a high level of skill or knowledge."[11] According to Moran, Campbell, and Toner, expertise comprises "the characteristics, skills, and knowledge that distinguish experts from novices and less experienced people."[12] According to Daniel Levitin, "expertise in any domain is characterized by a superior memory, but only for things within the domain of expertise."[13] Despite their differences, these definitions agree that expertise involves a high-level of performance in a specific skillset.

However, none of these definitions discuss *how* someone gains or acquires this expertise. In her recent book, "The Musician's Mind," Lynn Helding shares research that identifies three stages of development that eventually lead to expertise. These stages are "an early 'fun' stage (noodling around with an instrument); a second stage of middle development, where parents typically decide to find a teacher for the child; and a third stage, where the child takes over his own disciplined practice."[14]

Practice is typically associated with long periods of attentiveness focused on gaining or refining a specific skill. Practice looks different for everyone based on the skill they are working on or even the field in which their expertise lies. For example, a baseball player spends hours in

---

10 "Expertise," Merriam-Webster (Merriam-Webster), accessed July 11, 2021.
11 "Expertise," EXPERTISE | definition in the Cambridge English Dictionary, accessed July 11, 2021.
12 Aidan Moran, Mark Campbell, and John Toner, "Exploring the Cognitive Mechanisms of Expertise in Sport: Progress and Prospects," *Psychology of Sport and Exercise* 42 (2019): 8.
13 Daniel Levitin, "What Makes a Musician? Expertise Dissected," in *This Is Your Brain on Music* (Penguin Books Ltd, 2019), 191.
14 Lynn Helding, "Performance Studies," in *The Musician's Mind: Teaching, Learning, and Performance in the Age of Brain Science* (Lanham: Rowman & Littlefield Publishing Group, 2020), 180–181.

the batting cages focused on minute details of their form when "at bat." A surgeon or surgical resident spends time in a skills lab practicing upcoming procedures in order to ensure the safety of and a successful outcome for their patients. For singers, practice typically revolves around building efficiency in the five systems of singing: respiration, phonation, resonance, articulation, and registration. Countless books, articles, and other sources provide exercises in all of the five systems of singing, incorporating science-informed vocal pedagogy and anecdotal evidence by experienced and well-respected teachers in the field. Physical exercises for building or strengthening specific motor skills in each system of singing are beyond the scope of this research. However, it *is* important for the sake of this research to discuss various components of a practice routine that the existing scientific evidence supports.

Practice

Practice habits and routines are a "hot topic" in current motor learning research.[15] Musicians practice in a variety of ways based on the amount of time they have, their current health, and other various factors. The first thing to think about regarding establishing a practice routine is the amount of available time to devote to practice in each practice session. In general, research shows that distributed practice is more beneficial than massed practice. What this means is that practicing for a short period each day (or even multiple short periods each day) is going to yield stronger and more noticeable results than practicing twice a week for extended periods of time. Rest, including but not only in the form of sleep, plays an important role by aiding cognitive development. A recent study published by Buch et al. provides evidence that waking

15 Ibid., 108.

rest in particular aides in hippocampo-neocortical replay.[16] Waking rest refers to short increments of physical rest between repetitions of the skill being practiced. Buch et al. conclude from their findings that "much, if not all skill learning occurs offline during rest rather than during actual practice."[17] The results of this study indicate that memory consolidation, or learning a skill, occurs much more rapidly when moments of waking rest are incorporated into physical practice because, according to the authors, "fast waking replay reinforces hippocampus and neocortical associations learned during prior practice."[18]

Another important component to consider when establishing a practice routine is whether to implement *varied practice* or *constant practice*. In singing, variability is already somewhat built into our practice. A singer often focuses on technique in lessons with their teacher, style and diction in coachings with their accompanist, staging in rehearsals with a director, and so forth.[19] Varied practice refers to the conditions of practice. The current motor learning research shows that varying a few components of practice will enhance the specific task or skill that is being practiced.

Many singers have very specific sets of vocalises they use when they first enter the practice room, before diving into their repertoire. Then, when they have begun working on their repertoire, they might approach every piece (or even every phrase) with the same method. Yet the literature reveals that randomly ordered practice is more effective than blocked practice.[20] Blocked practice consists of training one specific movement or skill over and over again. Randomly ordered practice is as simple as it sounds — not repeating the same task over and over

---

16 Ethan R. Buch, Leonardo Claudino, Romain Quentin, Marlene Bönstrup, and Leonardo G. Cohen, "Consolidation of human skill linked to waking hippocamp-neocortical replay," *Cell Reports* 35 (June 2021): 5.
17 Ibid., 1.
18 Ibid., 6.
19 Helding, *The Musician's Mind*, 110.
20 Richard A. Schmidt and Timothy Donald Lee, *Motor Control and Learning: a Behavioral Emphasis* (Champaign, IL: Human Kinetics, 1999), 305.

again. Although this may be counter intuitive, a significant amount of research in motor learning shows that randomly ordered practice is more effective than blocked practice for long-term learning.[21]

It's also important to note the importance of deliberate practice. Practice sessions must be deliberate, specific, and effortful to be effective. Simply spending hours in a practice room without a plan of action will not encourage skill growth. According to Viskontas, the best deliberate practice includes five features:

> (1) leaving your comfort zone and entering a place where mistakes are likely; (2) working toward specific, achievable goals; (3) maintaining intensive focus on the task; (4) getting high-quality feedback and opportunities to correct errors in the moment; and (5) developing a new mental model of the skill you're trying to master.[22]

Deliberate practice requires the artist to be in a space, both mentally and physically, where mistakes are both likely to occur and likely to be accepted. Many singers don't want to practice where others can hear them due to the fear of judgement. In order to ensure success, a singer should find a private location where they feel comfortable for their practice session. Deliberate practice must be specific — singing through repertoire repeatedly will not encourage growth. A singer must work on specific sections or specific skills within a piece or vocalise. Deliberate practice requires intense focus. In our current society, it is hard to maintain focus amid numerous distractions, so it would be most beneficial to put electronic devices on "do not disturb" or to put them away all together. Deliberate practice requires high-quality feedback, encompassing not only the guidance a singer receives from their teacher or coach, but also the insights they glean from listening to and analyzing recordings of their own practice sessions. Finally, deliberate practice requires creating a new mental model of the skill a singer is trying to master. This

---

21 Helding, *The Musician's Mind*, 111.
22 Indre Viskontas, *How Music Can Make You Better* (San Francisco, CA: Chronicle Books, 2019), 82.

important yet overlooked feature of a high-quality deliberate practice routine is the ultimate focus of this dissertation.

However a singer chooses to practice, several prominent researchers in the field of cognitive neuroscience have suggested that achieving expertise in a given field or skill requires 10,000 hours of total practice-time. For instrumental musicians, athletes, and surgeons, 10,000 hours of practice might seem relatively feasible in a reasonable amount of time. If someone in one of the aforementioned areas of study spends 4-5 hours a day practicing, it would take roughly 5-6 years for them to master the desired skill. A pianist who begins lessons at age 5 and practices 2-3 hours a day would require 9-12 years of practice before achieving mastery. Upon entering a university, the pianist would then likely spend another 4 hours a day practicing for another 4 years, for an additional 5,800 hours of practice. Singers, unfortunately, do not have the luxury of being able to practice for nearly as many hours a day because of the anatomical nature of the vocal mechanism. If a singer practiced for even just 2 hours a day—already too much for many young singers—it would take a minimum of thirteen-and-a-half years to reach the putative benchmark for "expertise." It is also important to acknowledge that many singers don't begin formal training until their teenage years, after an initial voice change prompted by puberty. A singer who started formal voice training at age fourteen and practices for 2 hours a day wouldn't achieve "mastery" or expertise until at least age twenty-seven (and more likely at a later age still, since time spent practicing before that point will be limited by lack of vocal stamina).

The question of how to expedite progress toward expertise and mastery often arises among singers, voice teachers, and others involved in voice pedagogy. Are there ways to supplement physical practice, thus increasing the amount of time spent practicing per day while still protecting a maturing voice from overuse? Parallel research in sports medicine, physical

therapy/rehabilitation, surgery, and even instrumental music provides significant evidence that the incorporation of well-designed and specific mental practice (MP) routines effectively enhances motor skill acquisition and enhancement, accelerating the process towards expertise. Generally, studies show that mental practice activates the same neural pathways and cortical networks involved in physical practice of a known skill. In other words, mental practice effectively enhances the synapses that a person already possesses for a motor function. However, nearly all of the published research regarding mental practice has found that mental practice is *not* effective when used as a sole method of motor skill acquisition; mental practice is only effective when used in addition to a well-designed physical practice routine.

What follows is intended to present and assess the evidence that mental practice is beneficial for building and enhancing motor skill acquisition in singing. In the following chapters, all pedagogical examples and exercises were developed and written by the author unless otherwise noted. My hope is that this dissertation will therefore serve also as a resource, providing successful examples of how to incorporate mental practice into a student's practice routine and a teacher's studio teaching.

Chapter Two:

The Learning Process

Learning is a complex process that involves various types of information processing. Two of the most common terms used to define and differentiate between information processing systems are declarative learning and procedural learning. Declarative learning, or "know-that," is information that a person can speak about. Declarative learning results in a permanent change in behavior as a result of experience.[23] Procedural learning, or "know-how," refers to learning a physical skill by doing. Procedural learning includes both innate movements that people are born with and advanced skills.[24] Procedural learning results in a permanent change in behavior as a result of practice.[25] The majority of advanced muscular skills, or higher-order muscular tasks, are learned with a combination of declarative and procedural learning. When learning a new task, individuals often begin by reading or studying information to understand the mechanics of a certain skill. This declarative learning process could include watching videos, studying diagrams, or observing pictures. After time has been spent in the declarative learning stage, individuals must eventually attempt to perform the task they are attempting to learn. This is when procedural learning takes over. According to Lynn Helding, higher-order muscular tasks are "situated at the nexus of declarative and procedural learning…we must first *know that* in order to *know how*."[26]

Learning itself can be broken down into a complex, three-step process of attention, learning itself, and memory. The following diagram is adapted from Helding's *The Musician's Mind*. The left side of the diagram explains the anatomical brain activity that occurs in each stage

23 Helding, *The Musician's Mind*, 74
24 Ibid., 72.
25 Ibid., 74.
26 Ibid., 73.

of the learning process. The right side provides a slightly more detailed description of each brain activity.

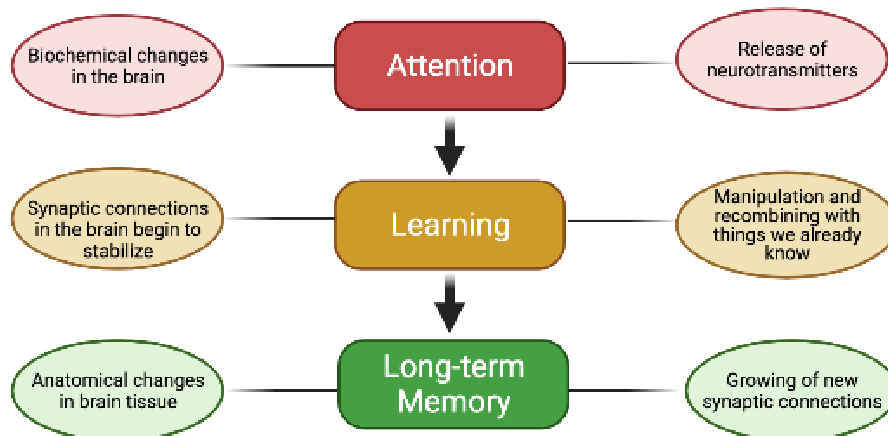


Figure 4: The Three Stages of Learning. Graphic created by Nicholas Klein (Seattle, WA, 2021)

Attention is one of the most important aspects in the learning process. Attention can be divided into sub-categories of "default mode" and "executive attention." The default mode is easily understood, as it is exactly what one would think based on its name — a person's normal state of being. Other names for the default mode include "daydreaming mode" and "mind-wandering mode." These two alternate names may be perceived negatively due to images or thoughts of laziness, but this mode is important for cognitive function. The default mode is where the brain goes "to plan, project, and envision our lives."[27] The executive attention mode removes distractions when necessary, heightening focus necessary for staying on task. It is worth noting that the human mind can only operate in one mode of attention at a time. When one

27 Ibid., 77.

system is active, the other system is passive. Within these two modes of attention, there is also an attentional switch, which directs the brain between the two modes of attention.

When operating in executive attention mode, a person is also experiencing mindfulness and heightened awareness. Mindfulness is awareness in action, or, according to Vanessa Cornett, a "moment-to-moment awareness" that "involves paying attention to what is."[28] When new information is presented, the *ascending reticular activating system (ARAS)* alerts the conscious mind that new information requires its attention. This alert sends the brain into a state of heightened awareness, ultimately resulting in executive attention and a higher level of focus.[29] Once the brain has been placed into executive attention mode, neurons release *neurotransmitters* (chemical messages), temporarily destabilizing the synapses, or gaps between brain cells where the neurotransmitters are exchanged. Research on attentional focus clearly shows that an external focus— on the movement effect—enhances performance and learning more than an internal focus—on the bodily movement itself.[30]

Attentional Aides

The human brain has a limited capacity for attention. It is difficult to maintain focus for extended periods of time, especially at younger ages. However, certain conditions or states can benefit attention. Emotion and desire in particular have a significant impact on how attentive one is to learning a specific skill or piece of information. That is, the human brain is more receptive to learning new information if the person learning the information is emotionally invested: as

28 Vanessa Cornett, *The Mindful Musician: Mental Skills For Peak Performance* (New York, NY: Oxford University Press, 2019), 4.
29 Leigh-Post, *Mind-Body Awareness for Singers*, 11.
30 Lynn Helding, "Motor Learning and Voice Training: Locus of Attention," *Journal of Singing* 72 (September 1, 2015): 87-91.

Helding writes, "Emotion sparks desire, which in turn ignites attention."[31] To be clear, by "emotion" I am referring not only to surface-level emotion. For attention to be ignited by emotion and desire, the emotion experienced by the learner must be *deep* emotion. Emotion is also helpful in the process of memory consolidation by coding human experiences into long-term memories. Stronger emotions create stronger memories for future recall.

Motivation is arguably one of the hardest mental states to maintain, but there are ways to enhance it. The commonplace method of motivating behavior by giving prizes or rewards for success is actually counterproductive to long-term learning. People are generally more motivated by intrinsic rewards, according to Helding, such as "joy in pursuing the endeavor itself, the excitement of discovery, a deep sense of meaning and contribution to a cause, or the freedom of charting one's own course."[32] If material rewards are proven to be counter-productive for long-term learning, then what can be done to increase motivation?

Many learners find success by setting achievable goals. When goals are written down and then achieved, people often feel a sense of pride or excitement, which is an exemplary internal reward. Goal setting has been shown to increase both motivation and overall achievement. Helding also shares the following regarding goal setting:

> Goal setting promotes focus, cultivates self-regulation by aiding impulse control, and helps calibrate efficient use of time and financial resources. These various benefits…promote positive feelings, which in turn feed more motivation.[33]

However, for goal setting to be beneficial for the learner, Helding writes that they must take the following into consideration:

---

31 Helding, *The Musician's Mind*, 79.
32 Ibid., 81.
33 Ibid., 83.

- The goal-setter must be the student/learner, and not the parent, teacher, or friend. Goal setting leads to self-motivation and greater persistence.
- Goals must be important to the student/learner. Goals that are not valued by the student/learner can compromise mental health and lead to lower motivation.
- Goals must be very specific. Specific goals are significantly more likely to be achieved than goals that are vague. It is also helpful for the students/learners to write down their goals and share them with a teacher or place them in a regularly visible place. Goals that are visible are more likely to be achieved than goals just kept in the mind.
- Goals have to be realistic. "Don't bite off more than you can chew," as the old adage goes.
- Goals must be both short-term and long-term. Students/learners are more likely to stay motivated if they are able to experience some form of quick success in achieving goals, while keeping the overarching, long-term goal in mind.
- Goal-setters have to be able to say how they are going to achieve their goals.[34]

The final attentional aid worth mentioning is sleep. Sleep is known to boost attention; however, the current research shows that not only does sleep boost attention, but it is also a critical phase in the learning process. A sleep study in 2013 demonstrated that the brain has

34 Ibid., 83–84.

created its own version of a lymphatic system, known as a glymphatic system. This system operates during sleep to remove any wasteful, toxic information accumulated during time awake. This waste removal process *detoxifies* the brain, which is why humans typically wake up refreshed and more able to pay attention. Additionally, sleep enhances neuroplasticity, which I discuss in more detail in the next section. Sleep also provides the right conditions for *synaptic pruning*, which is the process whereby weak synapses are removed, leaving only the strongest synaptic connections in the brain. Lastly, it is theorized that during sleep, the brain replays short-term memories to strengthen neural pathways and before sending them to long-term memory.[35]

Learning

With the aids of emotion, desire, motivation, goal setting, and sleep, the brain thereby enters a state that is more conducive to long-term learning. The next stage in the three-step learning process is *learning*. During this stage, neurons release additional neurotransmitters. As a skill is repeated, the number of synaptic connections in the brain begins to stabilize through a process called *memory consolidation*. During this stage, new information is first learned and absorbed into short-term memory, then sorted and manipulated in *working memory*, before being combined with what is already known.

Helding has defined *learning* in the following manner: "Learning is the process whereby we hold about seven bits, or four chunks, of information in mind, manipulate those bits or chunks, and recombine them with facts or experiences we already know."[36] In the learning phase, the human brain is physically reorganizing itself through *neuroplasticity*, and synapses are beginning to stabilize due to a process called *myelination*. Neuroplasticity refers to the brain's

---

35 Ibid., 85.
36 Ibid., 87.

capacity for structural and functional adaptation, which occurs when it acquires new information, retrieves information already stored, and combines the new and the old, altering itself in the process. Myelin refers to the wrapping that surrounds nerve cell axons to insulate them and increase the speed that electrical messages can be passed through the brain. Every movement is precisely timed as electrical signals travel through chains of neurons. Myelin *sheaths* wrap around these neurons, increasing the speed, signal strength, and accuracy. The more a circuit is fired (and thus the more a skill is practiced), the more myelin wraps around that axon, creating a stronger pathway.[37] The more myelin an axon has wrapped around it, in turn, the more quickly and efficiently the axon can pass the information.[38]

Working memory is the active process of learning. It starts by working with approximately seven bits of information (as few as five and as many as nine are also possible). Seven bits of information make up a "chunk" of information, of which the brain is able to manage only four at a time. When attempting to learn a new skill, the ability to do so successfully relies on the learner's ability to hold the information in the mind so that new information can be added to it. As the learner practices a skill multiple times, bits and chunks are combined (or recombined) to form stronger, more stable, and more myelinated axons for this specific skill. Any time a student or learner is practicing a new skill, the information will almost certainly collide with extant memories. As it consolidates old memories and new memories, the brain engages in the process of *constructive memory*, whose products are called *constructed memories*.[39] Memory itself is a messy process, with things that are already known constantly being altered and recombined with new information. For this reason, memories are never truly

37 Daniel Coyle, *The Talent Code* (London: Random House Business, 2020), 32.
38 Leigh-Post, *Mind-Body Awareness for Singers*, 55.
39 Helding, *The Musician's Mind*, 88.

stable. As the brain acquires more memories, the mind creates *schemas*, which are structures meant for organizing and retrieving any and all related information.

Schema Theory

The concept of the *schema* first emerged in 1920, when Henry Head refuted the idea that individual motor signals or mental images were responsible for specific movements.[40] Head studied neurological damage in patients and determined that after certain brain lesions, patients were unable to describe limb movements accurately. These observations led him to propose a new theory of the brain's system of organization, in which all new pieces of information are analyzed before being sorted into specific memory stores, or schemas. Head defined the schema as "a combined standard, against which all subsequent changes of posture are measured before they enter consciousness." In 1932, Frederic Bartlett modified Head's definition, adding details and clarifying the ambiguities in the process implicit in the concept of the schema.[41] Here is Bartlett's definition of the schema:

> An active organization of past relations, or of past experiences, which must always be supposed to be operating in any well-adapted organic response. That is, whenever there is any order or regularity of behaviour a particular response is possible only because it is related to other similar responses which have been serially organized, yet which operate, not simply as individual members coming one after another, but as a unitary mass…All incoming impulses of a certain kind or mode go together to build up an active organized setting.[42]

According to schema theory, as new information is learned, it is combined with previously acquired knowledge. It can also be thought of "as a mental structure of pre-conceived ideas, a framework representing some aspect of the world, or a system of organizing and

40 Graham F. Welch, "Improvability of Poor Pitch Singing: Experiments in Feedback" (dissertation, University of London, 1983): 83.
41 Ibid.
42 Ibid., 84.

perceiving new information."[43] According to Schmidt and Lee, "schema theory holds that there are two states of memory, a recall memory responsible for the production of movement and a recognition memory, responsible for movement evaluation."[44] Schema do not only represent declarative information; they also represent procedural information. This is what is meant by recognition memory — every time a student or learner is practicing, they generate feedback, which informs them so that adjustments can be made to the schemas, or the interior motor plans, involved in the practice.

Working Memory

Baddeley and Hitch developed one of the most influential models of working memory in an article published in 1974.[45] In this model, Baddeley and Hitch explain the ability to hold auditory-phonological and visuospatial information in the short-term memory.[46] This model involves three components: central executive control, domain-specific storage systems, and the episodic buffer. Central executive control is the home of human-willed intentions, or things that someone wants to do. Central executive control includes selective attention, planning of goal-oriented actions and behavior, and coming up with and carrying out problem-solving strategies. Domain-specific storage systems retrieve information from where it is stored in the brain and hold it there to assist the central executive system in performing a task. The episodic buffer plays an important role in "chunking" by combining multiple pieces of information into single units.

---

43 Lei Zhu, "Schema Theory and College English Reading Teaching," *English Language Teaching* 5, no. 11 (December 2012): 111–117.
44 Schmidt and Lee, *Motor Control and Learning*, 371.
45 Leigh-Post, *Mind-Body Awareness for Singers*, 62.
46 Alan Baddeley and Graham Hitch, "Working Memory," *The Cognitive Neuroscience of Working Memory*, 2007, 1-20.

The domain-specific storage systems of Baddeley and Hitch's model include the auditory-phonological loop, the auditory-tonal loop, and the visuospatial domain. The auditory-phonological loop models how humans "activate and repeatedly stimulate" auditory information, such as phonemes, to hold them in the mind for a variety of tasks.[47] The auditory-phonological loop includes such tasks as mental practice, thinking before speaking, or even the standard Alzheimer's test performed in many doctor's offices. The auditory-tonal loop is linked to the phonological loop model, but it involves the ability to hold tonal frequencies, rather than phonemes, in the mind. A singer activates the auditory-tonal loop when audiating or inner-singing. The visuospatial domain interacts in the vestibular system for spatial orientation, and musicians depend upon it by translating notated music into images that ultimately position the different bodily components in the correct place for efficient singing at the correct time.

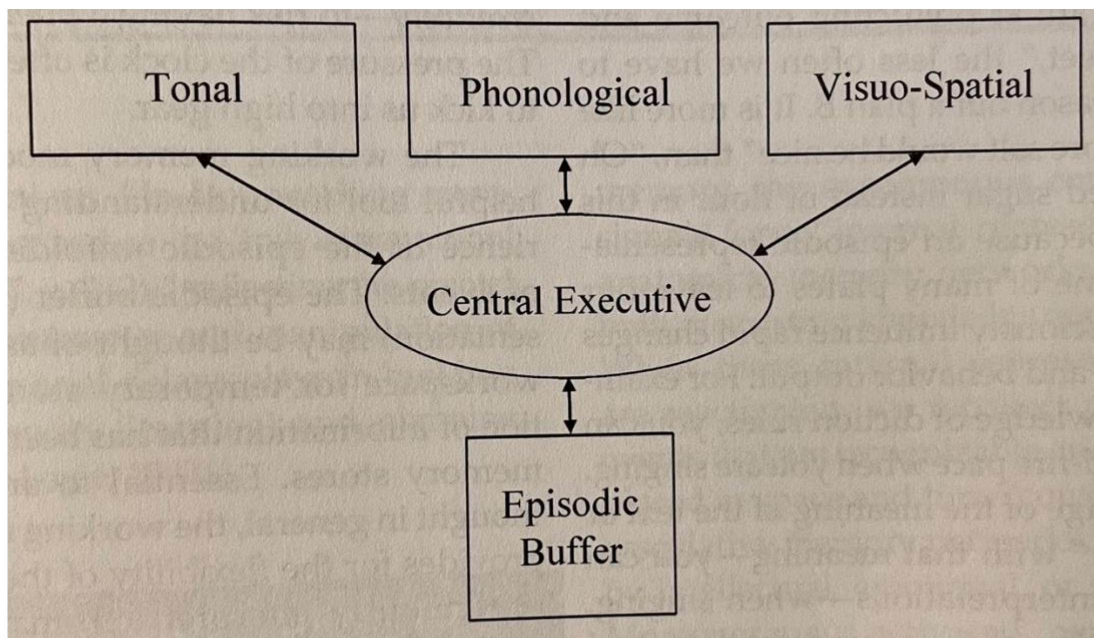


Figure 5: Working memory model for singing. Image reproduced from Karen Leigh-Post, *Mind-Body Awareness for Singers: Unleashing Optimal Performance*, (San Diego, CA: Plural Publishing, 2014): 67.

47 Leigh-Post, *Mind-Body Awareness for Singers*, 65.

The auditory-phonological loop, auditory-tonal loop, and the visuospatial domain are all active components in the working memory and learning process. It is through these systems, all ultimately controlled by the central executive system, that information is received, chunked, recombined, and placed into constructive memory for memory consolidation into the appropriate schema.

Long-Term Memory

We may regard much of the foregoing as an elaboration of Hebb's rule, which states that "Neurons that fire together wire together."[48] Recall that the learning process begins when synapses are destabilized. Short-term memory takes in new information and rapidly sends it to the working memory systems. Repeated practice of the same skill repeats the activation of the same neurons, creating a new memory or neural pathway. This pathway continues to strengthen by means of myelination the more this skill is practiced. After a memory has been practiced, myelinated, and consolidated, it becomes stored in long-term memory. This means that the skill or information has been fully learned, in the sense that it will be available for recall.

Long-term memory comprises two sub-systems: *explicit* and *implicit memory*. Lutz Jäncke succinctly explains the distinction, writing that "the explicit system contains consciously available information and comprises the semantic and episodic memory."[49] Semantic memory contains memory of facts, while the episodic memory is a system that holds events, memory associated with places, times, emotions, and other concept-based knowledge of an experience. The explicit system contains what is referred to above as declarative information. "The implicit

48 Helding, *The Musician's Mind*, 89.
49 Lutz Jäncke, "Music and Memory," *The Oxford Handbook of Music and the Brain*, November 2018, 235-238.

memory system," by contrast, "contains information that is not easy to verbalize but can be used without consciously thinking about it. The neural networks for the implicit memory mainly comprise premotor, cerebellar, and basal ganglia structures."[50] In other words, the implicit memory system is responsible for information that is remember unconsciously and effortlessly, while the explicit memory system is responsible for information that a person must consciously work to remember.

In long-term memory, the brain experiences anatomical changes in the brain tissue. New synapses grow, thereby altering the structure of the brain. Evidence that a skill has been learned and now resides in long-term memory lies in the ability to repeat the skill, a capacity that motor learning researchers often refer to as automaticity. Long-term memories are stored in different areas of the brain based on the information or skill with which they are associated. Once long-term memories are stored, they are able to be recalled to activate specific regions of the brain for necessary or desired functions.

The Motor System

As previously mentioned, the motor system comprises of numerous cortical structures: the basal ganglia, cerebellum, reticular formation, brain stem, primary motor cortex, premotor cortex, and the supplementary motor area (SMA). Each of these cortical structures or areas is involved in upper-level control which coordinate and form motor plans for specific tasks. Located at the top of the brain stem, the basal ganglia and the cerebellum are known to play an influential role in motor programming for speech production as well as other reproducible movements including singing. The basal ganglia receives information from the motor cortices

50 Ibid.

and then either blocks the thalamus from sending information back to the cortex or aids the thalamus in sending information to the cortex. It can suppress movements that are unwanted, or it can prepare motor neuron circuits for a movement. The basal ganglia can also send information directly to the cerebellum and brain stem. The cerebellum plays a significant role in learning, memory, self-monitoring, and "correcting [processes] commonly known as trial and error."[51] It is responsible for processing information and determining if an actual performed movement matches the intended movement. Additionally, the cerebellum is the part of the brain that effects the smoothness and fluidity of movements. Once the cerebellum receives information, it doesn't directly impact movement—it sends information to the deep cerebellar nuclei, which send signals to all of the motor cortices and the brain stem.

The *reticular formation* is a collection of gray matter that runs vertically through the brain stem. It sends information to the reticulospinal tracts of the spinal cord, which activate muscles that are responsible for balance and posture.[52] The reticular formation also sends signals from the eyes and ears to the cerebellum so that the signals can be turned into motor signals.

Also located within the brain stem are the *pons, midbrain, medulla oblongata, superior colliculus*, and the *red nucleus*. The pons is innervated by the reticular formation, but the majority of the pons consists of white matter which carries sensory and motor signals up and down the brain stem. The midbrain, which is also innervated by the reticular formation, contains motor nuclei for two cranial nerves that control eye movements. The medulla oblongata contains networks involved in motor functions including chewing, swallowing, breathing, speaking, and head, neck, and shoulder movements. The reticular formation runs through the medulla

---

51 Leigh-Post, *Mind-Body Awareness for Singers*, 122.
52 Saladin, *Anatomy and Physiology*, 521.

oblongata, and this intersection is responsible for regulation of heart rate, blood pressure, and rhythm and depth of breath.

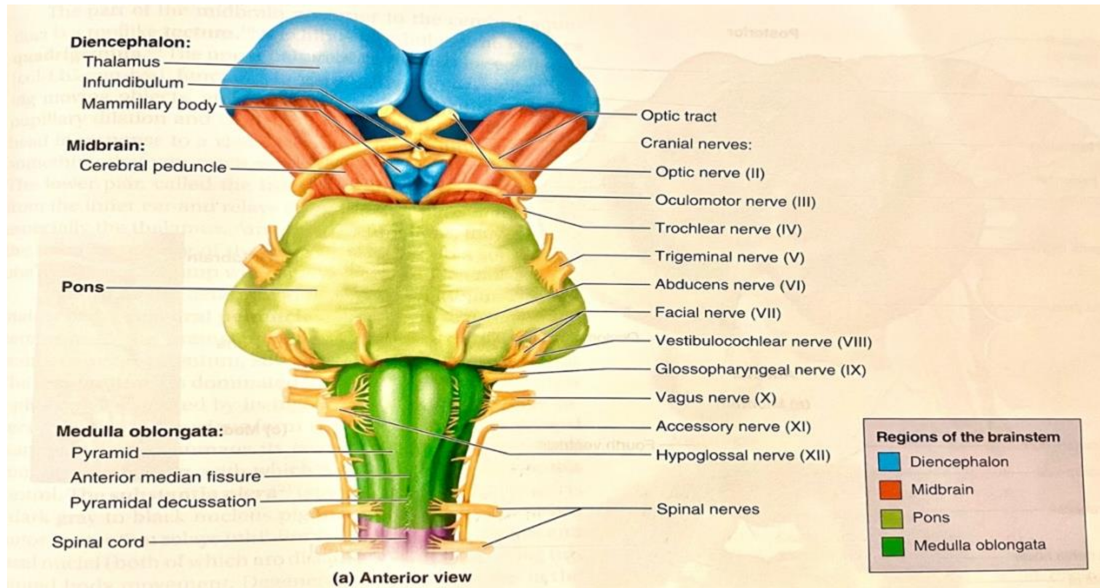


Figure 6: The lobes of the Cerebrum. Image reproduced from Kenneth Saladin, *Anatomy and Physiology: The Unity of Form and Function*, (New York, NY: McGraw Hill Education, 2015): 519.

The *superior colliculus* is responsible for eye movements based on visual stimuli. It also plays a role in affecting the muscles of the neck that are responsible for orientation of the head and eyes. Lastly, the red nucleus sends information from the cortex to the cerebellum. Although that is its main purpose, it is also involved in controlling movements of the arm.

The main components of the motor cortex are the primary motor cortex, the premotor cortex, and the supplementary motor area (SMA). The motor cortex is responsible for planning and executing nearly all voluntary movements. The primary motor cortex is known for its mapping of the muscle groups in the human body. It is involved in basic execution of voluntary movements. Stimulation of individual regions of the primary motor cortex causes movements based on the muscles associated with the stimulated region. As mentioned above, the laryngeal motor cortex is one of the regions of the primary motor cortex. The premotor cortex is not only

involved in the execution of movement; it also activates based on inferred intentions of movement.[53] It receives information from the sensory cortex, sends information to the primary motor cortex, and is involved in choosing motor programs based on sensory stimuli. It also regulates brain stem motor control functions in addition to the motor control functions of the primary motor cortex. The supplementary motor area (SMA) aids in selecting movements based on already-known movement programs.

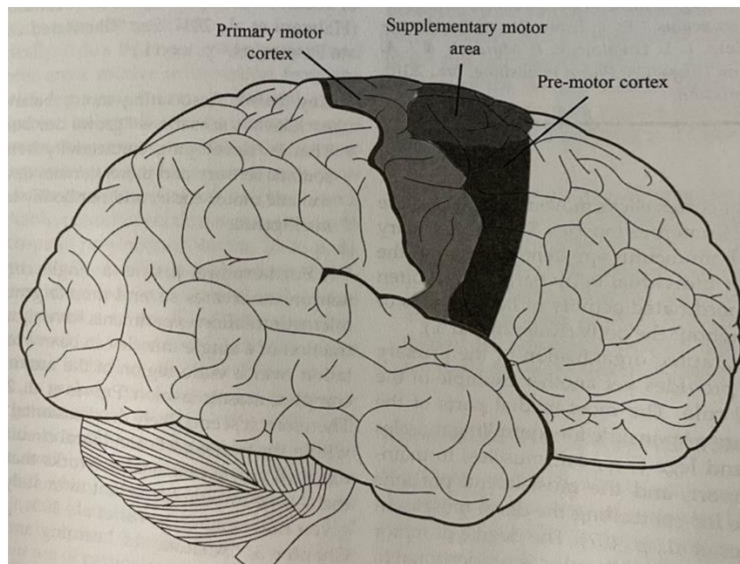


Figure 7: Motor cortex. Image reproduced from Karen Leigh-Post, *Mind-Body Awareness for Singers: Unleashing Optimal Performance*, (San Diego, CA: Plural Publishing Inc, 2014): 129.

Sensory information stimulates movement by influencing motor control. Schmidt and Lee describe a closed-loop model for motor control, which is influenced by executive control (see Figure 8).

53 Leigh-Post, *Mind-Body Awareness for Singers*, 131.

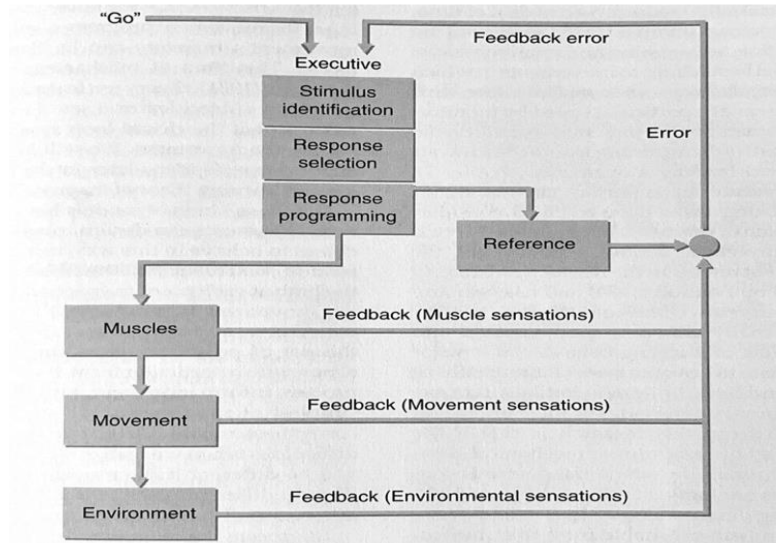


Figure 8: The expanded closed-loop model for movement control. Image reproduced from Richard Schmidt and Timothy Lee, *Motor Control and Learning: A Behavioral Emphasis*, (Champagne, IL: Human Kinetics, 1999): 115.

In this model, planning and execution of a motor function begins with an external stimulus or an internal signal. This initiates the action by prompting identification of the stimulus and selecting the appropriate response. Then, the motor cortices program the movements for the response selected, which eventually leads to contraction of muscles, causing movement. Movements then produce changes in the environment. Each part of this process, from the contraction of muscles on, generates information. The information is then processed for its correctness, signals that there has been an error (potentially), and provides feedback to alter the movement program (or not, if the movement was correct). This feedback then restarts the process with stimulus identification.[54]

Anatomically, external stimuli are received by various receptors: visual stimuli by the eyes, aural stimuli by the ears, and physical stimuli by proprioceptors. Proprioceptors are sensors that provide information about bodily movements.[55] They include the vestibular system, which is

54 Schmidt and Lee, *Motor Control and Learning*, 114–115.
55 Ibid., 110.

located in the inner ear and provides information about head movements. There are two small structures in the inner ear that provide this information: the saccule and the utricle. These two structures signal information about the head in comparison to the line of gravity. Near the saccule and the utricle, there are three fluid-filled pockets, called the semicircular canals. These structures sense directional movements of the body, including rotation. Muscle receptors are also proprioceptors, providing information about the states of the muscles where they are found. Additional proprioceptors are the cutaneous receptors, which are located in various places in the skin and are related to perception of movement. They signal sensations such as cold, heat, pressure, and touch.

Receipt of stimuli from any of the aforementioned receptors triggers a plan to execute a motor response, beginning in the premotor area. During the formation of a motor plan, neurons create a program for the sequence of muscle contractions. The supplementary motor area is also often involved in the planning of motor programs, especially in the execution of vocal-motor skills.[56] After the program is formed, it travels to neurons in the primary motor cortex. Most of the neurons that travel from the primary motor cortex carrying signals regarding motor functions will proceed along one of two major tracts: the *corticospinal tract* and the *corticobulbar tract*. The corticospinal tract carries motor signals to the spinal cord to cause movement of the body, and the corticobulbar tract carries motor signals to the brain stem to trigger movement of the head, neck, and face. Once signals reach the area that is meant to trigger the motor response, muscle contraction occurs, causing the appropriate part(s) of the body to move.

---

56 Sarah J. Wilson et al., "Finding Your Voice: A Singing Lesson from Functional Imaging," *Human Brain Mapping* 32, no. 12 (2010): 2127.

Motor Learning

One of the most important questions in learning a skill is "how?" How do people learn a new motor skill? Recall the distinction between declarative (know-that) learning and procedural (know-how) learning: declarative learning refers to the learning of factual information that one could state or declare, whereas procedural learning refers to the learning of physical skills by doing. The study and research of procedural learning is called *motor learning*. According to Helding, "motor learning is a process that is inferred rather than directly observed that leads to permanent changes in habit as the result of practice."[57] Schmidt and Lee add that motor learning, or the learning of skilled behaviors, has four defining characteristics: process, capability, unobservability, and permanence.[58] The process in question is the reception of a motor program from memory. The capability is an increased state of fluency and efficiency in movement for a specific skill. Unobservability means exactly what one would assume — motor learning is not directly observable. The processes that cause changes in capability themselves entail complex processes within the central nervous system, such as the reorganization of sensory information.[59] These processes can only be inferred from changes in motor behavior. Permanence means that a learned skill does not disintegrate within hours or even days, though it is a relative quality: if enough time is spent away from practicing a particular skill, the memory for that skill will disintegrate slightly, but it will not disappear entirely.

The measure of motor learning is a skill's repeatability, more specifically repeatability given varied conditions. *Retention* refers to the learner's ability to recall the information or skill after periods of rest. Such periods could be as short as a few hours, or potentially as long as

57 Helding, *The Musician's Mind*, 100.
58 Schmidt and Lee, *Motor Control and Learning*, 264.
59 Ibid., 265.

months (or even years…think about riding a bike). Transfer refers to being able to repeat a skill in a variety of conditions. For a singer, indeed, skills are often learned and practiced in the studio or a practice room; however, the ultimate goal is that the same skills cannot be performed in an audition room, on stage during a performance, or in any other setting necessary. To say that a skill has truly been learned, it must be able to be recalled and repeated in other settings outside of those in which it was first learned and practiced.

The motor learning field has described two modes of conscious attention: *controlled processing* and *automatic processing*.[60] Controlled processes include specific instructions and require direct control from the learner. Automatic processes often use a combination of emotion and imagery to create a physical response without direct attention being paid to the mechanics. Singers and teachers of singing often use a combination of both controlled and automatic processes. Beginners often benefit from more controlled processes and directives, whereas advanced learners may experience more success with automatic process directives.[61]

The directives used in both controlled processes and automatic processes are examples of feedback, which is an integral component of motor learning. Defined simply, feedback is any information learners receive about their performance. This information could come from teachers, directors, friends, or even learner themselves. The latter type of feedback is called *inherent feedback*. Inherent feedback is of two kinds, *proprioception* and *exteroception*: proprioception involves information that is felt by learners from within their own bodies; exteroception includes feedback from outside the body, typically using vision or hearing.

Augmented feedback involves information from an external source, such as a teacher or audio/video recorder. Schmidt and Lee note that augmented feedback is controllable by the

60 Helding, *The Musician's Mind*, 118.
61 Ibid., 119.

teacher, so the teacher can choose whether the feedback is necessary at the given time, or if it should be given at all, as it might cause distraction from the main focus. For teachers, augmented feedback can be given before, during, or after performance of a skill. Augmented feedback given before performance of a skill can be helpful to provide the student a sense of focus. Augmented feedback given during performance of a skill, known as concurrent augmented feedback, can potentially cause more harm than good. Language processing occurs more slowly than emotional processing, so concurrent augmented feedback often becomes processed with too little time for students to make any necessary alterations to their performances. Moreover, when students attempt to process incoming concurrent augmented feedback, they may be unable to process their own proprioceptive feedback, resulting in poor performance. Research shows that concurrent augmented feedback boosts short-term performance, but it actually depresses long-term skill acquisition and learning.

Augmented feedback given after a student's performance is referred to as terminal feedback. Terminal feedback can be broken down into three subcategories: instantaneous, immediate, and delayed.[62] Instantaneous feedback is feedback given with absolutely no time after the student has finished performing. This type of feedback includes teachers interrupting their students, causing them to stop, to provide feedback. Research on timing of terminal feedback shows that instantaneous feedback has the same negative effects on long-term learning as concurrent augmented feedback. Immediate feedback is feedback given a short period (a few seconds) after the student has finished performing. This type of terminal feedback allows the student to experience inherent proprioceptive feedback for a short period before being given augmented feedback. Research shows that this is the most effective type of terminal feedback.

62 Ibid., 133.

Lastly, delayed feedback is feedback that is provided to the student after a significant time lapse. This could be anywhere from fifteen minutes later in a lesson to feedback days after a lesson. This delayed feedback causes degradation of long-term learning since the students are not able to process the feedback while the memory of the performance is fresh in their minds.

Ultimately, motor learning requires and is aided by both inherent and augmented feedback. It is important, however, that feedback be given at appropriate times so that it doesn't detract from long-term skill acquisition. Inherent feedback, both proprioception and exteroception, occur by students/learners during their performance. Augmented feedback is shown to be the most successful when given a short period after the performance in a lesson. Immediate and delayed feedback, by contrast, are shown to impede long-term learning.

In closing, let us return to the practice-room considerations discussed above in the light of the foregoing information about the process of motor learning. In the domain of physical practice routines, distributed practice, or practice over shorter periods of time more often, leads to stronger acquisition, retention, and transfer of skills over time.[63] An added benefit to distributed practice rather than massed practice is a period of rest, aiding against fatigue. Variability in practice also affects learning, since an important part of learning a skill is the ability to repeat that skill in new settings and situations. By varying their practice conditions, learners are more likely to be successful when asked to perform a skill outside of their typical practice environment. According to a study by Shea and Kohl, practice of skills that are similar to, but slightly varied from, the skill being acquired increase the retention of the target skill.[64] Random practice involves practicing a set of skills in various orders during a practice session. A

63 Schmidt and Lee, *Motor Control and Learning*, 294.
64 Ibid., 299.

study by Shea and Morgan suggests that although blocked practice causes more effective short-term skill acquisition, random practice shows greater retention of skills over time.

Practicing is clearly crucial to the acquisition and development of motor functions. When planning a physical practice routine or schedule for a week, a singer should keep in mind that distributed practice is more effective than massed practice, varied practice is more effective than constant practice, and randomly ordered practice is more effective than blocked practice. All of these basic suggestions for practice hold the promise of promoting long-term skill acquisition and stronger skill retention over time.

Chapter Three:

Mental Practice

Although physical practice is the crux of how a singer acquires and develops motor and vocal-motor skills, it is worth asking whether a singer would benefit from incorporating mental practice routines into their practice, as do professionals in sports, medicine, and physical therapy. Definitions of mental practice (MP) vary widely. The *Oxford Dictionary of Sport Science and Medicine* defines mental practice as the following:

> A form of practice in which subjects produce a vivid mental image of actually performing a technique; that is, they do not imagine that they are watching themselves perform, but they actually carry out the activity in their imagination without overt physical movement.[65]

Speech-language pathologists Page and Harnish define mental practice as "the cognitive rehearsal of physical movements in the absence of physical, voluntary attempts."[66] Malouin and Richards, meanwhile, define mental practice as "the repetition or rehearsing of imagined motor acts with the intention of improving their physical execution."[67] These and most other definitions of mental practice, whatever their differences, agree that it involves the use of vivid mental imagery, imagination of the self physically performing a task, the an absence of physical movement, with the goal of improving physical function. In a musical context, mental practice methods might include the use of score analysis, mental imagery, performance scripts, attentive listening, third-person observation, and observation of detailed diagrams. Before looking at each of these methods of mental practice for singing in depth, let us first consider the following

65 Susan Mielke and Gilles Comeau, "Developing a Literature-Based Glossary and Taxonomy for the Study of Mental Practice in Music Performance," *Musicae Scientiae* 23, no. 2 (2017): 197.
66 Stephen J. Page and Stacy Harnish, "Thinking about Better Speech: Mental Practice for Stroke-Induced Motor Speech Impairments," *Aphasiology* 26, no. 2 (2012): 130.
67 Francine Malouin and Carol L. Richards, "Mental Practice for Relearning Locomotor Skills," *Physical Therapy* 90, no. 2 (January 2010): 241.

questions: What is the purpose of mental practice? Why should a singer consider adding mental practice to their routines? How might they do so? With what efficacy can they expect to implement mental practice?

What is the purpose of mental practice? Recent research in neuroscience, rehabilitation, and sports medicine demonstrates that mental practice can be used to rehearse a newly learned skill to strengthen its mental representation, or schema.[68] Mental practice is shown to cause the same cortical changes as physical practice. Bernardi et al. have shown that the use of mental practice leads to a greater efficiency and fluency in repetition of the motor skill being learned. In other words, mental practice has the ability to make a skill easier. In addition to creating a stronger mental schema and more efficient recall, incorporating mental practice into a singer's practice routine leads to a significantly lower vocal dose, enhances the ability to practice while experiencing vocal fatigue or injury, and allows a singer to practice in new environments where physical practice might not be possible (like while traveling), ultimately enhancing the overall amount of practice time spent, thereby increasing time to mastery.

Vocal dose refers to the amount of use the voice receives on a regular basis and the manner in which the voice is used. The vocal dose of a singer is typically significantly higher than that of a non-singer due to the time spent each day practicing, in addition to normal speaking obligations for work or other social commitments. When engaged in high intensity singing, the demand on the vocal folds is higher than in speaking, so by adding even an hour a day of high intensity singing to a normal day's worth of speaking, the vocal dose has been considerably raised. A higher vocal dose has the potential to lead to extreme vocal fatigue or even vocal injury if the voice is not cared for adequately, which includes periods of non-singing.

---

68 Nicolò F. Bernardi et al., "Mental Practice Promotes Motor Anticipation: Evidence from Skilled Music Performance," *Frontiers in Human Neuroscience* 7 (2013): 10. On schema theory, see Chapter 2.

By incorporating mental practice into a singer's practice routine, they will still be able to make notable strides in their singing or in the learning of new music without causing overuse of their instrument.

If a singer is experiencing any form of vocal fatigue or injury, ranging from muscular tension dysphonia (MTD) to more serious lesions, mental practice allows the singer to maintain a practice schedule while following the instructions of their healthcare provider, voice specialist, and voice teacher. In most cases of vocal injury, complete vocal rest is no longer the recommendation; however, a lower vocal dose generally still.[69] Mental practice for a singer dealing with a voice disorder could range from score analysis and attentive listening to the use of anatomically detailed diagrams and third-person observation of vocal-motor function to enhance their vocal rehabilitation.

Many singers spend countless hours on planes, trains, in ride shares, or in hotels as part of the professional life. Unfortunately, few such places allow for countless hours (or indeed any hours) of physical practice, which might be important if a singer is stepping foot off a plane and heading directly to a rehearsal or audition. The use of mental practice allows a singer the opportunity to practice in even the most inconvenient places. A singer can use score analysis, attentive listening, mental imagery, and performance scripts all in public spaces when they do not have much space to move or are unable to make sounds.

Turning back to the "10,000 hours rule" and the road to expertise, the evidence suggests that a singer can effectively pair mental practice with a physical practice routine to expedite the process towards mastering a skill or set of skills. Again, 10,000 hours is the number of hours that researchers have said is necessary to achieve mastery in a motor skill. If a singer begins

69 Kari Ragan, Vocal Pedagogy Lecture, University of Washington (Seattle, WA, February 2, 2021).

practicing at age thirteen and practiced one or two hours a day, five days a week, they would need no fewer than twenty years to achieve mastery. In *Mind-Body Awareness for Singer*, Karen Leigh-Post offers the following alternate plans for achieving 10,000 hours to mastery:

> Plan B:
>
> 1 to 2 hours per day: practice room
> 1 to 2 hours per day: mental rehearsal—Real-time sensorimotor imagery. Practice at retrieval and the construction of new outcomes. (May be done concurrently with weight-bearing workout to build visuospatial intelligence.)
>
> ___________
>
> 3 hours per day = 1,000 hours per year, or 10 years to mastery. Better.
>
> Plan C:
>
> 1 hour per day: Mindful listening to music
> 1 hour per day: Mental rehearsal—Real-time sensorimotor imagery. Practice at retrieval and the construction of new outcomes
> 1 hour per day: Ensemble rehearsal—Mindful reinforcement of musical skills
> 2 hours per day: Practice room (can be spaced out)
> 1 hour per day: Weight-bearing workout—Visuospatial intelligence; proprio-kinesthetic sense of balance and motion (can be done concurrently with mental rehearsal or mindful listening to music)
>
> ___________
>
> 5 to 6 hours per day = about 1,500 to 2,000 hours per year, or 5 to 7 years to 10,000 hours. Best.[70]

It is clear from Plan C that incorporating effective and well-planned mental practice into an existing physical practice routine rapidly reduces the number of years toward mastery. This does not mean that a singer is working less to achieve mastery, but rather that they are working more efficiently.

There are many different forms of mental practice. Most of the research on the efficacy of mental practice for motor skill enhancement is in the fields of sports medicine, surgery, physical therapy/rehabilitation, and instrumental music; unfortunately, little research has been done to

---

70 Leigh-Post, *Mind-Body Awareness for Singers*, 93.

study its efficacy for singing. Nevertheless, many voice researchers believe that the findings from these other fields can be applied to mental practice for vocal-motor skills.

To understand better the forms of mental practice that can be beneficial for the acquisition and refinement of vocal-motor skills, it is important to take a brief look at some of the current evidence about the success of methods of incorporating mental practice in the fields where it is more prominent. Analysis of these methods yields insights about how we might apply mental practice to singing, which will be a topic for subsequent chapters. The forms of mental practice that have been found most effective in sports medicine, surgery, physical therapy and rehabilitation, and instrumental music are the use of mental (or motor) imagery, performance scripts, attentive listening, third-person observation, and studying detailed anatomical diagrams. The rest of this chapter surveys each of these methods in turn.

Mental/Motor Imagery

Mental imagery refers to the process of creating an internal representation that simulates an experience when sensory input is absent.[71] A central component of mental imagery practice is that it occurs in the absence of any overt physical movement. Mental imagery practice was first documented in the 1800s in the ancient Indian practice of yoga, specifically in a religious context. In this context, visualization of health and a healthy lifestyle was thought to be essential for healing of sick people. "In 1894, W.B. Carpenter proposed the ideo-motor principle, stating that low-level neuromuscular patterns during imagining might correspond with those measured during overt action."[72] Since 1914, there has been extensive research into the positive effects of

71 Tadhg E. MacIntyre et al., "An Emerging Paradigm: a Strength-Based Approach to Exploring Mental Imagery," *Frontiers in Human Neuroscience* 7 (2013): 1.
72 Karin E. Hinshaw, "The Effects of Mental Practice on Motor Skill Performance: Critical Evaluation and Meta-Analysis," *Imagination, Cognition and Personality* 11, no. 1 (1991): 4.

mental/motor imagery. Much of this research has found that mental and motor imagery practice leads to increased corticospinal excitability and causes the same chemical signals to be sent from the motor cortices to the spine and brain stem as physical practice sends, thereby strengthening the neural pathways for specific motor functions. Developments in imaging have boosted this field: reviewing the literature, Guillot, Louis, and Collet write that "fMRI (functional magnetic resonance imaging) and PET (positron emission tomography) studies have extensively demonstrated that motor imagery and motor performance share the same neural networks, including the motor systems, as well as the inferior and superior parietal lobules."[73] Another interesting finding of these fMRI and PET studies is that areas that were highly active and influential in the formation of mental imagery were the premotor cortex, SMA (supplementary motor area), basal ganglia, and cerebellum—all of which are involved in planning and executing physical motor tasks. Different types of imagery (visual, auditory, and kinesthetic) activate different areas of the brain.

When a person is creating a mental image, the motor system gets primed for execution of that action, rehearsing and refining the motor program. However, simply imagining execution at a surface level will not create the same effects as physical practice. Within the literature on mental imagery, it is clear that for mental imagery to be beneficial to the learner, mental images must be *vivid*, and they must be created in the first-person perspective.

Vividness refers to the level of detail and accuracy with which a mental image can be created; specifically, it refers to a person's capacity for creativity. There will be more activation of the motor system and the cortical networks supporting a skill if the mental image is detailed. According to MacIntyre et al., "the vividness of our memories…provides a multisensory

73 Aymeric Guillot, Magali Louis, and Christian Collet, "The Neurophysiological Foundations of Mental and Motor Imagery," *Oxford Scholarship Online*, March 2012: 7.

episodic procedural memory that gives green exercise its sticky behavior effect (increased adherence and higher propensity for future engagement)."[74] In other words, the more vivid a mental image, the easier it will be to recall. There are tests to measure the level of a person's ability to create vivid images, but those tests are beyond the scope of this project.

The other important aspect of mental imagery is that it must be done from a first-person, internal perspective. A study by Jacobson shows that first-person, internal imagery has stronger effects on retention and recall than third-person, external imagery.[75] What this means is that mental images of another person performing a skill will not have as great an effect in activating the motor network of the imager as a mental image that embodies them performing the skill. A study by Ranganathan et al. was performed using *Visualization-Guided Brain Activation (VGBA)* training, in which participants were instructed using either specific external imagery or internal imagery to imagine their finger was pushing a button, which was used to measure strength of the push. The results of this study show that external imagery is significantly less beneficial for enhancing a motor skill. On the contrary, when given specific internal imagery instructions, there were significantly stronger results: according to Ranganathan et al., "this mental exercise was not simply a visualization of oneself performing the task; rather, the performers were instructed to adopt a kinesthetic imagery approach, in which they urged the muscles to contract maximally, and this was accompanied by significantly elevated physiological responses."[76] These results support the previous assertion that vivid mental images created in the first-person, internal

---

74 Tadhg E. MacIntyre et al., "Motor Imagery, Performance and Motor Rehabilitation," *Progress in Brain Research* 240, no. 0079-6123 (2018): p. 151.
75 Hinshaw, "The Effects of Mental Practice on Motor Skill Performance," 21.
76 Vinoth K. Ranganathan et al., "From Mental Power to Muscle Power—Gaining Strength by Using the Mind," *Neuropsychologia* 42, no. 7 (2004): 2.

perspective have a greater effect on the ability to retain and recall a skill for more efficient performance.

Performance Scripts

A performance script is a type of mental imagery in which performers can mentally guide themselves through the steps of a successful performance of some physical action or series of actions from beginning to end. The process of using a performance script begins with writing how one would proceed through a performance from start to end. This type of exercise requires you to choose your words very carefully, as some words might generate mental images that are not actually helpful in physical performance. A performance script should begin with the location right before the performance. In this script, the performers describe in detail how they want to feel, and they even include encouraging thoughts that might cross their minds during performance.[77] The performance script should include the performers' experiences both before and after the performance — things like being in the green room or backstage, and then also greeting the audience at a reception or stage door following a performance. The performance script should end with reflections on the performer's feelings about both themselves and their performance.

After writing the performance script, the writer/performer should read it aloud to make sure it sounds natural and sincere. This performance script can and should be read as often as needed, making edits based on new performance situations, to enhance motivation and inspiration. The use of a performance script should not only foster motivation and inspiration for practice and performance, but it should also aid in the formation of vivid mental imagery of both

77 Cornett, *The Mindful Musician*, 221.

motor skills and other performance aspects that are necessary for a successful performance. By writing, re-reading, and reciting a detailed performance script, the writer/performer creates stronger synaptic connections for the skills mentioned. Every time the writer/performer reads this script, the motor pathways associated with the mentioned skills are activated, causing a form of "replay" in the imagination. This mental replay causes more myelin to wrap the axons for the imagined skill, which leads to faster recall and quicker, more efficient performance of motor skills.

Attentive Listening

Attentive listening requires a heightened state of awareness and intentional focus; therefore, it cannot be practiced while engaged in another activity (like cleaning, cooking, or commuting). Humans are able to use executive influence to focus attention on a specific task or sound. The human mind allows itself to tune out unimportant or distracting sounds (or other external stimuli) to invest more energy into focusing on a specific task. While listening attentively, vivid mental images can be created that can influence motor function in turn.

Leigh-Post offers the following attentive listening exercise, which I will adapt for the purpose of singing in a later chapter:

> While standing, and preferably in a room with windows and a door that are opened to ambient sound, listen intently to a faint and distant sound. Follow the sound for several minutes using timbre information to determine its source. If you hear footsteps or a voice, is it a man or a woman? How old? Use intensity information to determine if the sound is moving toward you or away from you. Perhaps you hear a car or a truck. If you are in a room with others, can you detect the sounds of those breathing around you? Can you detect the ticking of an analog clock? What sounds are amplified? Repeat the exercise focusing on a variety of sound sources.[78]

78 Leigh-Post, *Mind-Body Awareness for Singers*, 12–13.

This example teaches a listener how to use selective attention to become hyper-focused on a specific sound. Although the example doesn't pertain directly to music, it shows how to place the mind in a state that can be helpful for mental imagery formation with respect to sound.

Harris and de Jong have shown that when people listen to music before performing an action, their attentiveness correlated with activation of the auditory-parietal-premotor sequence.[79] Furthermore, if a musician is listening to a piece they have practiced recently, there is an even more pronounced increase in premotor activation. What this suggests is that performers who learn to listen attentively, using a process similar to the one described above, are likely to activate the motor sequence associated with the music they are listening to.

Third-Person Observation

Although I have explained that a first-person perspective of imagery is more beneficial than a third-person perspective in supporting mental imagery and motor learning, there are benefits to using a third-person perspective for certain forms of mental practice. Page and Harnish, in work that focused on speech impairments in patients of stroke and patients with aphasia, provide evidence that third-person observation of motor skills can be beneficial in learning a new motor skill or refining an existing one. Indeed, the results of numerous studies show that observation of other's movements activate a *mirror neuron system* that benefits motor learning.[80] For example, Page and Harnish discuss the activation of mirror neurons during mouth and communication gestures; however, there is significant evidence to support the idea that mirror neurons activate in various systems of motor functions.

---

79 Robert Harris and Bauke M. de Jong, "Cerebral Activations Related to Audition-Driven Performance Imagery in Professional Musicians," *PLoS ONE* 9, no. 4 (August 2014), 7.
80 Page and Harnish, *Thinking About Better Speech*, 134.

Neuroscientists first discovered the mirror neuron system in 1996, in the premotor cortex of macaque monkeys, when Rizzolatti performed a study that observed mirror neurons discharging both when a macaque monkey does an action and also when it observes another individual (monkey or human) doing a similar action.[81] Since their initial discovery in 1996, mirror neurons have been studied in song learning in birds, and now in humans. Not until 2010, however, were mirror neurons directly recorded in the human brain.[82] Previously, neuroscientists had assumed that mirror neurons only exist in specific areas of the brain, but it is now clear that mirror neurons exist in many cortical areas, and they are widely believed to play a crucial role in mimicry and language acquisition. Notably, the mirror neuron system is unable to create or mimic skills that the observer hasn't acquired yet; rather, it is specific to skills that already exist in the observer's motor repertoire. Some mirror neurons are also activated by sounds observed during an action; and sounds associated with an action have the ability to elicit motor responses. Take Pavlov's dogs, for example: Pavlov hypothesized that dogs would salivate in response to placing food in front of them, but what he actually noticed was that his dogs began to salivate whenever they heard the footsteps of his assistant who was bringing them the food. This is a prime example (although before discovery of the mirror neuron system) of auditory stimulus activating the mirror neuron system.

Mirror neurons are not innate. They form through a combination of sensorimotor experiences—doing and observing the same action. The mirror system cannot respond only to observation. Observers must already have the observed motor function in their own repertoire for

81 Giacomo Rizzolatti and Laila Craighero, "The Mirror-Neuron System," *Annual Review of Neuroscience* 27, no. 1 (2004): 169.
82 "UCLA Researchers Make First Direct Recording of Mirror Neurons in Human Brain," *NewsRx Health & Science*, May 2, 2010, 128.

third-person observation to be effective. Mirror neurons transform visual stimuli into the specific motor capabilities of the observer.[83]

Hickok and Poeppel have modeled the efficacy of third-person observation and the mirror neuron system for motor function refinement.[84] Their model deals with phoneme-based learning using third-person observation and the mirror neuron system in children. According to Knott, who has described their findings, "the mirror system for phonemes allows the phonology of heard words to be represented as articulatory gestures, and thus ensures that phonology-meaning associations that the child learns passively, through hearing words spoken by mature speakers, can subsequently by used to actively generate words."[85] In other words, children learn to produce phonemes first by listening and observing more mature speakers and then by repeating the sound. This is the mirror neuron system in action.

Further evidence supporting the use of third-person observation for vocal-motor skill acquisition and refinement comes from phoneme-based rehabilitation in patients suffering from aphasia. Occurring after anatomically depicted diagrams (see below) have been shown to a patient, this form of rehabilitation therapy incorporates third-person observation (both aural and visual) of specific phonemes. As the patient recovers the ability to replicate discrete phonemes, the rehabilitation specialist then begins to string together more complex words comprised of multiple syllables.[86]

Third-person observation is a beneficial form of mental practice as long as the skill being observed already exists in some form in the motor repertoire of the observer. Observing a more

---

83 B. Calvo-Merino et al., "Action Observation and Acquired Motor Skills: An FMRI Study with Expert Dancers," *Cerebral Cortex* 15, no. 8 (2004): 1248.
84 Alistair Knott, "Linguistic Representations in the Brain: Current Models of Localization and Development," in *Sensorimotor Cognition and Natural Language Syntax* (Cambridge, MA: MIT Press, 2012), 216.
85 Ibid., 230.
86 Diane L. Kendall et al., "Phoneme-Based Rehabilitation of Anomia in Aphasia," *Brain and Language* 105, no. 1 (2008): 8.

proficient performer activates the mirror neuron system, strengthening the representation or schema that already exists for that particular skill.

Detailed Anatomical Diagrams

The use of detailed anatomical diagrams is a crucial component of rehabilitation for patients with aphasia. A detailed anatomical diagram is similar to an image one might find in a biology textbook, showing all of the specific body parts involved in creating a phoneme. The diagrams used for phoneme-based rehabilitation, however, are even more specific, in that they not only show the articulatory structures, but they also show the precise location and position of each articulatory structure necessary to create a particular phoneme. These detailed diagrams are often paired with proprioceptive and visual feedback of the patient's own articulatory positions for the same phoneme sound. Through observation and detailed instruction by a trained professional, differences can be noticed between the optimal position of the articulatory structures and the position of the patient's articulatory structures. This feedback can guide the patient to alter their articulatory position over time, creating phonemes that are more accurate.

Another example of the use of detailed anatomical diagrams is whenever a person goes to a physical therapist's office for a physical therapy session. Many physical therapists have detailed anatomical diagrams hanging on their walls or in books they share with patients. When they show these diagrams to a patient, the patient can form a better mental image of the motor sequence (including the contraction of specific muscles) necessary to perform any given motor function more efficiently. The diagram itself is not causing the patient to execute a function more fluidly; rather, it is aiding in the formation of a mental/motor image that can be used to alter and refine the already known motor sequence.

Chapter Four:

Mental Practice for Respiration

In order to incorporate mental practice for the system of respiration effectively with respect to singing, it is important to understand the mechanics of the respiration system. This dissertation is not intended to be a vocal pedagogy resource, and it does not offer great detail about the anatomy and physiology of the breath mechanism; before proceeding, however, a brief overview of this topic is necessary.

The two primary muscles of inhalation are the diaphragm and the external intercostal muscles, which are aided by several accessory muscles. During inhalation, the rib cage expands and the abdominal wall releases, creating negative pressure within the lungs by way of the contraction of the diaphragm. As the lungs expand, air pressure is equalized by having air drawn into the lungs.[87] Kari Ragan describes this process in detail: "the outward movement of the rib cage is due to muscle contraction (diaphragm and external intercostal muscles) and the presence of the internal organs beneath the rib cage resisting downward movement … while the outward abdominal wall movement is due to a release of the core muscles' contractions."[88] The rib cage is able to expand outward in a swinging motion (like the handle of a bucket) thanks to flexible cartilage that makes up the first one-to-one-half inches of each rib where it meets the sternum.

During exhalation, there are six primary muscles involved in expelling air from the body: the internal intercostals, rectus abdominis, internal and external obliques, transverse abdominus, and quadratus lumborum.

---

87 Kari Ragan, A Systematic Approach to Voice: The Art of Studio Application (San Diego, CA: Plural Publishing, Inc., 2020), 20–21.
88 Ibid., 21.

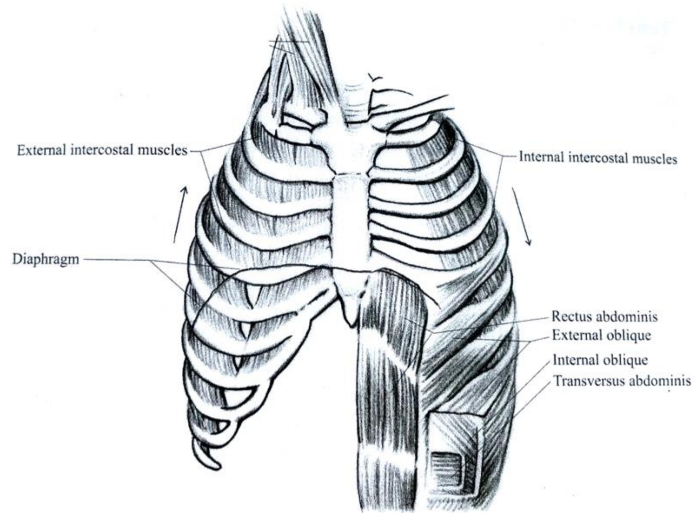


Figure 9: The primary muscles of inhalation and exhalation. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 23.

During exhalation, muscle contraction alters the pressure within the abdomen by making the rib cage smaller and compressing the abdominal viscera. This decreases the volume of the lungs and causes air to be expelled. For singing, there is an important relationship between the muscles of inhalation and exhalation. These sets of muscles work antagonistically to create breath management, controlling the rate at which air is released from the body.

Mindfulness for Respiration

In order to incorporate mental practice for respiration successfully, the learner must first achieve a state of heightened awareness, or mindfulness. There are numerous techniques for entering such a state; the following exercise, from Leigh-Post's *Mind-Body Awareness for Singers*, exemplifies one such technique:

> If possible, remove your shoes and stand in a room that has windows or doors that may be opened to ambient sound.
>
> 1. Stand at rest, breathing comfortably. We will call this neutral.
> 2. Notice the spaces surrounding you, inside the room and beyond.

> 3. Listen to the sounds surrounding you, inside the room and beyond. What happens when you recall a favorite melody (inner sing)?
> 4. Stand on your dominant leg, placing the toe of your other foot just ahead of you or in a tree pose, if you like. Now shift your weight ever so slightly from what is equalized pressure between the ball and heel of your foot so that about 75% of your weight is on the ball of your foot. Do this without lifting the heel of your foot from the floor and maintain easy balance. Try shifting your weight toward the heel of your foot. What changes? What information alerts your conscious mind?[89]

In this exercise, the body is aroused by the change in posture, which prompts the ascending reticular activating system. This prompting alerts the conscious mind to new information that needs attention. Because of the state of arousal while performing this exercise, the mind and body will be more receptive to changes in incoming sensory information. This means that by raising the state of awareness, visual, aural, or mental stimuli have a greater effect on the mind. This level of mindfulness allows the use of a performance script, detailed anatomical diagrams, mental imagery, and third-person observation to access and enhance motor sequence pathways more easily. Additionally, many exercises similar to the one above require a singer or student of singing to be off-balance serve multiple purposes, including lower abdominal/core engagement. Additionally, exercises that have a singer off-balance act as a distraction from other physical occurrences in the body, ultimately releasing unwanted tensions.

Performance Script for Respiration

As explained in the previous chapter, a performance script maps the performance of a specific skill as a series of discrete steps. Performance scripts include thoughts and feelings that are typically experienced before, during, and after the performance of the skill being practiced. The performance script must be as specific and detailed as possible, and it should be written in

---

89 Leigh-Post, *Mind-Body Awareness for Singers*, 11.

the first-person perspective. The following is an example of a performance script for practicing respiration (note, however, that every singer has a different experience of breathing, and this script might need to be altered based on experience):

> *I am beginning my practice session. As I look around my practice room, I can see a piano, my books of music on top of the piano, my water bottle on the piano bench, and my own reflection in the wall-length mirror. The room is warm. I can hear other student musicians practicing in rooms on both sides of me. I am wearing comfortable clothing that allows me to move freely. My body feels relaxed and released, which is exactly how I want it to feel for the remainder of my practice. My arms are gently hanging at my sides and my shoulders are released down and back. My feet are shoulder width apart and planted firmly on the carpeted floor. I am ready to focus on my breathing. I am watching myself in the mirror to make sure that I'm not seeing any physical tension in my body. As I breathe in, I feel and see expansion of my rib cage laterally without any rigidness around my sternum. My abs have released, allowing for my abdomen to expand as air is drawn into my lungs. I still feel a sense of freedom in my body, which I like. Once I have finished inhaling, I allow myself to begin exhaling. As I exhale with my lips in an [u] position, I feel my internal intercostals on the sides of my rib cage and my abs begin to contract. I feel the air passing through my lips. I am trying to control the speed at which these muscles are contracting. I feel a sense of buoyancy in my rib cage, like they are staying lifted, which is slowing down the contraction of my internal intercostals. My abdomen is slowly returning to its inward resting position. I am starting to run out of air. My abdomen has almost completely gone in, and my ribs are almost back to their resting position. I am out of breath. My body is still free. I am pausing for a few seconds before breathing back in. I release my abs, allowing my lungs to begin filling with air again. That breath felt free and relaxed. I am very happy that my body felt relaxed and released through the entirety of the breath. I am aware of how successful I was in managing my breath. I am hopeful that I will be able to continue this pattern of released and free breathing once I start singing.*

This performance script for respiration establishes a state of mindfulness—as an awareness of the space in the current moment—from the very beginning. After establishing mindfulness, the script generates mental imagery in first-person perspective to prime the motor system associated with breathing. This script is detailed in its use of specific muscle names and its description of how the muscle contractions (and their subsequent release) feel. It emphasizes positive thoughts and self-affirmation, creating a deeper emotional association with this motor sequence, which

will allow for stronger myelination and easier recall. After the learner writes their performance script (or adapts this one), it should be read aloud, making sure it sounds natural and genuine. This script can be read aloud or internally before any practice session, or whenever physical practice is not possible.

Detailed Anatomical Diagrams for Respiration

Detailed anatomical diagrams are useful in forming stronger mental images of the position of the many parts of the breathing mechanism. Unfortunately, the breathing mechanism is dynamic and constantly moving, which is something that can't be represented sufficiently in diagrams. For the purposes of mental practice for respiration, a diagram depiction that is most beneficial is one that includes the rib cage, diaphragm, external and internal intercostal muscles, the rectus and transverse abdominis, and the external and internal obliques. The following diagram appeared above (as Figure 9) but I have reproduced it below (as Figure 10) for further explanation and mental practice.

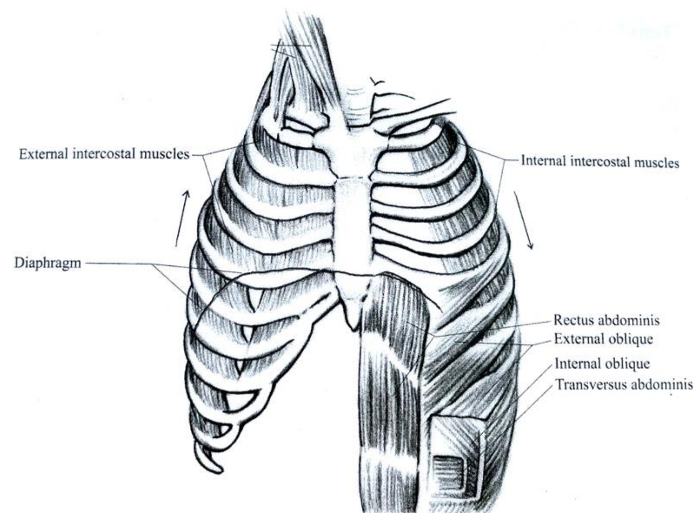
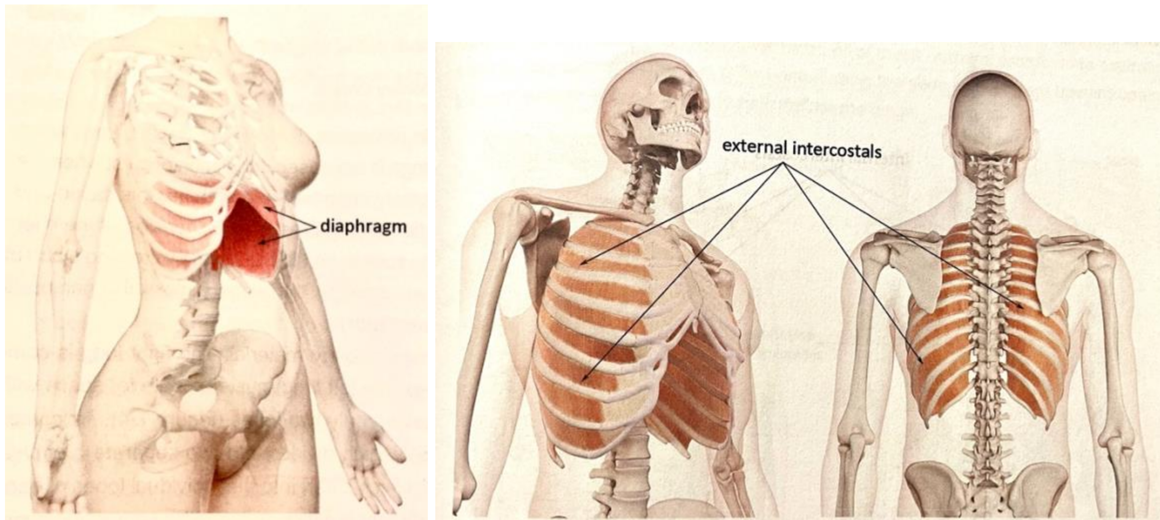
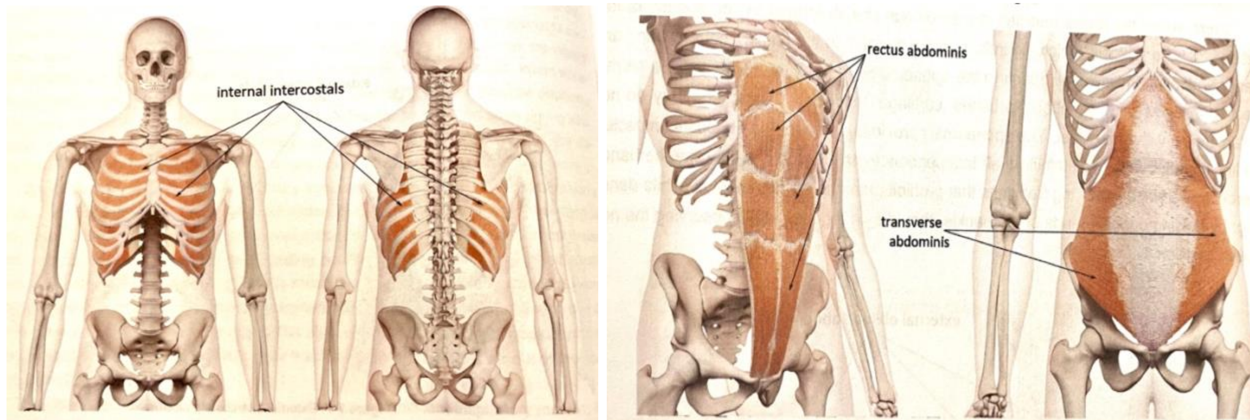
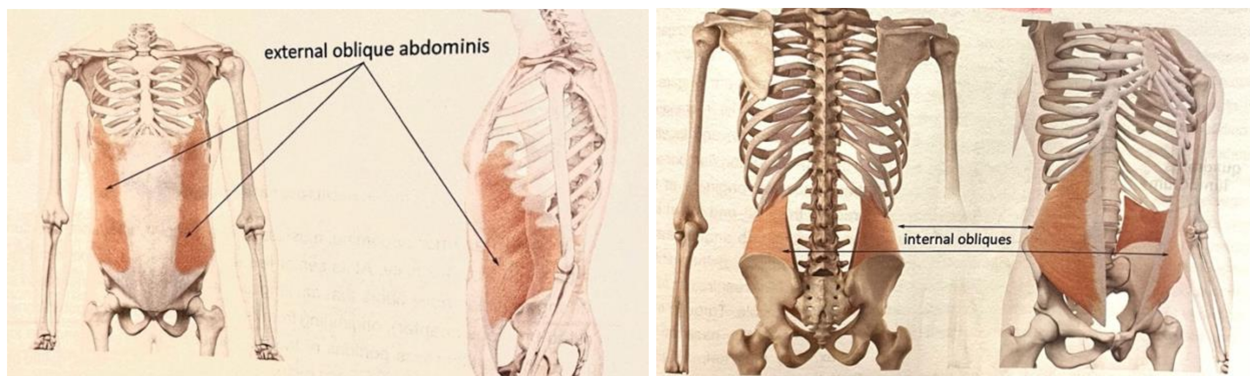


Figure 10: The primary muscles of inhalation and exhalation. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 23.

Other diagrams that are useful for mental practice for respiration show each individual muscle involved in respiration, rather than the photo above, which shows all the muscles in one diagram. The following diagrams from Scott McCoy's *Your Voice: An Inside View 3* show precisely where each muscle involved in inhalation or exhalation is located.







Figures 11–16: Muscles of respiration. Images reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 122, 125, 126–129.

In addition to diagrams that show solely the muscles involved in respiration, it is beneficial for the observer to see diagrams with arrows indicating directional motion for both inhalation and

exhalation. Figure 17 reproduces Figure 9 (and Figure 10), with arrows added to show the direction of motion for inhalation and exhalation.

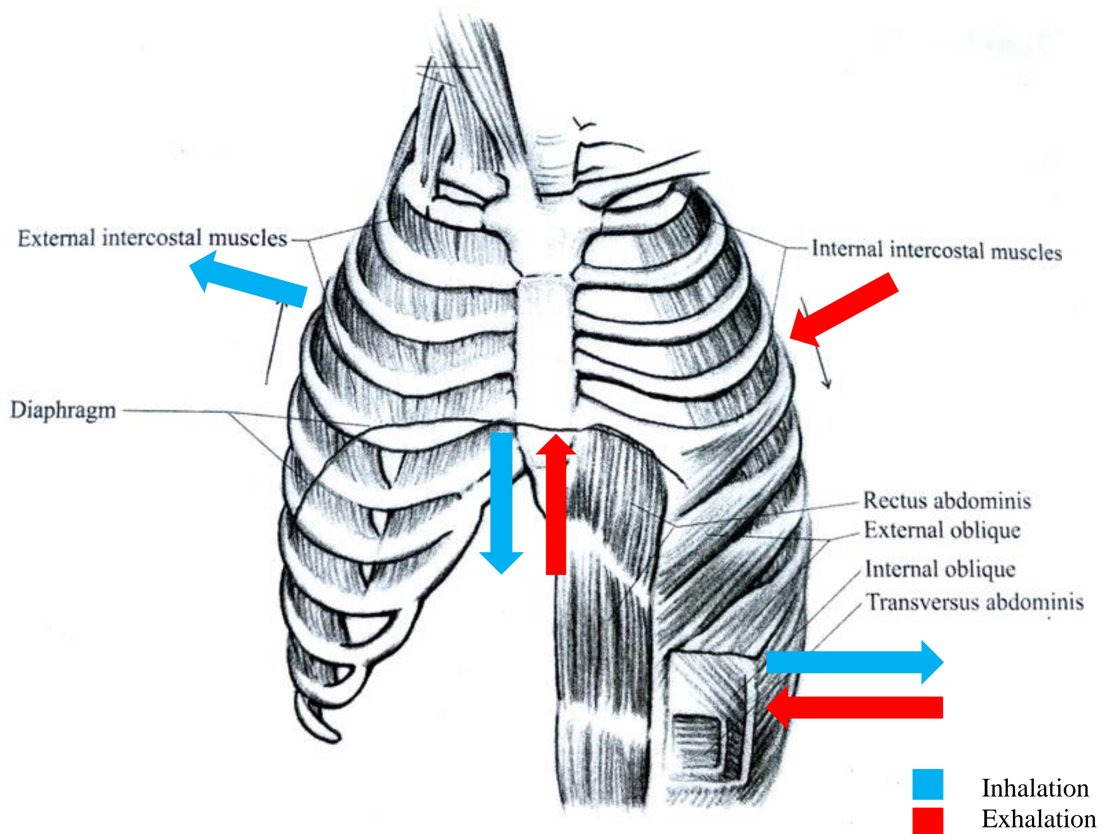


Figure 17: The primary muscles of inhalation and exhalation. Image reproduced and adapted from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 23.

The blue arrows in indicate that, during inhalation, the diaphragm flattens (displacing the viscera), the external intercostals cause the rib cage to expand, and the rectus abdominis, transvers abdominis, and internal and external obliques all release, allowing outward expansion of the abdominal wall. The red arrows indicate that during exhalation, the diaphragm raises to its initial dome shape located within the rib cage, the internal intercostals slowly depress the ribs and return them to their resting position, and the rectus abdominis, transvers abdominis, and internal and external obliques all contract, moving inward toward the center of the body.

One last set of diagrams that are useful in forming mental images comes from Dimon's *Anatomy of the Voice*. These diagrams do not show the full mechanism for respiration, rather they focus solely on the location and movement of the diaphragm.

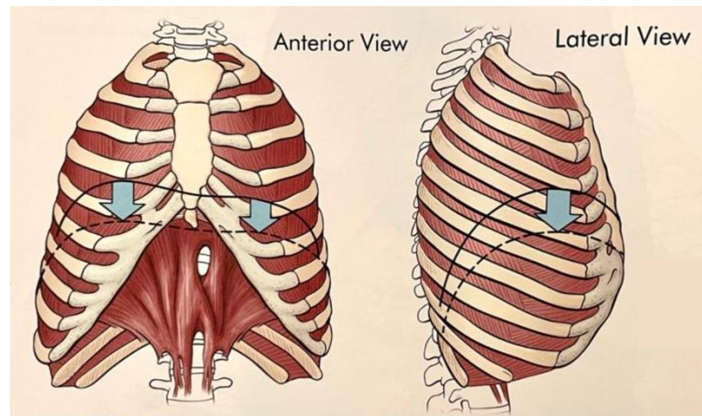


Figure 18: Front and side views of diaphragm and its movements during breathing. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 12.

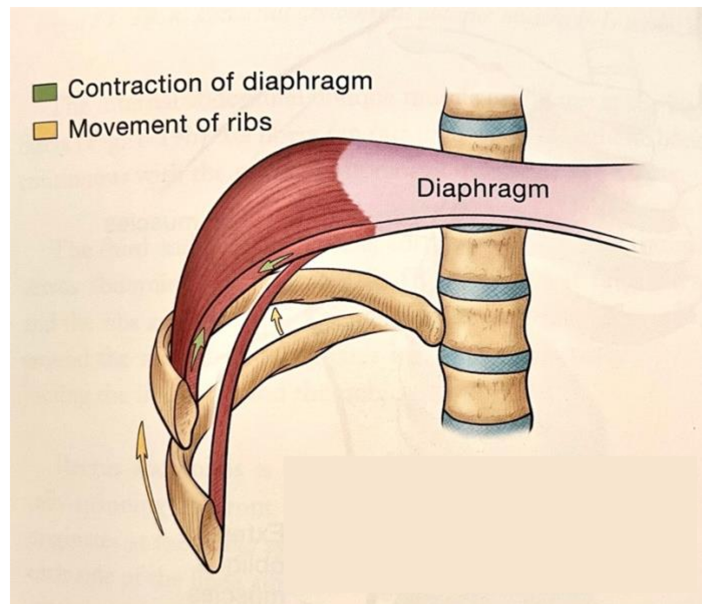


Figure 19: Action of the diaphragm in relation to rib movement. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 13.

The first diagram (Figure 18) shows the location of the diaphragm within the rib cage from both an anterior and lateral view. This diagram is beneficial for creating a detailed image and a body map representation to go along with mental imagery for the function of the diaphragm. Also in this first diagram are arrows that show the descending motion of the diaphragm during inhalation.

The second diagram (Figure 19) shows specific motion of the diaphragm and ribs during inhalation. The motion of the diaphragm is represented in light green arrows, while the motion of the ribs is shown in yellow arrows. As the diaphragm contracts, it flattens, causing the ribs to move upward in a swinging motion, similar to the handle of a bucket.

By observing any one of these diagrams or several of them in combination while in a state of heightened awareness, the observer/learner should be able to create a stronger mental representation of the physical motions involved in inhalation and exhalation and the correct position of each anatomical part of the breathing mechanism at maximum inhalation and exhalation. By creating stronger mental representations, the synapses that carry the signals for this motor sequence become more myelinated, allowing in turn for quicker and more efficient recall and reproduction of these specific movements.

Mental Imagery for Respiration

The use of a mental practice script and detailed anatomical diagrams for respiration both involve mental imagery practice, triggering the same motor sequences in the brain as physical practice of respiration; however, other forms of mental imagery have been used in voice teaching and practice for centuries. Lynda Moorcraft writes: "Vennard believed that imagery that focuses the singer's attention on backwards sensations produces increased mellowness, rather than

focusing on physical function, which could cause unwanted tension."[90] In other words, mental imagery is used in the voice studio or voice practice to influence a singer's technique without the singer needing to focus on the execution of physical processes involved in healthy and efficient vocal technique. Examples of mental imagery for breathing include: inhale as if you're smelling roses; exhale as if you're blowing out birthday candles; breathe from/into the ground. None of these images provides a direct instruction on the function of breathing for singing; however, they often accomplish the ultimate end goal of released inhalation into the abdomen and controlled exhalation. For some singers, voice pedagogy is too scientific, and there is some evidence to show that voice lessons and practice sessions that incorporate a significant amount of scientific explanation can cause more tension in the singing mechanism. Therefore, imagery that incorporates commonplace or familiar experiences may be more beneficial for some students.

For example, when following the instruction to breathe as if smelling roses, the soft palate lifts, the throat relaxes, and the larynx lowers. These are crucial components in breathing for singing. This instruction doesn't directly affect the release of the abdominal wall or the engagement of the external intercostals, but it provides direction for a free and released, deep breath. Likewise, the instruction of breathing from/into the ground encourages a low breath that involves release and relaxation lower in the trunk (thorax/abdomen) of the body. The instruction to exhale more slowly than usual, as if blowing out birthday candles, allows a singer to control the speed at which they exhale, which ultimately effects the contraction of the internal intercostals and abdominal muscles, as well as the relaxation of the diaphragm.

Another example of mental imagery for respiration is the image of a balloon. Balloons expand in all directions when filled with air, just as the lungs should. When a balloon is left

90 Lynda Moorcroft, "Directional Imagery in Voice Production," *The Inaugural International Conference on Music Communication Science*, December 5, 2007, 103-106.

untied, it can release air quickly in an uncontrolled fashion, or more slowly if the person holding the balloon releases the air in a controlled and consistent stream of air. When the air is released in a controlled fashion, the balloon deflates at a slower pace, similarly to how the rib cage and abdominals contract at a slower pace when a singer properly manages breath during exhalation. Another way in which the imagery of a balloon is beneficial for creating mental images for respiration relates to the concept of buoyancy. When balloons are full, and even when they begin to release their air, they remain buoyant. When thinking about breathing, a singer should try to maintain a sense of buoyancy in their rib cage. This buoyancy allows the ribs to stay expanded without becoming rigid or stiff.

Detailed and specific anatomical explanations, diagrams, and instructions are sometimes necessary to help a student understand how the system of respiration for singing functions. These methods help form stronger mental image representations in the motor cortices, which effectively enhances skill acquisition and fluency. However, scientific explanations aren't always beneficial. The use of alternative mental imagery like smelling roses or blowing out birthday candles can also have positive effects on motor skill enhancement. By relating a more commonly practiced sensation with the breathing mechanism for singing, the brain makes connections from prior knowledge and experiences (stored as schemas) and combines those experiences to strengthen the motor sequence and schema for breathing for singing.

Teacher-Directed Mental Imagery for Respiration

In the voice studio, augmented feedback (feedback given by the teacher) is crucial for the development both of motor skills and also of the students' ability to analyze the performance of motor skills. However, providing feedback after the fact isn't the only job of the voice teacher.

Voice teachers are responsible not only for teaching how to sing, but also for teaching them how to think. A useful tool in teaching that requires mental imagery on the student's end is feedforward processing.[91]

Feedforward processing occurs when the teacher asks the student to visualize the desired motor function, using specific instructions, before they perform a task. To utilize feedforward processing properly, students should close their eyes, eliminating external stimuli, while listening to the teacher provide a detailed description of the desired motion. Students then attempt to imagine themselves in the first-person perspective feeling as the teacher has vividly described. After hearing the description, the student should perform the task. This whole process should take less than a minute. The goal is that the teacher provides as detailed a description of what will physically by occurring as quickly as possible, so as not to take up too much lesson time. The feedforward processing script for respiration below is similar to the mental practice script above, with the difference that this script is meant to be recited by the teacher in the second person.

> *Your body feels relaxed and released, with your arms gently hanging at your sides and your shoulders are released down and back. Your feet are shoulder width apart and planted firmly on the floor. As you breathe in, feel the expansion of your rib cage laterally without any rigidness around the sternum. Release your abs, allowing for the abdomen to expand as air is drawn into your lungs. Try to maintain a sense of freedom and flexibility in your breathing. As you exhale with your lips in an [u] position, feel the muscles on the sides of your rib cage and the entirety of your abs begin to contract. The air is passing through your lips and you are controlling the speed at which your muscles are contracting. Your rib cage should feel buoyant, like your ribs are staying lifted. Your abdomen is slowly returning to its' inward resting position. You are starting to run out of air. Your abdomen has almost completely gone in, and your ribs are almost back to their resting position. Once you are out of breath, pause for a few seconds before breathing back in. Then, release your abs, allowing the lungs to begin filling with air again.*

91 Helding, *The Musician's Mind*, 130.

Every singer has their own unique experiences with breath: some feel breath more into their back, while others may feel breath lower into their pelvic floor. It is crucial that the teacher adapt this script to meet the needs of each individual student and their body at whatever stage of development; it is also crucial that this script, and feedforward processing generally, should only last about a minute or less. If additional information is added to address back or lower pelvic breathing, it is likely that some of the information in the script above will need to be removed.

Third-Person Observation for Respiration

Third-person observation allows a learner to enhance an already acquired motor function by watching a more fluent performer perform the same skill. For respiration, third-person observation occurs frequently — in the voice studio, watching videos of other singers on YouTube, watching live performances, observing the teacher, etc. However, third-person observation is not beneficial as mental practice unless the observer is intently focused on observing one specific skill. In other words, if a singer is watching a video of other artists while paying attention to their breathing, how they approach higher notes, or even how they articulate in a foreign language, they are unlikely to benefit directly from the experience unless they take certain steps. If the intention is to study a specific skill in another artist, the student must first perform a mindfulness exercise, much like the one above, to heighten awareness and focus. By placing the mind in a more aroused state, a singer can focus nearly all their attention on observing that specific skill. With attentional focus honed on a specific skill or motor function, the brain is primed for the mirror neurons associated with that function to engage, sending chemical frequencies through the synapses and myelinating the axons with every recurring observation of the same skill.

In the voice studio, third-person observation of breathing is extremely common, especially among beginning singers. Students often observe their teacher's breathing, sometimes even placing their hands (with permission) on the teacher's thorax. Fortunately, in the voice studio there is often little distraction, so a mindfulness exercise is not entirely necessary before this third-person observation. In this situation, it is crucial that the teacher performs the skill more than just once, allowing the student to focus on every detail of the teacher's breathing. Breathing is not a lengthy process; therefore, it is perfectly acceptable for a teacher to model a healthy and efficient breathing technique numerous times without feeling like time is being wasted in a lesson.

In addition to third-person observation of respiration, an additional component is what Cornett refers to as "noticing out loud."[92] This phrase describes the act of putting thoughts and observations into words. After observing a skill, a singer clearly communicates what they are seeing, feeling, or thinking. In the case of respiration, noticing out loud might sound like:

> *I am seeing outward expansion of the rib cage.*
> *I am seeing release and expansion of the abdominals.*
> *I am seeing the ribs and abs contract slower than they expanded.*
> *I am feeling engagement of my abs and intercostals as I exhale.*
> *I am hearing nothing. The breath is quiet.*

The observer must choose precise words to describe what is being experienced and that the observations are articulated in the same order they are noticed. This type of noticing out loud draws further attention to the things noticed and develops awareness to enhance individual performance of the same motor function.

92 Cornett, *The Mindful Musician*, 217.

Conclusion

Respiration is a dynamic and complex system that is the foundational source of all singing. It is crucial that a singer practice respiration physically. But there is also a place for mental practice in practicing respiration: mindfulness exercises, performance scripts specific to respiration, detailed anatomical diagrams of the muscles of inhalation and exhalation (and their function), mental imagery, and third-person observation, can all help a singer increase the efficiency with which they breathe for singing.

Chapter Five:

Mental Practice for Phonation

Phonation is the production of sound from the vocal tract. Before discussing mental practice for the purpose of enhancing phonation, let us first survey the basic vocal fold structure, the structure of the larynx, and how the vocal folds vibrate in order to understand the coordinated function of the phonatory system. The vocal folds are made up of multiple layers of tissue and muscle. The layers within the vocal folds are the *epithelium, superficial lamina propria, intermediate lamina propria, deep lamina propria,* and the *thyroarytenoid muscle*. Each layer of the vocal folds has a different density and viscosity, and this variegated, layered composition allows the vocal folds to vibrate in a wavelike motion, creating the mucosal wave.

Vocal fold vibration is initiated by a combination of muscle activity that causes adduction, or the closing of the glottis, along with subglottal and supraglottal air pressure. A vibration cycle begins by muscles bringing the vocal folds together so that air pressure builds up below them. This air pressure then causes the vocal folds to open from underneath. Due to the elasticity of the vocal fold layers, the vocal folds open in a wavelike motion from the bottom to the top as air passes through them. To complete the vibration cycle, the vocal folds come back together as a result of their elasticity. The coordination of muscle activity and breath producing the wavelike motion results in what is referred to as *balanced phonation*. The pitch level determines how many times this cycle repeats every second. In addition to the muscles, tissue, and air pressure that impact vocal fold vibration, the shape of the vocal tract also effects how the vocal folds vibrate due to acoustic energy created. Ragan explains this dynamic: “as sound

waves travel through the vocal tract, some of the energy feeds back to the source (vocal folds) and may either help or hinder vibration."[93]

The vocal folds are housed in the larynx, which is comprised of bone, cartilage, joints, ligaments, membranes, and intrinsic and extrinsic laryngeal muscles. The larynx is suspended from the hyoid bone, which is the only free-floating bone in the human body. The intrinsic and extrinsic laryngeal muscles are responsible for adduction and abduction (closing and opening) of the vocal folds, lengthening and shortening (which alters pitch) of the vocal folds, stiffening of the vocal folds (which alters timbre), and elevation and depression of the larynx (which impacts both timbre and vocal flexibility).

Mindfulness Exercise

To achieve a state of heightened awareness and mental arousal for mental practice for phonation, the same mindfulness exercise proposed for respiration can be used again.

> If possible, remove your shoes and stand in a room that has windows or doors that may be opened to ambient sound.
>
> 1. Stand at rest, breathing comfortably. We will call this neutral.
> 2. Notice the spaces surrounding you, inside the room and beyond.
> 3. Listen to the sounds surrounding you, inside the room and beyond. What happens when you recall a favorite melody (inner sing)?
> 4. Stand on your dominant leg, placing the toe of your other foot just ahead of you or in a tree pose, if you like. Now shift your weight ever so slightly from what is equalized pressure between the ball and heel of your foot so that about 75% of your weight is on the ball of your foot. Do this without lifting the heel of your foot from the floor and maintain easy balance. Try shifting your weight toward the heel of your foot. What changes? What information alerts your conscious mind?[94]

93 Ragan, *A Systematic Approach to Voice*, 71.
94 Leigh-Post, *Mind-Body Awareness for Singers*, 11.

Performing this exercise places the mind into a state of heightened awareness. This level of mindfulness allows the use of a performance script, detailed anatomical diagrams, and mental imagery to access and enhance motor sequence pathways for phonation more easily.

Performance Script for Phonation

As explained above in the section on respiration, a performance script maps the performance of a specific skill as a series of discrete steps. It should include thoughts and feelings that the writer-performer typically experiences before, during, and after the performance of the skill being practiced. The performance script should be as specific and detailed as possible and should be written in the first-person perspective. The following is an example of a performance script for practicing phonation:

> *My breath and body are free and released. I am ready to start making sung sounds. My body feels relaxed, released, and in sync with my breath, which is exactly how I want it to feel for the remainder of my practice. I am watching myself in the mirror to make sure that I'm not seeing any physical tension in my body. As I breathe in, I feel and see expansion of my rib cage laterally without any rigidness around my sternum. My abs have released, allowing for my abdomen to expand as air is drawn into my lungs. Once I have finished inhaling, I allow myself to begin quietly humming. I feel a gentle closure of my vocal folds without a glottal attack. The air is moving steadily through them, causing a consistent, balanced, and steady sound. I like the feeling of this hum. It is resonant and easy. I feel a gentle buzzing sensation in my lightly closed lips. I feel space in the back of my mouth between my molars. I feel gentle vibrations equally on both sides of my larynx. The sound is not forced or pressed. My body is free and grounded. I am sustaining this hum for as long as I comfortably can on one note, paying attention to the easy buzz I am feeling. I feel myself beginning to run out of air. As my ribs, abs, and lungs return to their resting position, I gently release my hum. I feel my vocal folds coming apart gently. The sound stops. I still feel a sense of relaxation and ease in my pharynx and larynx. I am pausing for a few seconds before breathing back in. That note felt free and released. I am very happy with how easy that felt and sounded. I am ready to repeat that hum on a different, slightly higher pitch. I release my abs, allowing my lungs to begin filling with air again. Once I have finished inhaling, I allow myself to begin humming again. I am aware of how successful I am being in creating a free and easy tone. I*

> *am hopeful that I will be able to continue this easy tone production as I continue singing more difficult exercises and songs.*

This performance script for phonation begins where the previous performance script for respiration concluded, and it represents a continuation of the same hypothetical practice session. After establishing a state of mindfulness, first-person mental imagery primes the motor system associated with sustained phonation. This script is detailed in its references to specific body parts and in accounting for how the functions of these body parts feel in the body. It uses positive thoughts and self-affirmation, creating a deeper emotion associated with this motor sequence, thereby promoting stronger myelination and easier recall. After the learner writes a performance script (or adapts this one), it should be read aloud, making sure it sounds natural and genuine. This script can be read aloud or silently before any practice session, or whenever physical practice is impossible.

Detailed Anatomical Diagrams for Phonation

Similar to respiration, *phonating* is a dynamic process requiring movement from various parts of the vocal mechanism. For this reason, detailed anatomical diagrams should display images of the vocal folds at rest (or before phonation), during active phonation, and after phonation.

Before looking at how the vocal folds vibrate, it is important to have a basic understanding of what the structures look like inside the larynx.

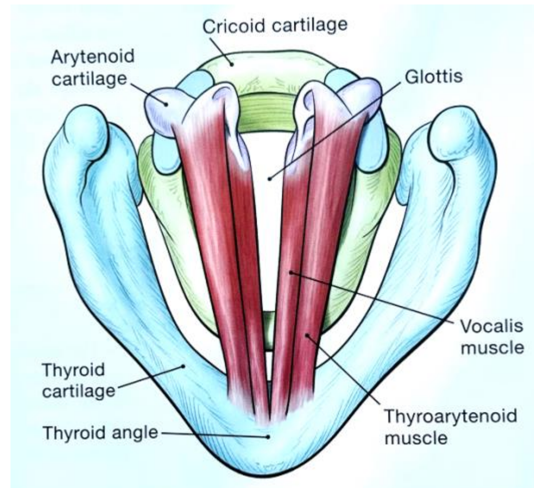


Figure 20: Vocalis and thyroarytenoid muscles, as viewed from above. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 35.

In this diagram, the point of the thyroid angle (in blue at the bottom of the image) is located at the front of the larynx. The thyroarytenoid muscle, which is one of the parts that comprises the actual vocal folds, is shown in red. It attaches to the thyroid cartilage at the thyroid angle and runs to the arytenoid cartilage, located at the back of the larynx.

Additional muscles and cartilages of the larynx are responsible for closing, opening, and stretching the vocal folds during phonation.

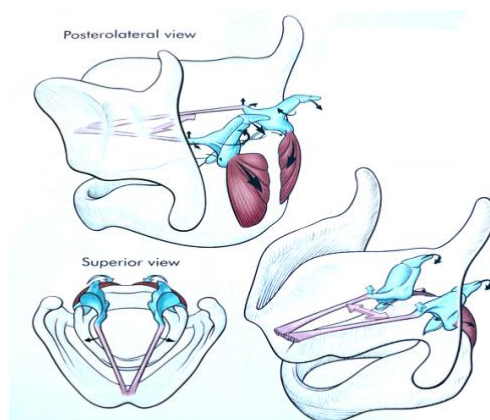


Figure 21: Action of the posterior cricoarytenoid muscles, the openers. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 37.

In the diagram above, the blue horn-like structures are the arytenoids (cartilage), and the red muscles located on the back of the larynx are the posterior cricoarytenoid muscles. The posterior cricoarytenoid muscles pull on the arytenoid cartilages, causing them to rotate outward to fully abduct (open) the vocal folds. During adduction, the lateral cricoarytenoid muscles rotate the arytenoid cartilages inward, causing the vocal folds to adduct (close), as shown in the diagram below.

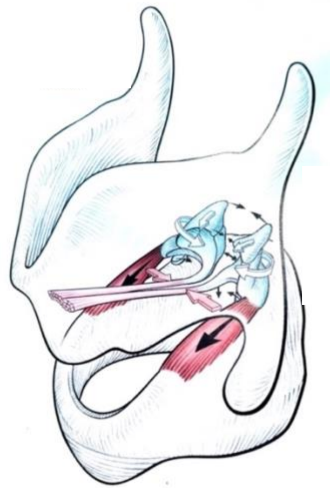


Figure 22: Action of the lateral cricoarytenoid muscles, which close the glottis. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 38.

Another important functional occurrence in the larynx for phonation is the action of the cricothyroid muscle, which is responsible for stretching the vocal folds, resulting in pitch variation. Figure 23 illustrates the two parts of the cricothyroid muscle, the *pars recta* and the *pars obliqua*.

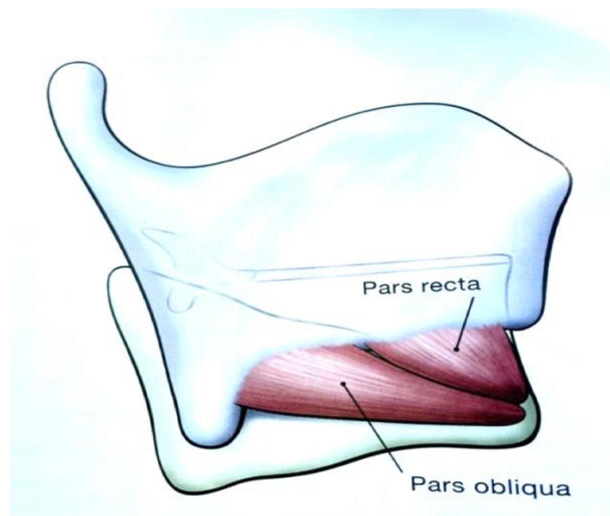


Figure 23: The cricothyroid, a stretching muscle. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 40.

The *pars recta* pulls the thyroid cartilage down while the *pars obliqua* pulls the thyroid cartilage forward. Together, these motions cause the thyroid cartilage to rotate and be pulled forward, which stretches the vocal folds.

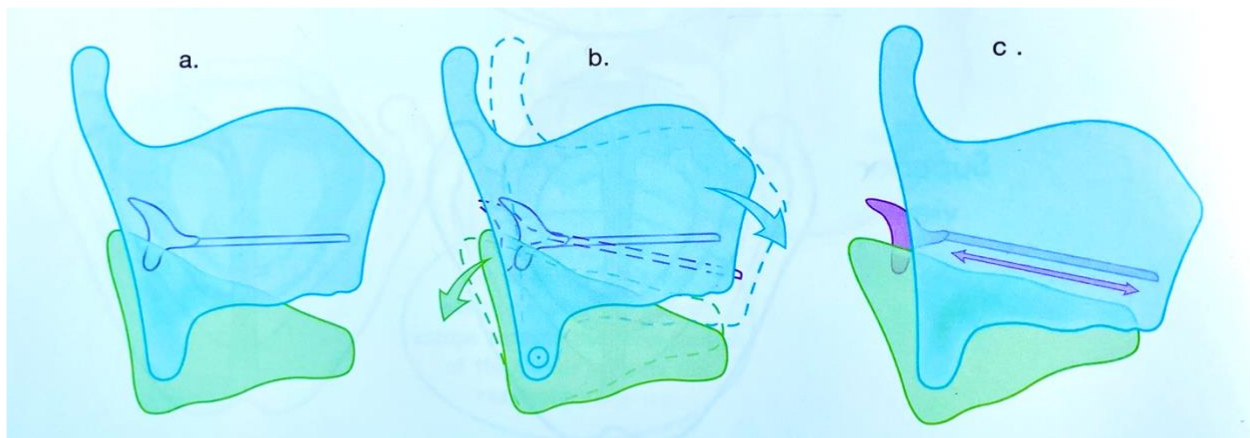


Figure 24: Stretching of the vocal folds. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 40.

In addition to understanding the general structure and function of each part of the vocal mechanism, a singer needs to know what healthy vocal folds look like in both their abducted (before and after phonation) and adducted (during phonation) positions.

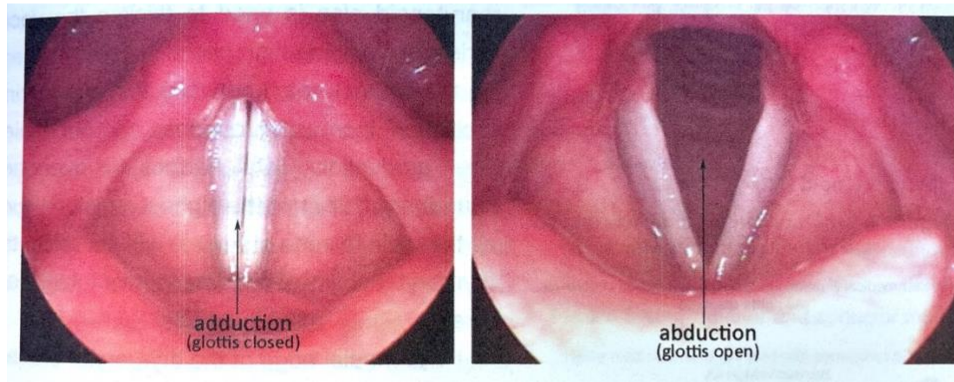


Figure 25: Adduction and Abduction. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 163.

Figure 25 illustrates healthy vocal folds. The white color of the vocal folds indicates that the tissue is healthy. On the left-hand side, the diagram indicates that the glottis (the space between the vocal folds) is closed, meaning that active phonation is occurring. The image on the right-hand side indicates that the glottis is open, meaning that the person is breathing. By knowing what healthy vocal folds look like in both closed and open phases, a singer can begin to form a mental picture of what phonation looks like in their own bodies. But these images are just a starting point, because phonation involves a slightly more complex process than they capture. During phonation, the vocal folds don't come together horizontally, like closing a pair of sliding doors, as we might infer from these pictures; rather, they come together in a wave-like motion, from bottom to top.

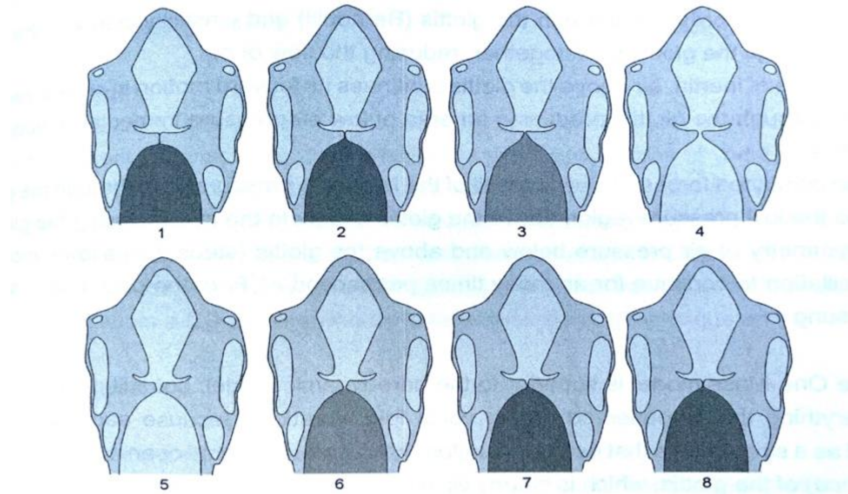


Figure 26: Steps in vocal fold oscillation. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 155.

Figure 26 depicts an eight-step cycle comprised by a singular vocal fold vibration. In step one, the internal laryngeal muscles bring the vocal folds together. In step two, the vocal folds are very subtly coming apart at their bottom. In step three, the vocal folds are entirely apart at their bottom while remaining in contact at their top. In step four, both the top and bottom of the vocal folds are apart (abduction), but the bottom of the vocal folds is moving inward again. In step five, there is further inward motion of the bottom of the vocal folds, leading to step six, which shows the bottom of the vocal folds returning to an adducted (closed) position. In steps seven and eight, the middle and tops of the vocal folds return to an adducted, or closed position. A crucial component of vocal fold vibration missing in this image is the presence of air flow; for this reason, Figure 27, though it illustrates the process in fewer steps (and thus less granular detail) than the previous image, shows how breath below the vocal folds (subglottal) causes the vocal folds to come apart from bottom to top during vibration in a wave-like motion.

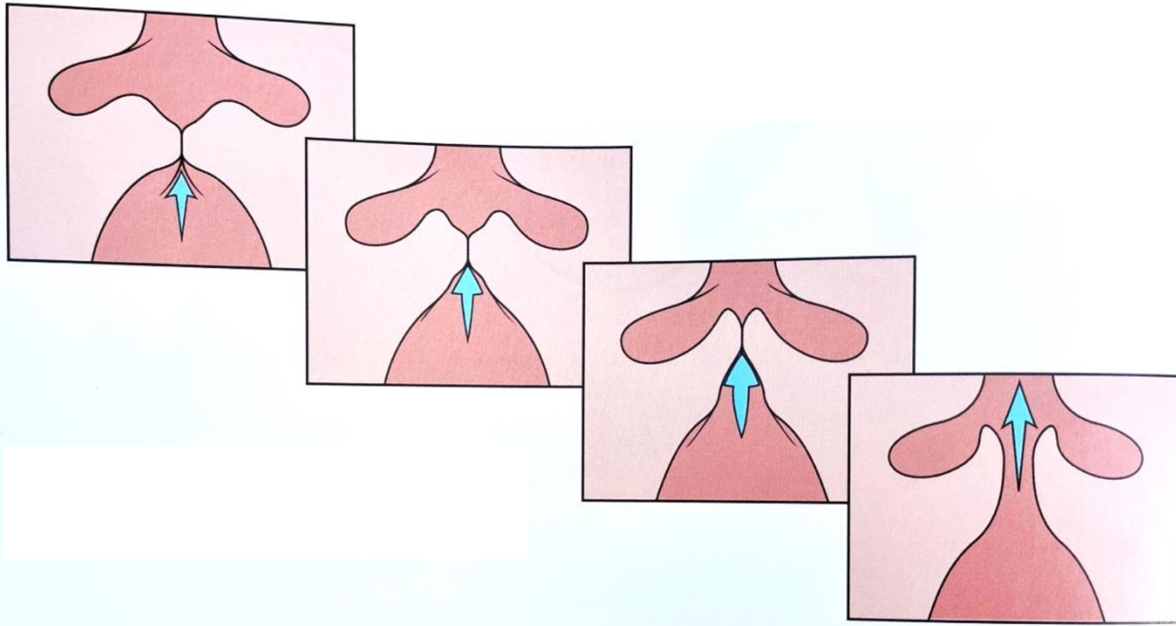


Figure 27: Wave action of the vocal folds. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 42.

Voice teachers often have images like these displayed in their studios. Many teachers use such images merely to offer brief, one-off explanations of how the vocal mechanism works. What teachers may not realize is that these images interact with the mental representations of vocal function their students form, creating more detailed mental images to use during mental (or physical) practice to enhance phonation. A teacher can and should refer to these images often during a lesson. Even just asking a student to observe them probably activates the synapses in the brain associated with sustained phonation (singing), creating more efficient and fluent recall of these functions for later recall and performance. Once again, it is important to note that while any detailed anatomical diagrams are better than none, the most beneficial examples will have arrows indicating dynamic motion during specific stages of phonation. Such arrows help students better understand how the different muscles and cartilages interact with one another during the process of phonation.

Mental Imagery for Phonation

Speech-language pathologists and voice rehabilitation specialists rely upon the concept of *flow phonation* in voice therapy to encourage more balanced onsets and offsets when phonating. Flow phonation typically uses words that begin with aspirated (breathy) consonant sounds to encourage breath flow through adducted vocal folds. A singer can also benefit from attending to the concept of flow phonation. Ragan offers the following example of how mental imagery can incorporate flow phonation to encourage balanced phonation:

> *Imagine saying the word "who." The [u] should feel like there is a lot of space inside the mouth with rounded lips, a lifted soft palate, and a relaxed. jaw. Once this vowel shape is properly mapped, visualize sending air through the vocal folds to produce the word. The breath should not be forced through the vocal folds but rather released from the lungs by contraction of the muscles of exhalation. Imagine that as the breath flows, the vocal folds gently come together, bottom first, in a wave-like motion, causing a gentle and consistent phonated [u]. Imagine keep the [u] sustained for as long as the breath allows, and then releasing the [u] gently at the end of the breath. This release should feel easy, without any grabbing or tension within the larynx.*[95]

This exercise effectively uses the mental image of speaking a word that is part of everyday language to achieve a more balanced and efficient phonation, created by coordinating breath and adduction of the vocal folds.

Other forms of mental imagery are also helpful in imagining balanced and efficient phonation. For example, visualization of hands coming together, bottom to top, in a wave-like motion can help a singer create a more vivid mental representation of the action of the vocal folds during vibration. After observing this motion numerous times, a singer can envision the order of the action from breath and adduction through the mucosal wave, and finally to abduction. When using visual imagery, it is important to visualize with as much detail as possible. A singer must make sure that the visualization of hands coming together in a wave-like

95 Ragan, *A Systematic Approach to Voice*, 94–95.

motion happens gently and in a balanced manner. If one hand moves more strongly or quickly, that could affect the mental representation of phonation in the brain, causing one vocal fold to work harder than the other during actual phonation. This unbalanced phonation could potentially lead to a variety of vocal injuries including vocal fold lesions or muscular tension dysphonia (MTD).

Another image that a singer may find helpful in producing consistent, sustained phonation is the image of a paint brush painting a single stroke. Imagine that a paint brush (lungs) is full of paint (air). As the paint brush comes into contact with a surface (the vocal folds), it begins to create a paint stroke (sound). As the paint brush is guided along the surface, the stroke is consistent, not jagged, and uninterrupted. This is how phonation should feel. Phonation occurs when breath and muscles are coordinated, creating a balanced and efficient sound. If the vocal folds are over-adducted or if the rib cage and abdomen are rigid, this could cause disruption or rigidness in phonation, heard as an unsteady, pressed, or “locked” sound. The mental imagery of a consistent, uninterrupted paint stroke can be associated with a balanced and efficient tone production.

I have suggested these images as examples, but this is not an exhaustive catalogue. Voice teachers have developed many other forms of mental imagery to teach balanced and efficient phonation.

Teacher-Directed Mental Imagery for Phonation

In the studio, voice teachers often guide students to achieve balanced and efficient phonation through directed imagery. Some voice teachers use more anatomical images, discussing the different muscles and cartilages involved in phonation, while others use more

commonplace images. The above examples of hands coming together in a wave-like motion and a consistent paint stroke are examples of images that could be used by singers in their own practice but could also be used and directed by a teacher during a lesson.

Another form of teacher-directed mental imagery that encourages balanced and easy phonation involves having the student imagine that their vocal folds are velvet ribbons.

> *Imagine rubbing two pieces of velvet ribbon together gently. Velvet ribbons are expensive and delicate, made of finely woven fibers. The fibers of one ribbon wave when rubbed against the second ribbon, changing direction, and balancing the fibers of the other ribbon. When you rub these velvet ribbons together gently without extra pressure or force, it feels almost like the ribbons are floating on top of one another. The velvet ribbons represent the vocal folds working together. They are balanced, working in coordination with one another. They are gently coming together, almost like they are floating on the surface of their counterpart.*

Most students have experienced touching something delicate, soft, and plush, which is what makes this analogy relatable. The description of the ribbons sliding gently across the surface of one another mimics the sensation of pliable muscular antagonism within the system of phonation. The muscle activation from the thyroarytenoid or cricothyroid must not be too strong, lest the singer produce a pressed, or over-adducted, sound. The gentle sliding of the ribbons represents the gentle wave-like motion caused by the multiple layers of the vocal folds during vibration.

Voice teachers should also recognize that lessons offer opportunities to perform physical actions that their students can schematize with the appropriate motor sequence response. For example, many voice teachers use hand and arm gestures to demonstrate consistent phonation on the breath. These motions often include sweeping and fluid gestures that last for the duration of a phrase or exercise. If they perform such motions enough times during a lesson, a student will likely associate that gesture with a particular phrase or exercise every time they sing it. When mentally practicing for balanced and efficient legato singing, for example, a singer can visualize

their teacher making a sweeping gesture. This visualization will prompt the motor system to fire the motor sequence for balanced phonation, which includes muscle and breath coordination.

Conclusion

Phonation, like respiration, is a dynamic and complex system that requires coordination of numerous muscles, cartilages, and breath. It is crucial that phonation be practiced physically on a very consistent basis. However, adding mental practice in the form of mindfulness exercises, a performance script specific to balanced and efficient phonation, detailed anatomical diagrams of the system of phonation, and student- and teacher-directed mental imagery can effectively enhance the efficiency with which a singer phonates.

Chapter Six:

Mental Practice for Registration

Registration refers to series of contiguous pitches that are produced using the same physiological process and that share a similar timbre.[96] The human voice has multiple registers, which result from specific vocal fold configurations and vibration patterns that generate similar timbres throughout the range of each register. The elements of the vocal folds that determine registration are the *vertical phase difference*, *amplitude of vibration*, *open* and *closed quotients*, and *length* and *stiffness*.[97] Additionally, acoustics have a significant effect on registration events, as changes in timbre often result from harmonics of the vocal folds interacting with formants of the vocal tract.

The vertical phase refers to how much the vocal folds are coming into contact with one another. In Mode 1, or chest voice, for example, the vertical phase is higher than in Mode 2, or head voice (a detailed explanation of these registers follows below). This means that more of the vocal folds come into contact with one another in the chest voice than in head voice. The amplitude of vibration refers to how far apart the vocal folds move during each vibration cycle. In Mode 1, the amplitude of vibration is high because vocal folds are short and have little longitudinal tension. In Mode 2, the amplitude is lower because of a slower glottal closing rate, longer open phase, and narrower area of contact. The open and closed quotient refers to how much time the vocal folds spend adducted or abducted. In Mode 1, the closed quotient is high and the open quotient is low, meaning that the vocal folds spend more time together than they do apart. In Mode 2, the open quotient is high and the closed quotient is low, meaning that the vocal folds spend more time apart than together.

---

96 McCoy, *Your Voice: An Inside View*, 249.
97 Ragan, *A Systematic Approach to Voice*, 115.

In the following discussion of registration events, the terms "male" and "female" are used referring to sex assigned at birth, regardless of gender identity. Registration events typically vary depending on the gender assigned at birth. It is also worth noting that a transmale singer who has undergone hormone replacement therapy will experience registration events similar to those of a singer assigned male at birth. In all voices, there are four commonly known registers. These registers and registration events will vary from singer to singer, even within the same gender identity.

- Mode 0: fry/pulse
- Mode 1: chest/modal
- Mode 2: head/falsetto
- Mode 3: whistle/flageolet

Mode 0, or fry/pulse, is also known as "vocal fry." In this register, there is low lung pressure and airflow, a low level of activity of the thyroarytenoid, and complete adduction of the vocal folds at their most relaxed state. This register is not harmful to the voice when used sparingly, and can actually be used to encourage a vocal "reset" or relaxation of the vocal folds if the sound is too pressed.

Mode 1, or chest voice, is typically used by male classical singers and male and female singers in contemporary vocal styles. In Mode 1, the vocal folds are thickened by contraction of the thyroarytenoid. Because of this thickening, there is a high vertical phase. Mode 1 is also used in male speech and often in female speech patterns.

Mode 2, or head/falsetto, is typically used by female classical singers, falsettists and countertenors, and in both female and male contemporary singers (for specific style or colors). In Mode 2, the cricothyroid is more dominant in production than the thyroarytenoid which causes

the vocal folds to lengthen and become narrower in height. Because of this, the vertical phase is much lower and the vocal folds spend more time apart than together.

Mode 3, or flageolet/whistle, refers to the highest range of notes produced by the human voice, typically associated with notes above C6. In this mode, the glottis might never fully close, meaning that the vocal folds might never fully come into contact with one another, although they continue vibrate. This mode is often heard as breathy or airy, caused by more aspiration, or air escaping through the open glottis due to less interference from vocal fold closure.

Practitioners of Western classical singing more often refer to registration events using the term *passaggio*. Both male and female voices experience a *primo* (first) and *secondo* (second) *passaggio.* In male voices, the *primo passaggio* is often thought of as a "non-event," meaning that it is typically unnoticed by the singer or listener. This registration event usually occurs in the range of F3-C4, with some variance for each individual singer. The *secondo passaggio* typically still leaves a male singer in Mode 1 (unless deliberately switching modes for a timbral shift), but it necessitates a realignment of resonance through formant tuning and vowel modification. In the male *secondo passaggio*, a singer often needs to round their vowels towards an [o] to facilitate formant tuning. The exception to this generalized rule is tenors, who will often use [e] or [æ] in the upper register above G4.

In contrast, female voices typically experience physiological changes in the *primo passaggio*, shifting from Mode 1 to Mode 2. This registration event necessitates a realignment of resonances or vowel modification and typically occurs between the range of C4-F4. Additionally, in the female *primo passaggio*, breath pressure must be altered. However, the *secondo passaggio* for female voices is solely a resonance shift and not a shift in laryngeal source (the muscles used to affect vocal fold vibration). This registration event typically occurs

between C5-G5, with slight variance for each individual voice. In the female *primo passaggio*, registration events are often aided by more closed vowels, such as [i], [e], and [u]. In the female *secondo passaggio*, vowels typically need to be more opened, tilting every vowel posture closer to an [a] vowel.

A singer spends significant amounts of time in the voice studio focusing on registration. Exercises for registration need to be very specific in their design, as Ragan explains:

> A vocal exercise designed to facilitate a laryngeal source registration change (vocal folds) or acoustic change (vocal tract) will require recalibration of other parts and the whole. Registration exercises focus on making adjustments to the vibrational mode (laryngeal source) of the vocal folds on a continuum from chest registration (high closed quotient, increased vertical phase difference, and high amplitude of vibration) to head registration (high open quotient, increased vertical phase difference, and low amplitude of vibration) and resonance strategy from brassy resonance…to a lofted resonance.[98]

Mental practice to enhance registration is difficult, since registration is a complex physiological event. Nevertheless, all of the techniques surveyed may be helpful: entering a heightened state of awareness and examining detailed diagrams, mental imagery, third-person observation, and attentive listening can all effectively enhance more efficient registration in both Mode 1 and Mode 2 and facilitate registration events.

Mindfulness Exercise

The mindfulness exercises presented in the chapters on respiration and phonation can also be used to establish mindfulness before mentally practicing registration. However, they are not the only exercises for heightening awareness and placing a singer in a state of attentional focus. For example, the following exercise from Cornett's *The Mindful Musician* can be used before a performance script to establish a sense of mindfulness in preparing for a specific task:

98 Ragan, *A Systematic Approach to Voice*, 121.

> Find a quiet place where you will not be bothered. You may choose to sit or recline comfortably. If you are worried that you will fall asleep or miss an appointment, set a quiet alarm for 10, 15, or 20 minutes, depending on how long you wish to practice this activity. Close your eyes or direct your gaze downward and allow your mind and body to settle. You may wish to focus your attention on your breathing for a minute or two as you gradually relax. Begin to imagine the best-possible scenario for an upcoming [practice session]. Include as many details as possible, and as many of your imagined senses as you wish. Remember to affirm all of the positive thoughts and feelings you want to experience before, during, and after this [practice]. Be realistic and optimistic![99]

After completing this activity, a singer will find themselves in a heightened mental state, and thus better able to devote more attention and focus to mental practice for registration. This activity should be followed directly by a performance script, the use of diagrams, and mental imagery practice for registration.

Performance Script for Registration

A performance script for registration is unique in that it must have two very distinct sections: a first, focused on Mode 1, or chest registration, and a second, focused on Mode 2, or head registration. Each section should include specific details about the physical sensations of chest or head registration, as well as the thoughts and feelings that a singer typically experiences before, during, and after practicing or performing in a given register. Just as in the cases of the performance scripts for respiration and phonation, this one should be as specific and detailed as possible, and it should be written in the first-person. The following is an example to follow the performance script provided for phonation (see Chapter 5):

> *My breath is free and released. My body is free and released. My voice feels free, easy, and singing doesn't require much physical effort. I am ready to start making sounds in both my chest and head voice. I need to work each register separately before bridging the two together. As I begin to sing in chest voice, I feel my vocal folds coming together. They are coming together fully, creating what feels like a more full-bodied sound. This sound sounds more edgy, like a reed instrument. On*

99 Cornett, *The Mindful Musician*, 220.

a [v], I do some fifth glides, feeling the pressure in the chest voice diminish slightly while still maintaining full contact throughout the vocal folds. It feels slightly lighter, but still has an edge to the sound. The air is moving steadily, causing a consistent, balanced, and steady sound. I open the [v] to an [æ]. This [æ] is helping me feel a brighter and more ringing sensation in my chest voice without any excess pressure or engagement of the laryngeal muscles. I feel gentle vibrations equally on both sides of my larynx. I use these fifth glides of [v] to [æ] all across my range in chest register, feeling a sense of freedom while still maintaining full closure of the vocal folds. As I do these glides in various parts of my range, I monitor the height of my larynx to make sure it is staying neutral. I don't want my larynx to shoot up. I don't want my larynx to feel tight. I want my larynx to remain neutral or neutral-low and I want to feel a sense of free suspension. I am aware of how successful I am being in creating a free and easy chest voice tone. Now that my chest voice is working the way I want it to, I need to work in my head voice/falsetto. In my falsetto, I am going to do 5-tone descending scales on [u]. I choose [u] because I know that it encourages activation of my cricothyroid more than activation of my thyroarytenoid. As I begin to sing, I feel my vocal folds coming together. They are coming together much lighter than in chest voice, creating what feels like a more hollow, flute-like sound. I feel the sensation of a yawn while singing in my falsetto, which is helping me to maintain a sense of relaxation in my throat. As I practice these descending 5-tone scales, I notice that I am using significantly more breath than in my chest voice, which is expected. It still feels free…just like it is moving quicker and through thinner vocal folds. I still feel gentle vibrations equally on both sides of my larynx. I continue to monitor the height of my larynx to make sure it is staying neutral. I am aware of how successful I am being in creating a free and easy head voice/falsetto tone. Now that I have created sounds in both chest and head/falsetto that I like the sound and feeling of, I have to work on bridging the two registers together. I start in my falsetto just above my passaggio using a flute-like [u]. I sing a free and easy descending 5-tone scale, passing through the passaggio. At the bottom of the scale, without a break or breath, I transition to my chest voice and sing a 3-tone scale, ascending and descending on [væ]. I like this exercise because I know it is working on coordinating both my thyroarytenoid and my cricothyroid. As I begin, I focus on the sense of yawn and neutral larynx in my falsetto. I monitor the height of my larynx and the speed of my breath. The head voice portion of this exercise still feels free and easy. When I get to the tonic of the scale, I switch to my chest voice and sing on [væ]. I want to feel an easy, smooth transition from falsetto to chest. I monitor my breath and think of the lighter sound I want to make. When I sing in my chest voice, the sound remains free and released. As I continue this exercise across my passaggio, I am aware of how successful I am being in creating a free and easy tone while transitioning from head/falsetto to chest register. I'm hopeful that this lighter chest voice sound and the free head voice sound will continue to encourage freedom in my sound as I continue to practice.

This performance script for registration addresses specific physiological occurrences and sensations that occur in both mode 1 and mode 2 registration. By visualizing the vocal folds coming together at different thicknesses and with different amounts of pressure, a singer can create more accurate mental images of what is occurring during either mode of registration. Additionally, this performance script uses another form of mental imagery, namely auditory imagery, in describing Mode 1 as having a more full-bodied, edgier sound similar to a reed instrument. Conversely, this script describes Mode 2 as having a lighter, hollower sound similar to a flute. These auditory descriptions help a singer associate the desired timbres with the registrations they are attempting to use. If a singer is mentally practicing in Mode 2, for example, "visualizing" the sound of a flute (or another sound, such as an owl hooting) can encourage activation of the same motor sequence that will produce a Mode 2 registration. Likewise, if a singer is mentally practicing in Mode 1, "visualizing" the sound of a reed instrument, such as a saxophone or an oboe, can encourage activation of the motor sequence that produces sound in Mode 1 registration.

Ultimately, this performance script is intended to increase the mental representations, visual and aural, of singing in both registers and then through the *passaggio*. By using a detailed script that provides the name of the muscles involved as well as descriptions of the thickness of the vocal folds and the quality of sounds produced in each register, a singer may effectively activate the appropriate motor sequence, firing more neurons through the appropriate synapses, and myelinating axons to strengthen specific skills for registration.

Detailed Anatomical Diagrams for Registration

As explained above, the muscles and cartilages of the larynx interact differently in each register. In order to effectively use detailed anatomical diagrams of the larynx for mental practice for phonation, we must understand where the main components of phonation are located in the larynx. Figure 28 provides a top-down view of the larynx. This image clarifies the locations of the thyroarytenoid (dominant in Mode 1) and the cricothyroid (dominant in Mode 2). Also shown in this image are the posterior and lateral cricoarytenoids, and the transverse and oblique arytenoids. Although Mode 1 involves more thyroarytenoid activation and Mode 2 more cricothyroid activation, in both cases there is some activity on the part of the less dominant muscle. The lateral and posterior cricoarytenoids and the oblique and transverse arytenoids are also involved in closing the glottis in various formations for different registration.

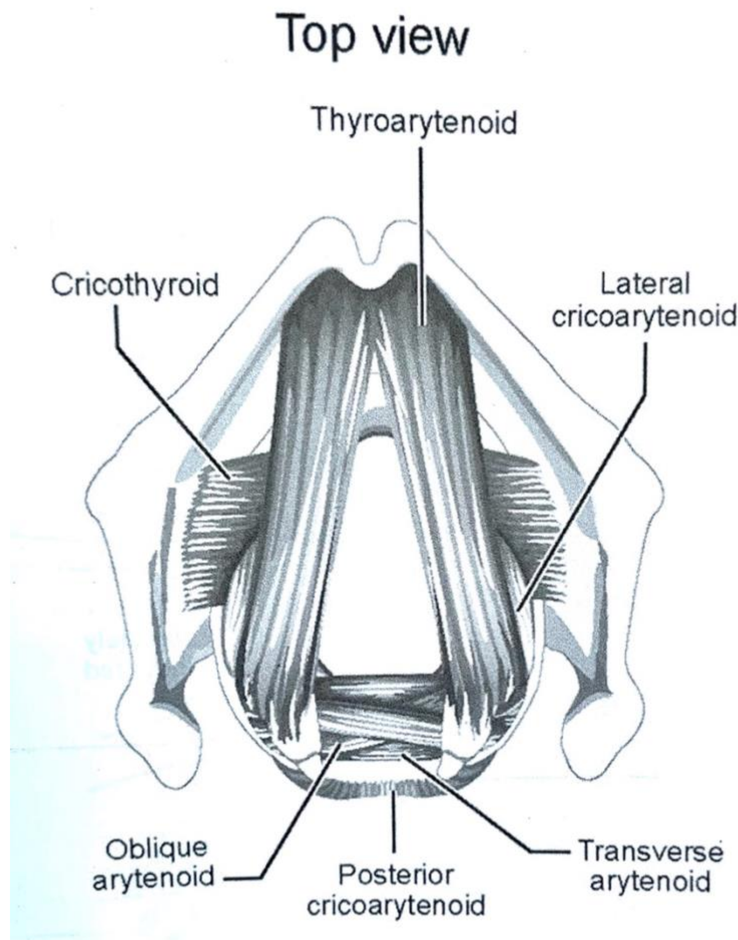


Figure 28: Top view of the larynx showing the intrinsic laryngeal muscles. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 117.

Once a singer is clear about the location of the muscles responsible for variations in registration, additional diagrams can be used to illustrate the shape and position of the vocal folds in each register. Observing such diagrams will promote the formation of stronger mental images, which will then aid in future physical practice. This activity should lead to more myelinated axons of neurons associated with the motor sequence for any vocal register.

Figure 29 offers a simplified depiction of the amount of thyroarytenoid contraction in three registers: head/falsetto, mixed (that is, a mixture of head and chest), and chest.

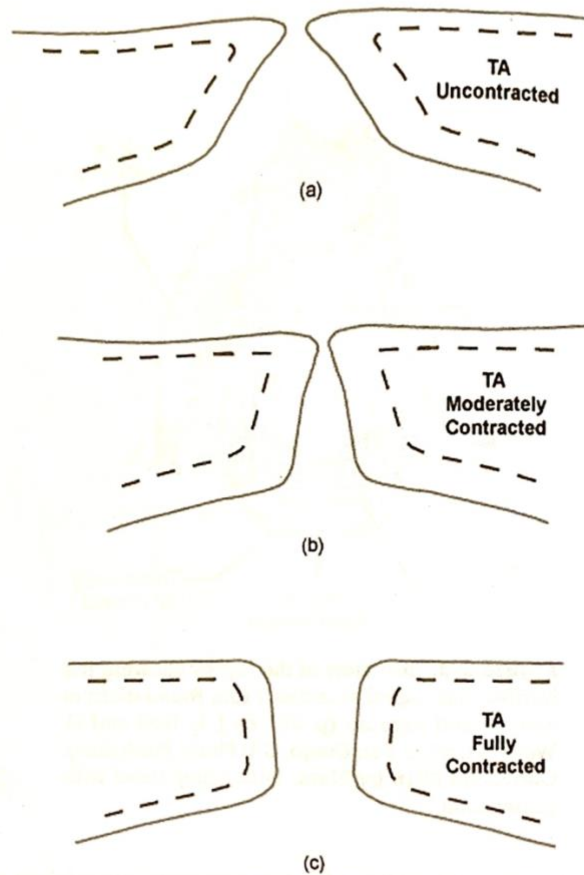


Figure 29: Vertical adduction of the vocal folds in (A) CT-dominated head register (B) mixed register, and (C) TA-dominated chest register. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 118.

In the first position (a), the thyroarytenoid is minimally contracted, which implies that the cricothyroid is dominant in the type of production that requires this vocal fold configuration. Because of the mostly passive thyroarytenoid and the cricothyroid dominant production in Mode 2, less of the body of the vocal folds comes together during vibration. This vocal fold configuration tends to lead to a lighter, more hollow, and flute-like sound. In the third position (c), the thyroarytenoid is fully contracted, which implies that the cricothyroid is mostly passive in this register. Because of the dominance of the thyroarytenoid muscle in Mode 1 registration,

more of the surface of the vocal folds comes together. The resulting sound is typically louder and has more of an edge or brassiness.

Vertical phase is the term which describes the amount of surface area of the vocal folds that adducts during a vibration cycle. Each register has a different vertical phase, which contributes to its unique timbre. In Mode 1, the vertical phase is at its highest level, meaning that the full body of each vocal fold is meeting the full body of the other vocal fold during vibration.

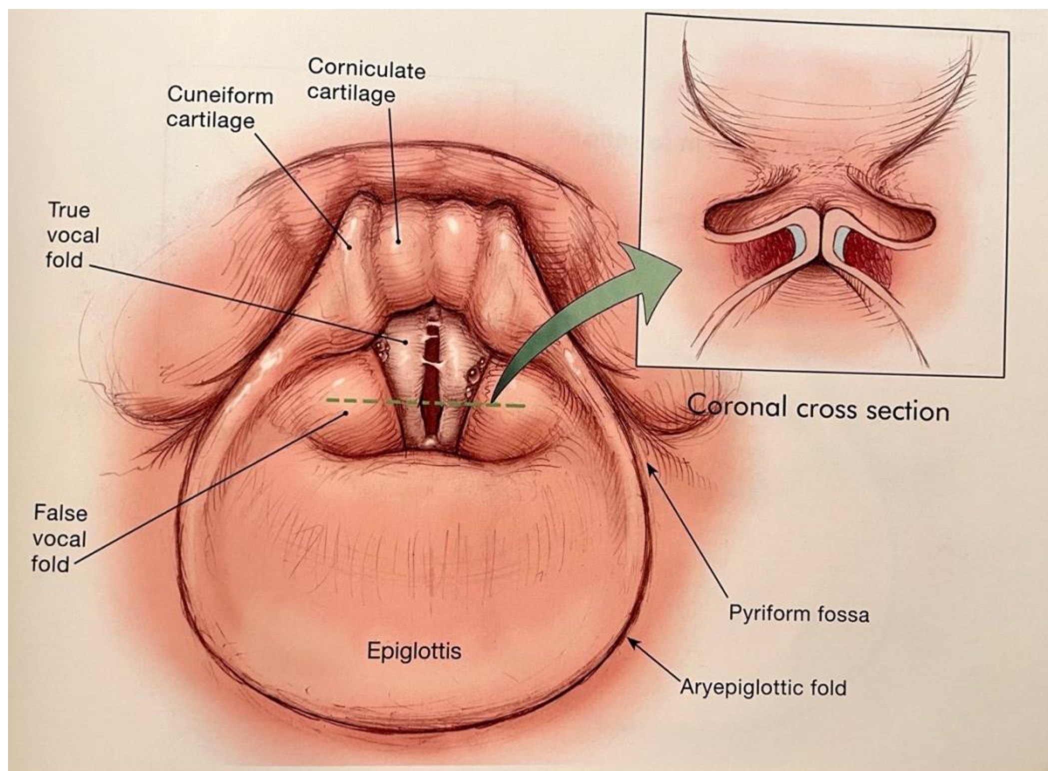


Figure 30: Vocal folds in chest voice. Inset: the entire body of each vocal fold is in contact with the other one as it vibrates. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 43.

In addition to knowing what the vocal folds look like at full adduction in Mode 1 registration, it is important for the purposes of mental practice and forming detailed mental images that a singer understand the motion of the vocal folds in Mode 1, too. Figure 31, which is

similar to Figure 26 (see Chapter 5), shows the vibration cycle of the vocal folds in Mode 1, when the thyroarytenoid is the most dominant muscle involved in phonation.

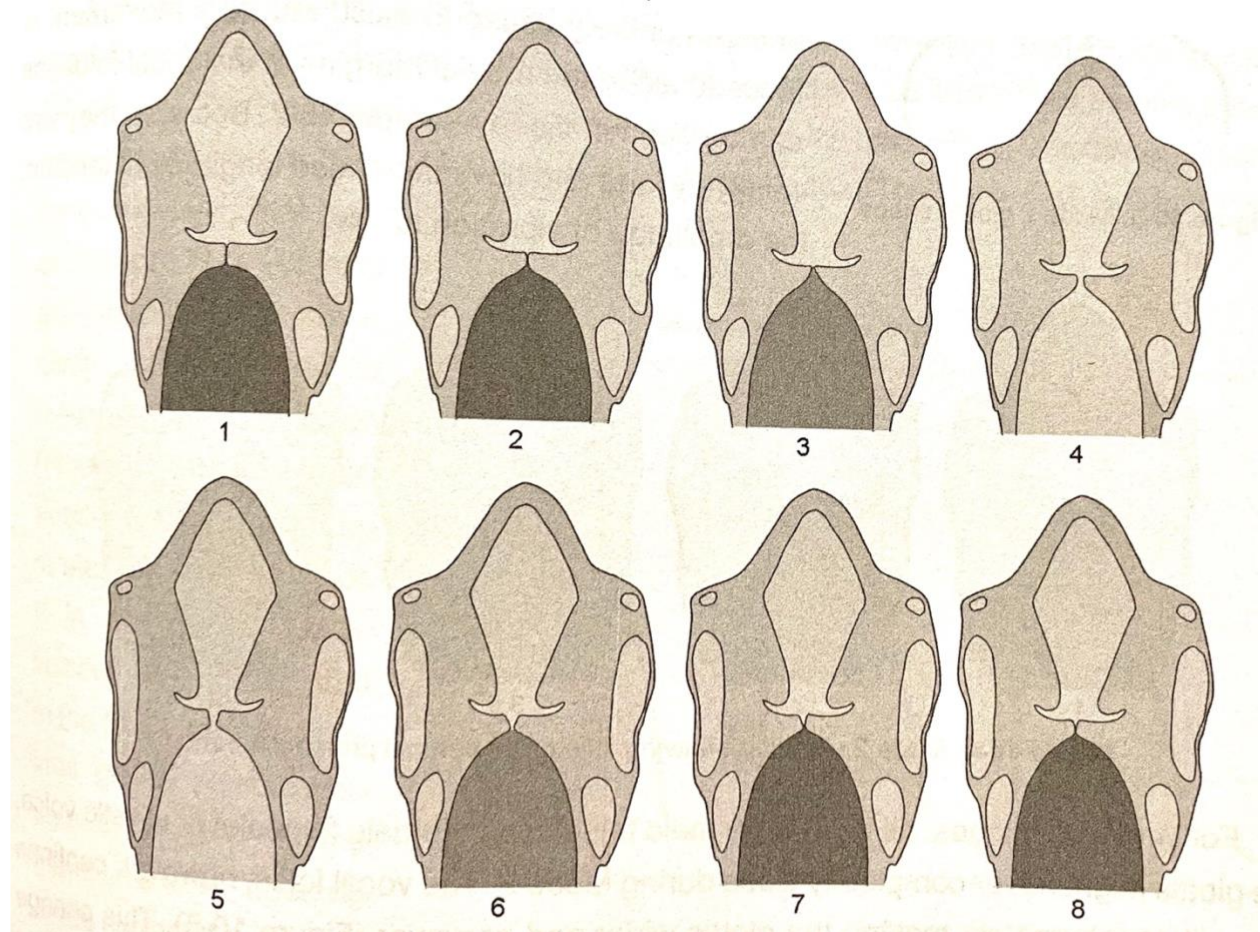


Figure 31: Mode 1 cycle of vibration showing vertical phase difference at glottis. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 231.

Here, it is easy to see how the entire body of the vocal fold comes together in a wave-like motion. During the vibration cycle, the vocal folds come together at the bottom first, followed by closure at the top. Then subglottal air forces the bottom of the vocal folds to come apart, after which the top opens as well. For our purposes, the most notable elements of this process occur in

steps one and eight. In both of these steps of vocal fold vibration, the entire body of the vocal folds is coming together, which is a characteristic of Mode 1 registration.

In Mode 2, the vocal fold vibratory cycle is similar but there is less contact of the body of the vocal folds.

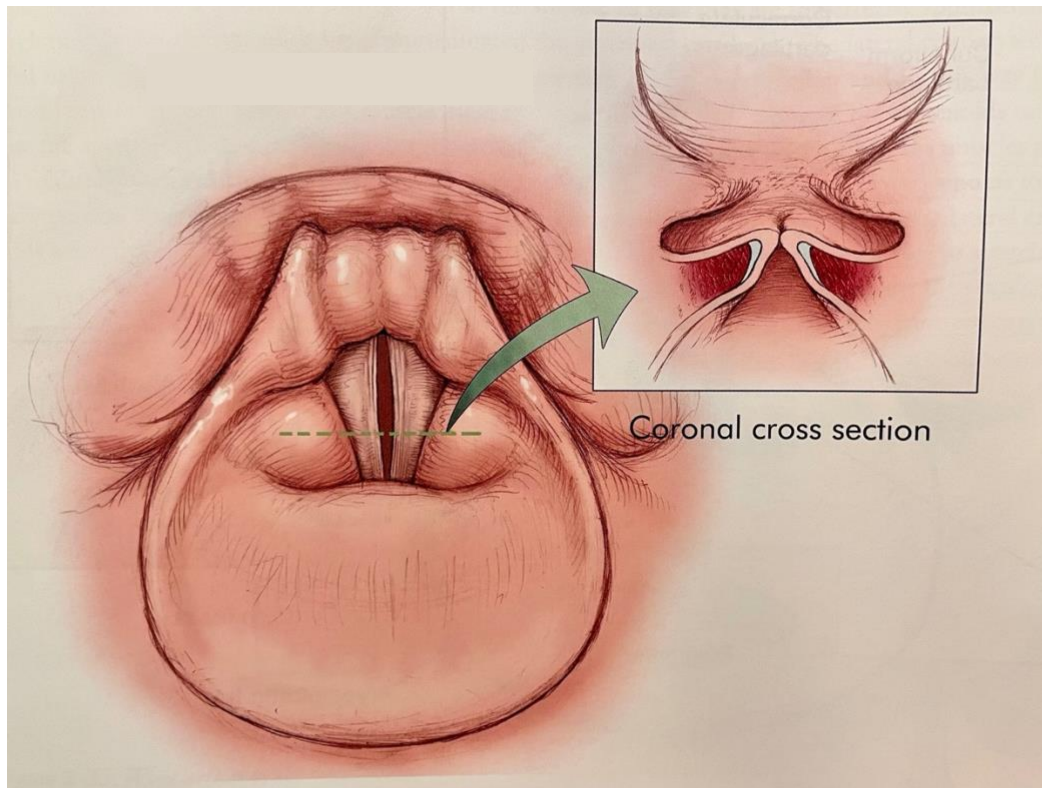


Figure 32: Vocal folds in falsetto. Inset: only the inner margin of each vocal fold is in contact as it vibrates. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 44.

Figure 32 depicts the vocal folds in falsetto; it doubles as a representation of head register for female voices. Note the coronal cross section shown in the image: here, it is clear that only a portion of the vocal folds comes together during Mode 2 registration. In other words, the vertical phase in Mode 2 is much lower than in Mode 1. For each cycle of vibration in Mode 2, less of the vocal folds come together, as Figure 33 demonstrates below.

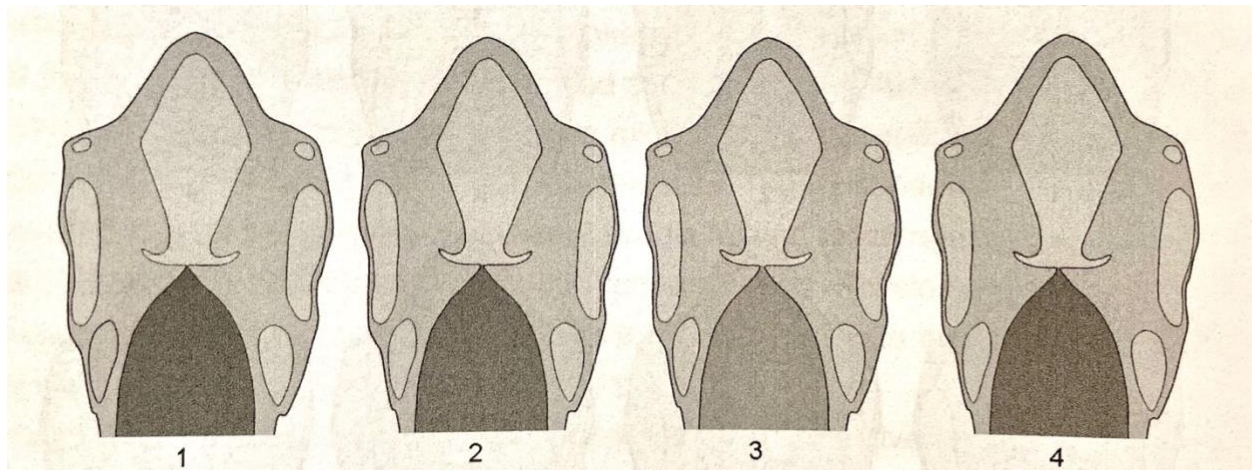


Figure 33: Mode 2 vibration showing little or no vertical phase difference. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 232.

When observing an example like Figure 33 in order to form a more detailed and specific mental representation of the vocal folds in Mode 2, it is important to observe not only the vertical phase (or the lack thereof), but also the amplitude, or how far apart the vocal folds separate during vibration. It is easy to notice in steps two through four of Figure 33 that the amplitude is very low, or that the space between the vocal folds during their open phase is very small. This is a stark contrast to the amplitude of Mode 1 registration, when the vocal folds travel farther apart during a vibratory cycle.

In Mode 3, the vocal folds continue to vibrate; however, it is common that the glottis doesn't ever fully close, as we see in Figure 34.

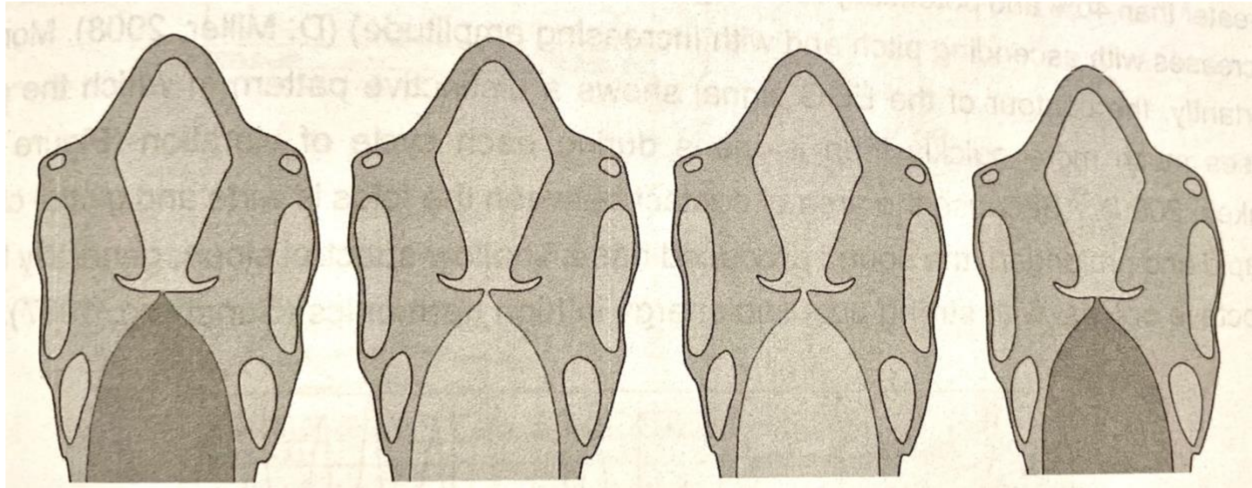


Figure 34: Incomplete glottal closure during flageolet or falsetto production. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 233.

In this registration mode, because the vocal folds are still vibrating but not closing, there is still a constant change in the width of the glottis. As Scott McCoy explains, "this change in dimension alone is sufficient to induce pressure variations in the air that are identified as sound."[100]

To incorporate any of the above diagrams for mental practice of registration effectively, I recommend using them in conjunction with diagrams that represent phonation (for examples, see Chapter 5). I make this recommendation because the systems of registration and phonation are closely intertwined, with the muscles of phonation having a large impact on registration and vice versa. Moreover, if a singer were to attempt to form specific and detailed mental images of registration without awareness of how phonation occurs, crucial knowledge would be missing, and they would form less vivid, more disjunct mental image representations of registration.

100 McCoy, *Your Voice: An Inside View 3*, 232.

Teacher-Directed Mental Imagery for Registration

In the voice studio, teachers can provide feedback based on the individual performance of a student. In regard to registration, much (but not all) of the feedback teachers offer is based on the sound produced and how the teacher perceives that sound. For example, in Mode 1, a sound can have more or less brassiness or edge to it, or in Mode 2, a sound can be more or less airy. These variations in timbre directly relate to the configuration of the vocal folds, the collision force, and the amplitude.

When working with younger students, teachers often describe a student's sound as pressed, forced, or pointed. Generally, these terms describe not only the sound being produced, but also the glottal configuration and the collision force that produce it. Pressed, forced, or pointed sounds in Mode 1 are often a result of the vocal folds adducting too hard and too thickly. Although it is known that in Mode 1 the full body of the vocal fold comes together, there is some variation in exactly how thick the vocal folds can or need to be, depending on the style, the desired aesthetic, and the genre in which a singer is performing. Ragan has developed a slide rule, reproduced below as Figure 35, to demonstrate the continuum of laryngeal source activity and resonance activity across registers.

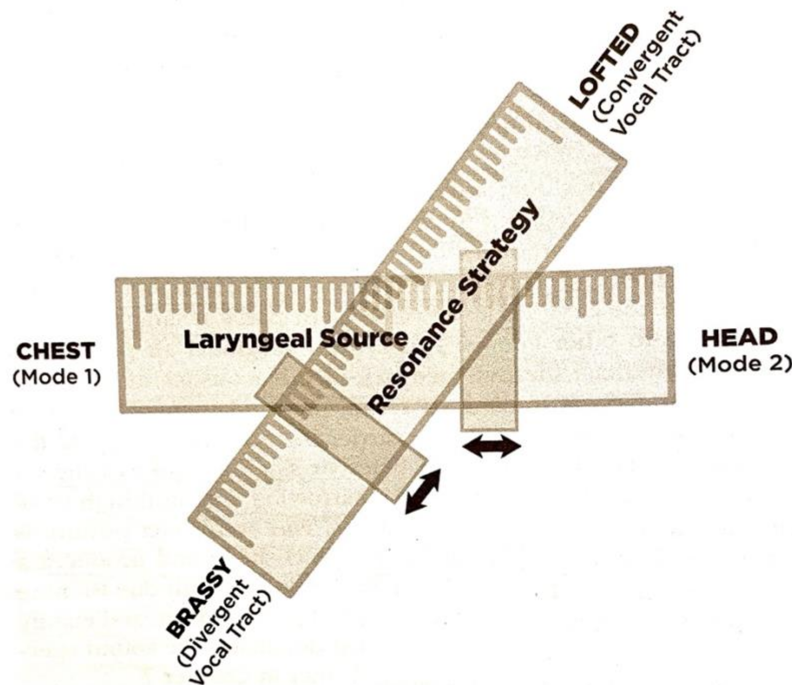


Figure 35: Image of two slide rules to demonstrate the continuum of laryngeal source and resonance strategy choices while singing. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 119.

This diagram demonstrates that the laryngeal source configuration varies within each register. As shown in this diagram, resonance can be adjusted from brassy to lofted within various laryngeal source configurations. In other words, a sound can be brassy or lofted in Mode 1 or Mode 2, but the ideal aesthetic ultimately determines which laryngeal source and resonance strategy combination will be used.

If a teacher hears a student singing with a pressed or forced tone, there are numerous ways to encourage the student to slightly thin out the vocal fold configuration. First, one can use the hands in a wave-like motion, as in the example provided in Chapter 5. Here, teachers should show their students what vocal fold vibration looks like in Mode 1, including variations of this vibration. If teachers press their hands together more forcefully during the demonstration, their

students will witness a representation of the pressed and forced sound they are producing. If teachers begin to show the vibration pattern with less force when the hands come together, or even with the very bottom of the hands staying slightly apart, their students will then see a representation of Mode 1 when the vocal configuration is less forced and constricted. As students transition into Mode 2, their teachers may demonstrate how the vocal folds come into contact with one another less than before, supporting the formation of mental images that match the vocal fold configuration in Mode 2.

Teachers also facilitate the use of the detailed anatomical diagrams shown above. Many voice teachers have posters, drawings, and charts in their studios for quick and easy reference. During a voice lesson, teachers can and should make time to use these posters for explanation and demonstration. Although time spent not singing is sometimes thought of as a waste of lesson time, even just a few minutes observing these diagrams with input and direction from the teacher is beneficial in skill development.

The vocabulary teachers use also plays an important role in how their students perceive information about singing. If a student's singing is too pressed, for example, their teacher could encourage them to sing with a "lighter" or "warmer" sound. Alternately, the teacher could also simply indicate that the student is singing too thickly and should thin out the vocal folds.

Many beginning students, male and female, have trouble accessing Mode 2. There are numerous reasons for this, such as the influence of natural speech patterns in Mode 1, or prior familiarity with genres and styles of music in which Mode 1 is the primary laryngeal source. In such instances as these, teachers often use auditory imagery to elicit Mode 2 registration. For example, teachers might tell a post-puberty male singer to use their "little kid voice," or to sing like a flute. Another common image employed to elicit Mode 2 registration is the "Julia Child

voice," since Julia Child often spoke (in a manner many students recognize) in a "lofted" Mode 2 register.

Teachers can also successfully support the understanding and performance of registration through the use of vocal demonstration. Demonstration of this kind is most beneficial when the biological sex of the teacher and student is the same, owing to changes in the vocal mechanism at puberty. Moreover, demonstrations by teachers of the same biological sex help students observe physical adjustments to the body and vocal tract when transitioning between registers.

Whatever method a voice teacher chooses to help each registration, their ability to guide a student in forming more detailed, accurate, and specific mental images will prove to be an effective use of lesson time. Yes, students can form mental images on their own; however, voice teachers are able to provide more specific details of anatomy, function, and sensations during physical performance of a skill. This addition helps the mental image representations become as detailed as possible, which more effectively enhances the motor sequence for that skill in turn.

Third-Person Observation for Registration

Many singers say that one of the most influential learning techniques in their singing development is watching and listening to other singers of the same voice type. Neuroscientific evidence affirms that the brain processes information received from watching another person perform the same skill, and that such information often activates the mirror neuron system. When a singer observes other singers, they can observe visual information about the singer's body, breath, and even mental state. The observing singer can also hear the color and timbre of the tone and registration choices of the performing singer, among other things.

It can be harder to discern aurally which register another singer is using. Crucial to third-person observation of registration for mental practice purposes is that the observing singer have the same voice type as the performing singer. This similarity will enhance the observing singer's ability to imagine exactly what sensations are felt during sound production. Additionally, third-person observation of registration for mental practice requires that the observing singer be intently focused on specific registration choices and the sound that results from those choices. Below is a guided practice routine designed to facilitate mental practice of registration using third-person observation:

1. Briefly close your eyes, eliminating all extraneous stimuli.
2. Focus your attention on a specific ambient noise, attempting to make that noise the only thing you hear.
3. Once your mental state has been aroused and your awareness heightened, open your eyes and focus on the singer in front of you. Try to allow all other objects or people in the space to fade into the distance.
4. Observe the position of the singer's body. Are they relaxed? Aligned? How is their posture?
5. Are you able to see the larynx of the singer? Is it prominent? (Males tend to have more prominent larynxes than females)
6. Once the singer begins singing, listen intently to the sound.
7. First, discern whether the sound is being produced in mode 1 or mode 2. How can you tell? What timbre do you hear? What is the range?
8. As you are listening to timbre of the sound, can you describe it? Does it remind you of a color? Is the color a bright color or dark or a warm color? Does the timbre remind you of an instrument? Is the sound brassy or flute-like? Does brassiness sound like a brighter color or a warmer color? What about flute-like?
9. Does the tone sound free? Pressed? Hollow?
10. As you begin to refine the details of the sound you are hearing, observe actions in the body. Does the body look free and grounded? Does it look like the singer is working hard or not? Can you see any change to the height of the larynx? What is the shape of the lips? What about the jaw?
11. Do any of your observations about the body correlate to the sound that you hear?
12. Pay close attention as the singer continues. Do changes in registration occur? Are there changes in timbre? Are the changes in sound accompanied by any noticeable physical changes?

13. Are there any general observations? Does the timbre change without a registration change as the voice goes higher in the range? Is this associated with any laryngeal shift?
14. Listen and watch as a singer sings through various modes of registration. As you are observing and listening, try to imagine what they are doing physically to produce the timbre and quality of sound they are achieving in both registers. Can you imagine how the vocal folds are coming together? Can you imagine the height of the larynx? Can you imagine where they are feeling sympathetic vibrations? Can you imagine the shape of the vocal tract inside the mouth?
15. As you are creating a mental image of the singer's physical position for registration, try to be as detailed as possible, imagining every specific detail.
16. Associate this mental image with an aural representation. Does your mental image create a bright or dark sound? A brassy or flute-like sound?

In keeping with the techniques surveyed in previous chapters, this process asks an observing singer to begin by establishing a sense of mindfulness and heightened arousal or awareness. Once the observing singer arrives in a state of heightened awareness, the next stage involves observing specific visual and aural stimuli linked with the registration choices of the performing singer. As the observer begins observing details about the performer's production of register, they create a mental image of the physical posture and muscle interaction that must be involved in generating this sound. Then, the observer begins analyzing that sound by means of mental images. These images should include both physical and mental representations of the sound and its production, as well as aural representations, so that the observer strengthens their mental image for the particular registration being practiced. The cues above are designed to help the observer form more vivid mental images, for example by asking the observer to associate sound with colors or with other instruments. In this way, an additional level of detail accrues to the observer's mental representation of the sound being produced, in this case, by another singer.

Third-person observation for mental practice of registration involves the mirror neuron system, which (as discussed in Chapter 2) activates when a person observes an action that is already within their motor repertoire. Activation of the mirror neuron system does not depend

upon performer and observer belonging to the same species, or indeed the same voice type. However, because vocal registration is a unique process that varies among voice types (even more so than just among singers of the same assigned sex), singers are bound to benefit most directly from observing someone of the same voice type. The reasoning here is that in order for the mirror neuron system to activate, the motor sequence must already exist within the motor repertoire of the observer. A tenor's voice and their choice of registration differs from that of a mezzo-soprano (even though the range of some repertoire might be similar), and *the motor sequences involved may also be fundamentally different*, so singers of these two particular voice types would handle registration events differently.

Ultimately, third-person observation of registration for mental practice is likely to offer substantial benefits to a singer. If they are able to establish mindfulness and/or arousal before beginning their observations, they will be more likely to create highly detailed and specific mental images comprising both visual and auditory components. These mental images could then be recalled for later mental imagery practice or during physical practice to enhance registration choices and facilitate registration events.

Attentive Listening for Registration

Attentive listening is a major component in third-person observation of a skill; but what about when there isn't another person to observe? Is it possible to experience the same benefits while just listening to a recording? Harris and de Jong have shown that "passive listening to music [evokes] auditory-parietal-premotor activations when subjects [have] attentively listened to this music before, while the premotor activation even further [increases] when such music

pieces [have] actually been practiced."[101] Moreover, they write, sound observation can effectively activate the mirror neuron system.[102] Their evidence supports the idea that attentive listening practice indeed activates and strengthens motor sequences that correspond with auditory stimuli, meaning that attentive listening for specific skills in singing can effectively enhance physical performance of those skills.

Auditory stimuli enter through the cochlea of the inner ear and travel along the ascending auditory pathway, which includes (in order) the pons, midbrain, thalamus, and the auditory cortex. Once the auditory signals reach the auditory cortex, a serious of mental processes creates an aural mental representation. This mental representation is stored and represented by a system of neurons that correlate with that particular auditory stimulus, but also with the motor sequence of physically reproducing the same sound.

As with any other form of mental practice, a heightened state of awareness and mindfulness must be established first. Upon achieving a state of mindfulness, attentive listening follows a similar sequence as third-person observation. The following guide facilitates attentive listening are part of mental practice for registration. The guide begins by establishing a state of mindfulness and then asks the listener a series of questions to prompt the formation of detailed and specific mental images.

1. Find a quiet room or place free from all distractions.
2. Briefly close your eyes, eliminating all extraneous stimuli.
3. Focus your attention on a specific ambient noise, attempting to make that noise the only thing you hear.
4. Once your mental state has been aroused and your awareness heightened, open your eyes briefly to turn on a recording. Try to only open your eyes enough to see the device that the music is coming from, keeping your eyes in a sort of haze.

101 Robert Harris and Bauke M. de Jong, "Cerebral Activations Related To Audition-Driven Performance Imagery in Professional Musicians," *PLoS ONE* 9, no. 4 (August 2014): 7.
102 Ibid.

5. Once you have started the music, close your eyes again. You should devote all your attention and energy to listening.
6. Once the singer begins singing, listen intently to the sounds that are made.
7. First, discern whether the sound is being produced in mode 1 or mode 2. How can you tell? What timbre do you hear? What is the range?
8. As you are listening to timbre of the sound, can you describe it? Does it remind you of a color? Is the color a bright color or dark or a warm color? Does the timbre remind you of an instrument? Is the sound brassy or flute-like? Does brassiness sound like a brighter color or a warmer color? What about flute-like?
9. Does the tone sound free? Pressed? Hollow?
10. Pay close attention as the singer continues. Do changes in registration occur? Are there changes in timbre? Can you describe the changes?
11. Are there any general observations? Does the timbre change without a registration change as the voice goes higher in the range? What other things do you notice in regard to registration?
12. Listen as the singer works through various modes of registration. As you are listening, try to imagine what they are doing physically to produce the timbre and quality of sound they are achieving in both registers. Can you imagine how the vocal folds are coming together? Can you imagine the height of the larynx? Can you imagine where they are feeling sympathetic vibrations? Can you imagine the shape of the vocal tract inside the mouth?
13. As you are creating a mental image of the singer's physical position for registration, try to be as detailed as possible, imagining every specific detail.
14. Associate this mental image with an aural representation. Does your mental image create a bright or dark sound? A brassy or flute-like sound?
15. Keep your eyes shut for a few seconds after the recording ends.
16. During the silence, allow yourself to focus intently on the sounds and registration you just observed.
17. After you feel that you have formed the most detailed mental and aural image possible, open your eyes.

Just as in third-person observation for mental practice of registration, this attentive listening guide attempts to place the mind in a state of mindful arousal by eliminating all extraneous stimuli. The remaining steps focus on guiding the listener in creating the most vivid and detailed mental and aural image possible so that it can be stored and associated with the motor sequence for registration when needed for physical practice or performance. Additionally, research shows that this type of attentive listening activates the mirror neuron system, which suggests that listening attentively to the registration choices of a singer performing a piece of

music in the listener's repertoire engages the motor sequences for registration.[103] This engagement causes increased myelination of the neurons involved in this sequence, which will have the downstream effect of making physical practice of this skill more efficient.

Conclusion

Registration is a complex system that relies heavily on the interactions between, and the coordination of, the laryngeal muscles and cartilages that impact the vertical phase, amplitude, and collision force of the vocal folds, which ultimately produce unique vocal colors and timbres. It is crucial that a singer practice Mode 1 and Mode 2 registration physically on a consistent basis to ensure muscle and breath coordination. A singer may also supplement their physical practice by adding well-designed mental practice to their routines. Mindfulness exercises, performance imagery and performance scripts specific to registration, detailed anatomical diagrams of the system of registration in all modes, and teacher-directed mental imagery can effectively enhance the efficiency and coordination throughout and across registers. Finally, third-person observation of registration and attentive listening can also activate the mirror neuron system, myelinating the neurons of the motor sequences for registration and thereby enhancing the fluency and ease of recall in later physical practice.

103 Ibid., 7.

Chapter Seven:

Mental Practice for Articulation

In singing, the term articulation encompasses both the organs that allow humans to create words as well as the specific pronunciation of phonemes in various languages. According to James C. McKinney, "articulation is the process by which the joint product of the vibrator and the resonators is shaped into recognizable speech sounds through the muscular adjustments and movements of the speech organs."[104] The speech organs to which McKinney refers are now known as *structures of articulation*, and they are the jaw, tongue, soft and hard palate, lips, and pharynx. Muscles within the articulatory system also contribute to vocal tract shaping and play a significant role in resonance and vocal timbre.

The muscles of the jaw activate to open and close the mouth. The primary muscles that elevate the jaw are the *masseter, internal pterygoid*, and the *temporalis*. These three muscles serve two functions, opening the jaw and elevating the larynx. Unfortunately for the purposes of singing, these two functions are also in conflict with one another: the same muscles responsible for lowering (or opening) the jaw also assist in elevating the larynx, which is generally not an ideal position.

The muscles of the tongue originate in the blade (or dorsum) and connect to other structures in the head and the neck. The tongue has four intrinsic muscles in two pairs: the *inferior* and *superior longitudinal muscles* and the *vertical* and *transverse muscles*. The primary role of these muscles is to shape the tongue, meaning that they have the capacity to lengthen, shorten, curl, uncurl, narrow, flatten, and widen the tongue, and they also move it upward and downward. The extrinsic muscles of the tongue are the *palatoglossus, genioglossus, styloglossus*,

---

104 James C. McKinney, *Diagnosis and Correction of Vocal Faults: A Manual for Teachers of Singing and for Choir Directors* (Nashville, TN: Waveland Press, 1994), 27.

and *hyoglossus*. These muscles are connected to either the soft palate, pharynx, jaw or hyoid bone and are responsible for extending, raising, lowering, pulling back, and curling the tongue. Additionally, the tongue is crucial for the articulation of language: as McCoy writes, "the formants of the vocal tract that are responsible for vowel definition are dependent on correct tongue placement and shape."[105]

The soft palate, also called the *velum*, is part of the swallowing mechanism and is also involved in yawning, laughing, and sobbing.[106] The soft palate comprises a series of muscles that retract or raise the palate in order to close the nasal cavity during swallowing, guiding food to the esophagus instead of into the nose. It is also possible to raise or lower the soft palate to affect different levels of nasality in singing. When raised, the soft palate is pulled against the back of the throat, which closes off the nasal cavity. This action is performed by the *levator palati* muscle, which makes up the majority of the soft palate. It originates from the skull and the auditory tubes and forms an arched structure, which draws the palate upward and backward.

The *pharynx*, more commonly known as the throat, is made up of three sub-sections: the *oropharynx*, *nasopharynx*, and *laryngopharynx*. While resonance is impacted by the entirety of the vocal tract, the pharynx is the primary area in which the voice may resonate, which it does by amplifying select frequencies produced by the vocal folds. The shape of the pharynx may be altered by the *superior*, *inferior*, and *middle constrictor* muscles, and this alteration in shape can either enhance or detract from resonances of specific pitches. Contrary to popular belief, there are no muscles in the pharynx that cause the throat to open. As Ragan writes: "The pharynx is at its widest state when in a neutral position."[107]

---

105 McCoy, *Your Voice: An Inside View 3,* 251.
106 Ragan, *A Systematic Approach to Voice*, 158.
107 Ibid., 160.

All of the articulatory structures enumerated above act together in a complex and interconnected fashion, for which reason, according to McCoy, “action in one area can easily impact another.”[108]

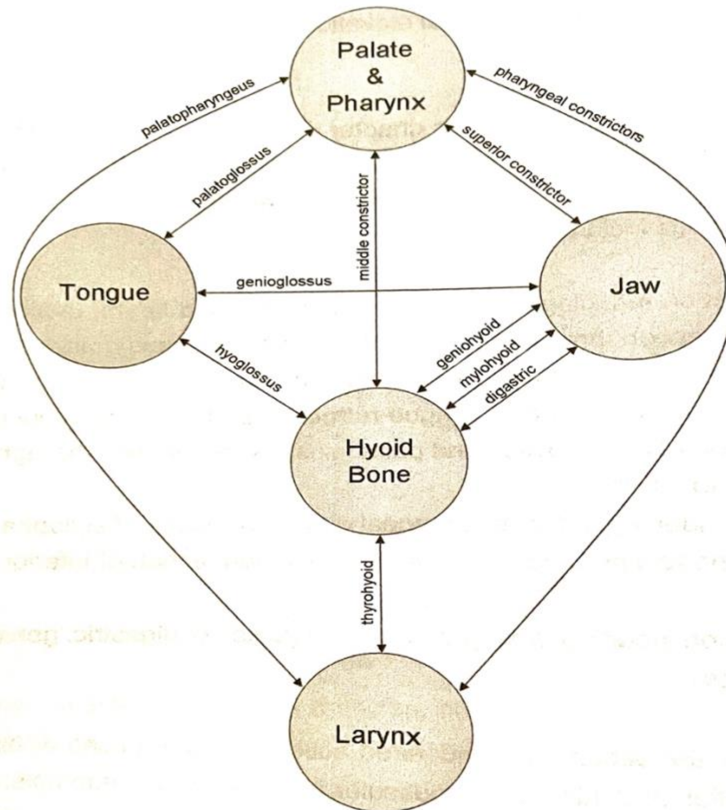


Figure 36: Articulator Interconnections. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 262.

Figure 36 demonstrates this principle by illustrating how changes in the articulatory system can significantly (both beneficially and negatively) impact the system of phonation. Elevation of the soft palate impacts the elevation of both the tongue and the larynx because the levator palati is connected through the palatoglossus and the hyoglossus muscles. Sticking the tongue out causes laryngeal elevation, as does pulling the tongue back and up because the styloglossus and

108 McCoy, *Your Voice: An Inside View 3*, 261.

palatoglossus are connected through the hyoglossus to the larynx. Widening of the pharynx causes elevation of the larynx by means of the *stylopharyngeal* muscle. Similarly, narrowing of the pharynx also causes laryngeal elevation by means of the *inferior pharyngeal constrictor*.

Experienced singers are able to counteract the secondary articulatory actions by means of conscious relaxation; in order for this technique to be effective, however, they must be aware of these interconnections. A singer frequently experiences immense amounts of tension arising from one or more secondary actions of the articulatory system. Time and practice, both physical and mental, support the proper engagement of a particular articulatory structure without causing such unwanted secondary actions.

Articulatory Patterns

Articulatory patterns and postures vary in numerous ways between languages. For this reason, it is important that a singer understand both the general and specific rules of articulatory patterns in the languages in which they are likely to sing. The specifics of articulation for every vowel and/or consonant in French, German, Italian, and English—the languages of the classical tradition with whose voice pedagogies this dissertation is expressly concerned—are beyond the scope of this project. What follows is a basic overview of generalized articulatory patterns in these languages to assist in understanding the differences between them for the sake of explaining mental image formation with respect to articulation.

French Lyric Diction

In French, the pronunciation of written vowels varies on the basis of where the letter occurs within words or whether it has accent marks. As a general rule, when the letter /a/ is not

nasal and not combined with another vowel, it is pronounced as a bright [a]. The letter /a/ is not pronounced [a] when it has a circumflex accent (â), when it is followed by the [z] sound, or when it is followed by a silent /s/.[109] In these cases, the letter /a/ is pronounced [ɑ].

The letter /e/ with no accent and at the end of a syllable is generally sung as [ə]. An /e/ with no accent followed by the letter /n/ is often pronounced as a nasal [ɑ̃]. The letter /e/ is also pronounced as a nasal [ɑ̃] when followed by /m/ or /n/ plus a different consonant within a word.[110] The letter /e/ followed by a pronounced consonant at the end of its syllable is generally pronounced [ɛ]. When accents are added above the written letter /e/, the articulation of that vowel changes. The letter /é/ is always pronounced [e]; however, the letter /è/ is always pronounced [ɛ] and the letter /ê/ is pronounced [ɛ] except during harmonic vocalization. Generally, all variations of the letter /e/ are all going to occur in the front of the mouth with the front of the tongue more forward and arched (to varying degrees), the lips rounded, and the jaw released.

The letter /i/ when not nasal and not combined with another consonant is pronounced [i]. When followed by the letters /m/ or /n/, or when at the end of a word, the letter /i/ is pronounced nasally as [ɛ̃]. Both pronunciations of this letter are frontal, occurring with the front of the tongue forward and arched and the lips relaxed.

In French, most occurrences of the letter /o/ are open: [ɔ]. The letter /o/ is only pronounced as a closed [o] when it is the final sound of a word, when it is followed by a [z] sound, or when it has a circumflex accent: [ô]. The letter /o/ will be pronounced nasally, [õ], when it is followed by an /m/ or /n/ in French lyric diction.

109 Thomas M Donnan, French Lyric Diction (Lanham, MD: University Press of America, 1994), 11.
110 Ibid., 15.

The letter /u/ is generally pronounced as [y] when it is not written in combination with another vowel. The letter /u/ is nasalized when followed by the letters /m/ or /n/, when at the end of a word, or when followed by a different consonant within the middle of a word. Unlike the other vowels, the circumflex accent does not alter the pronunciation of the letter /u/, therefore an /û/ is still pronounced [y].

Semivowels are vowels that are articulated quickly to the point of not being heard as a true vowel. Semivowels in French include [j], [w], and [ɥ]. For the [j] and [ɥ], the tongue starts in the [i] position and rapidly releases to a more relaxed state. For the [w], just like in American English, the tongue is already relaxed in the mouth.

On the basis of this brief and general overview, we may conclude that, with a few exceptions, French lyric diction occurs more in the front of the mouth with rounded lips and a forward tongue placement. To be sure, singers may need to make specific modifications in order to accommodate variations in color or resonance, or in the case of specific exceptions to the general rules.

German Lyric Diction

German Lyric Diction categorizes vowels according to the length of the vowel, tongue position, sound quality (bright or dark), height in the mouth, or the distance from the opening of the mouth (front, central, back).[111] Generally, German pure vowels can be categorized into four sections: front, back, central, and mixed.

Front vowels in German include [i], [I], [e], [ɛ]. To produce these vowel sounds, the front of the tongue is arched forward with the front of the tongue higher and the sides slightly touching

111 Amanda Johnston, *English and German Diction for Singers: A Comparative Approach* (Lanham, MD: Rowman & Littlefield Publishers, Incorporated, 2016), 187.

the upper molars. The tip of the tongue should be resting against the lower teeth. The jaw is positioned slightly lower and back. The lips should be relatively neutral in these vowels. It is important to note that within this general category of front vowels, there will be slight variations in the arch of the tongue from one vowel to the next.

Back vowels in German include [o], [ɔ], [u], and [ʊ]. To produce these vowels, the tip of the tongue is resting at the lower front teeth and the lips are rounded and forward without any tension. The back of the tongue is raised to varying degrees for these vowels. There needs to be increased vertical space in the back of the mouth caused by lifting the soft palate.

Central vowels in German include [a], [ə], and [ɐ]. The schwa, [ə], is considered a mid-central vowel, while the turned A, [ɐ], is considered a more open, central vowel. In German, the [ə] is related specifically to the vowel that directly proceeds it. According to Amanda Johnson, the [ə] is pronounced "in the same tongue and/or lip position as the previous vowel. The sound quality is thus colored by its environment."[112] The German [ə] is not quite as open as the English neutral vowel, but also not quite as closed as the French [ə].

Johnson writes that "mixed vowels are formed by the action of two articulators simultaneously."[113] There are four IPA symbols that are classified as German mixed vowels: [y], [Y], [ø], and [œ]. These vowels can be further classified as open or closed and follow the same general rules as open and closed pure vowels.

Also worth briefly mentioning are the ich-laut [ç] and ach-laut [x], which are voiceless fricatives that occur palatally and uvularly, respectively. The [ç] is formed by placing the tongue in the [i] position and then sending air quick passing by the alveolar ridge.[114] For proper

112 Ibid., 182.
113 Ibid., 198.
114 Ibid., 171.

production of the [ç], the tongue should be the only articulator involved, as too much rounding of this vowel could result in a sound closer to [ʃ]. The [χ] is formed by placing the tongue in the position for an [a] and the quickly sending air towards the center of the hard palate.[115] Finally, there are numerous dialects throughout German-speaking regions in which pronunciation of the [ç] and [χ] will vary, some producing the [χ] farther back on the palate or the [ç] as an [ʃ].

Italian Lyric Diction

In Italian Lyric Diction, vowels are categorized by the position of the tongue: front vowels, back vowels, and low vowels. The three front vowels are [i], [e], and [ɛ]. These vowels require the tip of the tongue to remain in contact with the lower front teeth while the front of the tongue comes forward and rises toward the hard palate. Additionally, these front vowels have a slight relaxation of the lips. The three back vowels in Italian Lyric Diction are [u], [o], and [ɔ]. For proper articulation of these vowels, the tip of the tongue remains in contact with the lower front teeth while the back of the tongue is raised toward the soft palate. These vowels require more rounding of the lips when compared to the production of Italian front vowels. The low vowel in Italian lyric diction is the [ɑ]. This vowel is spoken with the tongue in a lower position, resting on the floor of the mouth. The tip of the tongue remains touching the bottom front teeth, but the lips are in a natural and neutral position. For singing, the middle of the tongue will be slightly higher in the mouth than in spoken Italian.

According to Colorni, whether a vowel is "alone or combined with…another, Italian vowels maintain their original distinctive acoustic qualities."[116] What is meant by this statement

115 Ibid., 174.
116 Evelina Colorni, *Singers' Italian: A Manual of Diction and Phonetics* (New York, NY: Schirmer Books, 1976), 13.

is that Italian singing and speaking generally avoids the use of diphthongs. This means that single vowel sounds are much more sustained in Italian than in English. There are some exceptions to this rule, however. Italian doesn't completely avoid diphthongs — there are just few of them compared to English. Compared to English diphthongs, Italian diphthongs are never just one letter, rather they are spelled phonetically, showing all the vowel sounds that should be pronounced.

Language Articulation Conclusions

According to Appelman, there are more than fifteen English dialects spoken by Americans in the United States, three of which are considered more prominent than the rest: the Eastern dialect (western Ohio to the east coast), the Southern dialect, and the General American dialect (spoken by over 115 million people in the United States).[117] For singing in the three previously discussed languages, American singers must learn how to articulate various word sounds appropriately and authentically. In French, German, and Italian lyric diction, vowels are classified as front, central, or back vowels. While the position of the lips does have some impact on the production of vowel sounds, the most crucial physiological component of authentic foreign language articulation is specific position of the tongue for each vowel sound.[118]

Mindfulness Exercises for Articulation

As with any learned skill, mindfulness and a heightened state of awareness are absolutely necessary to successful incorporation of mental practice to refine the performance of said skill.

---

117 D. Ralph Appelman, *The Science of Vocal Pedagogy: Theory and Application* (Bloomington, IN: Indiana University Press, 1986): 203.
118 Ibid., 248.

Mindfulness primes certain areas of the brain to become more receptive to external or internal stimuli, therefore honing attentional focus on the skill being practiced. Articulation is no exception to this principle. Due to its very specific nature with minute variations from one articulatory position to another in a variety of languages, it could be argued that mindfulness is even more important for articulation than it is to the motor skills that were the subjects of earlier chapters. This particular skill requires a sense of mindfulness and attentional focus that is more internal, as the details that can easily change a vowel or consonant to another all occur within the vocal tract.

Performance Script for Articulation

The following performance script is specific to mental practice for articulation in German. This mental practice script can and should be modified to allow for successful mental practice for articulation in other languages.

> *I'm noticing that my jaw feels released and my tongue is resting forward and at the bottom of my mouth. Looking in the mirror, I can see that my lips are relaxed. I close my eyes for a few moments. I am gathering my thoughts, bringing my attention to my tongue, teeth, lips, and throat. My throat feels relaxed, like the beginning of a yawn. I can feel the liquid motion of my tongue as I move it up and down and back and forth. I can feel the sides of my tongue gently touching my upper molars as I arch my tongue. I can feel my jaw hanging, released. It doesn't feel held or locked in place…it feels tension-less. I begin to think about the German front vowels. I can feel my tongue arching forward, still released and liquid. My goal vowel is an [i]. I can feel the tip of my tongue resting on the bottom front teeth. The blade of my tongue is arching high and forward, gently resting against my canines. My lips feel naturally rounded, but not pushed forward and not tight or pursed. I can feel the air and tone flowing quickly through the space between my palate and tongue. I feel confident that this position produces an authentic German [i] sound. As I transition from the closed German [i] to the open German [I], I can feel the motion of my tongue. The tip of my tongue stays where it is, gently touching my bottom front teeth. The blade of my tongue stays arched high, but the middle of my tongue lowers slightly. I practice alternating between [i] and [I] multiple times, feeling the motion of my tongue. The motion doesn't feel stiff or rigid, but free and liquid. I feel that I can*

alternate between these two vowels without experiencing any tension in my tongue or jaw. I want to focus now on the closed [e] and the open [ɛ]. I place my tongue in the [i] position that I already feel comfortable with. I feel the blade of my tongue high and the tip of the tongue resting on my bottom front teeth. I'm going to transition to the [e] vowel now. I feel the tip of my tongue stay in the same place, resting on my bottom front teeth. I feel my jaw lower slightly. The blade of my tongue lowers very slightly, gently resting right behind my upper canines. I want to practice going from [i] to [e] a few times so I can become familiar with how subtle the change is in the position of my tongue and jaw. After a few repetitions, I notice that my articulators are moving freely and without any tension or rigidity. Now I feel ready to practice going from [e] to [ɛ]. As I transition from [e] to [ɛ], I feel my jaw lower. The blade of my tongue lowers slightly from the palate due to the lowering of my jaw. The tip of my tongue stays behind my bottom front teeth. I notice that the motion between [e] and [ɛ] is very small. I can make this transition easily with my tongue staying loose and my jaw staying released. In both the [e] and [ɛ], I notice that my lips are subtly rounded, but not tense or tight. They still feel natural and relaxed. The next vowel I need to practice is the [ɑ]. To go from [ɛ] to [ɑ], I know that my jaw doesn't have to lower anymore, so it can stay stationary without being tight or rigid. I also know that the shape of my lips doesn't have to change. Thinking about my tongue, I am aware that the tip of my tongue stays in its resting position behind my bottom front teeth. This means that to go from [ɛ] to [ɑ], the only real change occurs in the blade of my tongue. I feel the arch of my tongue lower slightly. Because of this, I feel the contact point of my tongue blade on my teeth move further back in my mouth. This feels like a slightly larger motion than any of the vowel transitions I've practiced yet. I still feel a sense of liquidness, which means my tongue isn't tight or experiencing tension. I'm aware of the motion of my tongue on the palate. that I feel comfortable with the transitions of the front and central vowels, I am going to practice the German back vowels.

This performance script describes in detail the changes felt when transitioning between front vowels in German. This script may be altered to account for back vowels and the ich-laut and ach-laut. Note that it identifies specific parts of the articulatory system and describes the motion of each of them. Though admittedly long, the details included in this performance script will aid in creating more vivid mental images of the proper articulatory posture of each front vowel sound in German, as well as how to fluidly transition from one to the next. These mental images will enhance the synapses associated with articulation in German Lyric Diction, leading to more

efficient and aurally accurate singing. This script should be altered for use with French and Italian Lyric Diction, but the process will remain similar.

Detailed Anatomical Diagrams for Articulation

The use of detailed anatomical diagrams for articulation stems from their use in rehabilitation of patients with aphasia or who have suffered a stroke. In both circumstances, patients can regain some of their speech ability after using such diagrams. Just as in both of these therapeutic situations, the use of detailed anatomical diagrams for articulation in singing is most effective when it is also paired with third-person observation, teacher-directed imagery, and/or attentive listening, which is addressed below.

Successful use of detailed anatomical diagrams for articulation should begin with observation of diagrams of the entire articulatory system. This allows the observer to fully comprehend where each structure lies within the vocal tract. The example diagrams below are not language-specific, and they only include depictions of articulatory postures for commonly sung vowels. Anatomically detailed diagrams of the articulatory structures for the production of consonants, fricatives, and mixed vowels can be found in the appendix.

Before looking at specific articulatory postures for various vowels, a singer first needs to be familiar with the anatomy of the articulatory structures. Figure 37 represents a sagittal view of the vocal tract and articulatory structures.

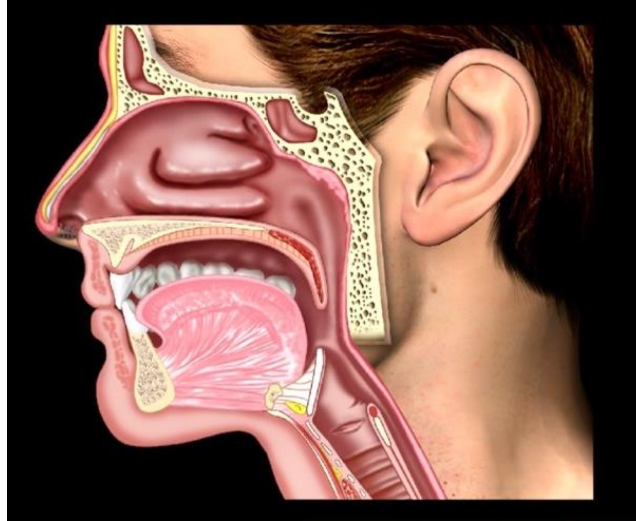


Figure 37: Head Anatomy. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

Here the tongue, hard and soft palates, teeth, lips, pharynx, and nasal cavities are all in natural resting position. In this position, the tongue is lying flat along the bottom of the mouth. The soft palate is lowered, showing a connection between the oropharynx to the nasopharynx, and the teeth and lips are closed. Figure 38 shows how the articulatory postures change for specific vowel pronunciations.

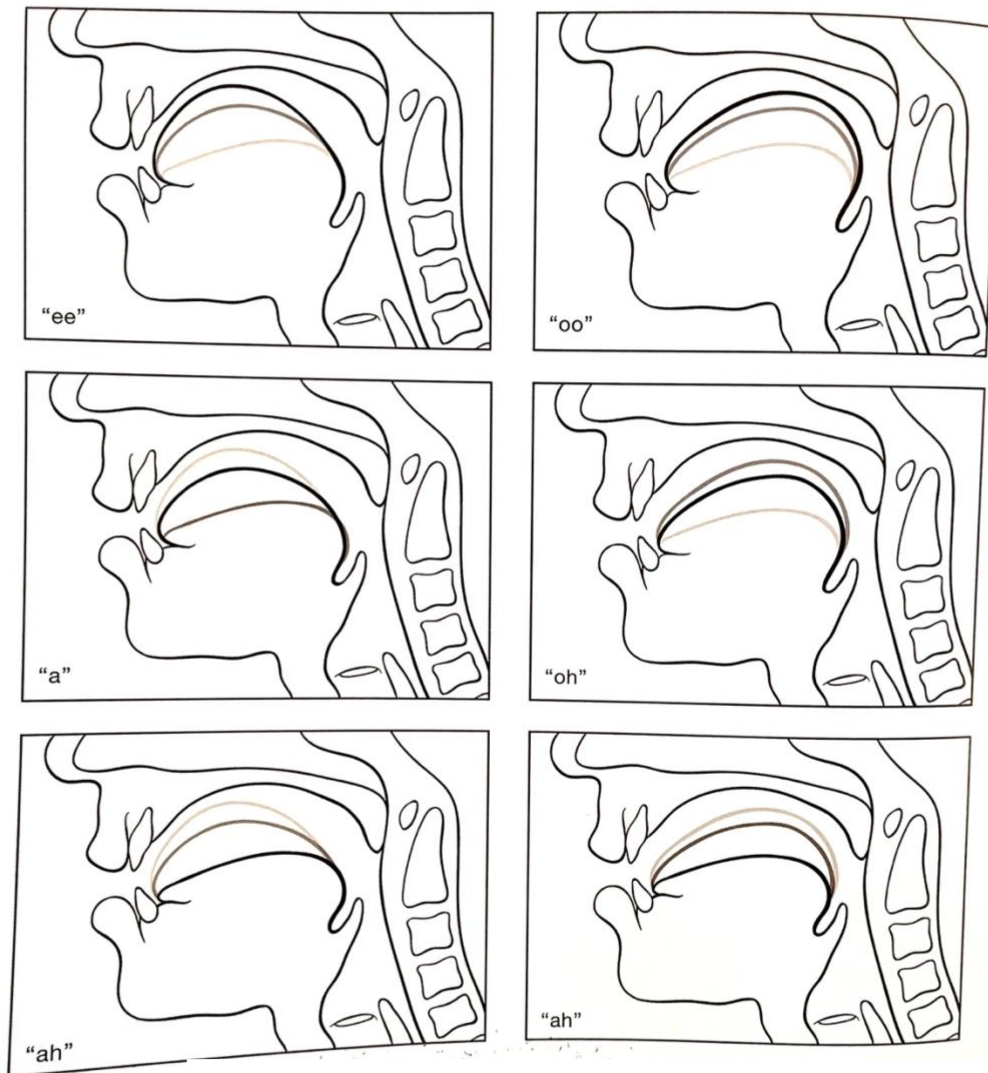


Figure 38: The position of the tongue determines the kind of vowel that is produced. The left column shows "front" vowels and the right shows "back" vowels. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 70.

In Figure 38, it is easy to observe the variations in position of the tongue for all of the vowels, especially the variation of the forward tongue arch for the "front" vowels (located on the left) and the tongue arched further back for the "back" vowels (located on the right). Although this diagram offers a comparison of tongue posture from vowel to vowel, it is nevertheless missing some important information in vowel production and articulatory posture, such as the position of

the lips, teeth, and variation in the pharynx. Figures 39-45 are exemplary diagrams in this respect, because they have colored indicators that show the variations of position of the articulatory structures for specific vowels.

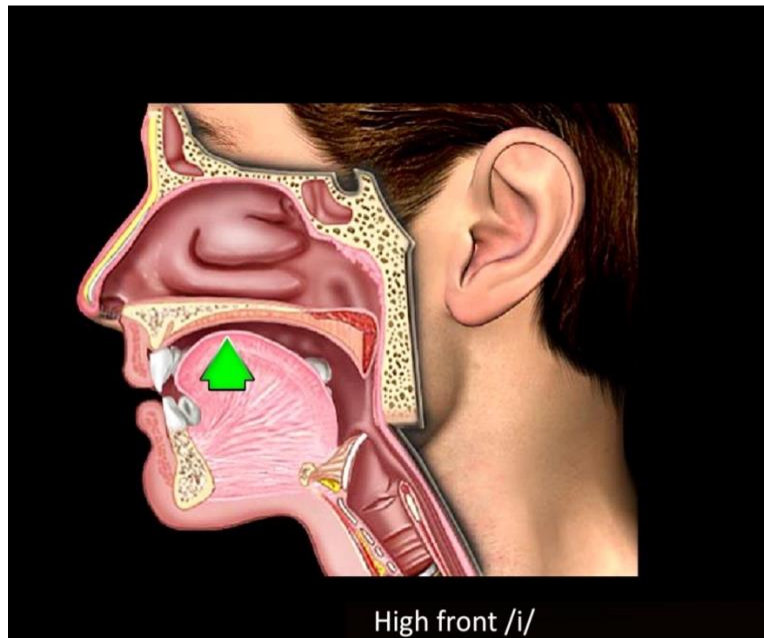


Figure 39: High front [i]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

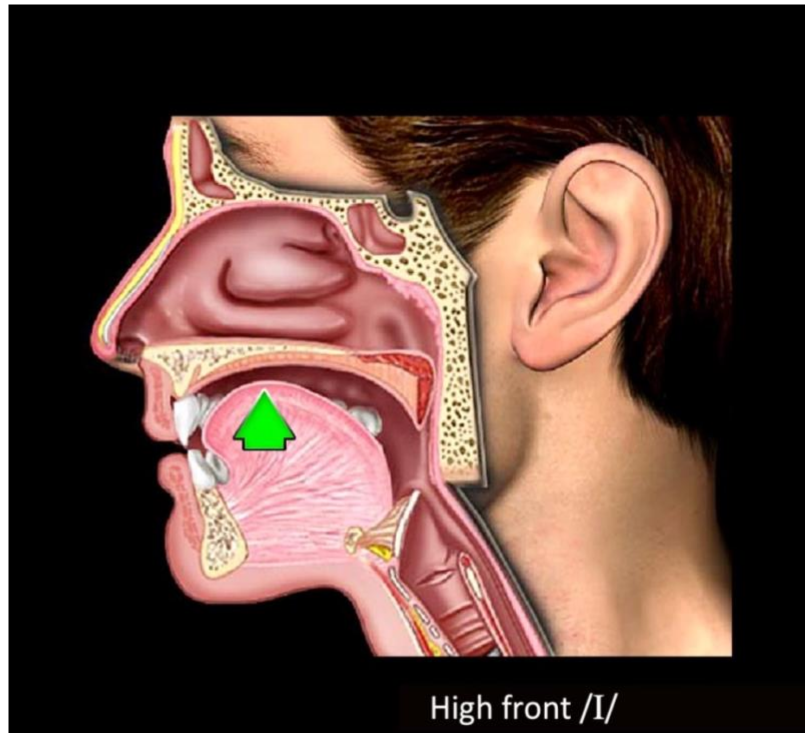


Figure 40: High front [I]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

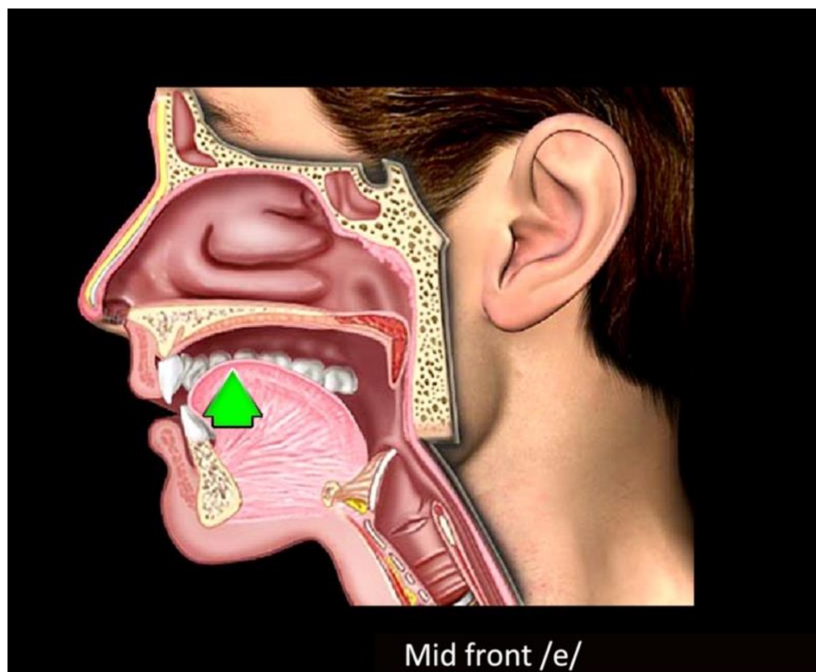


Figure 41: Mid front [e]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

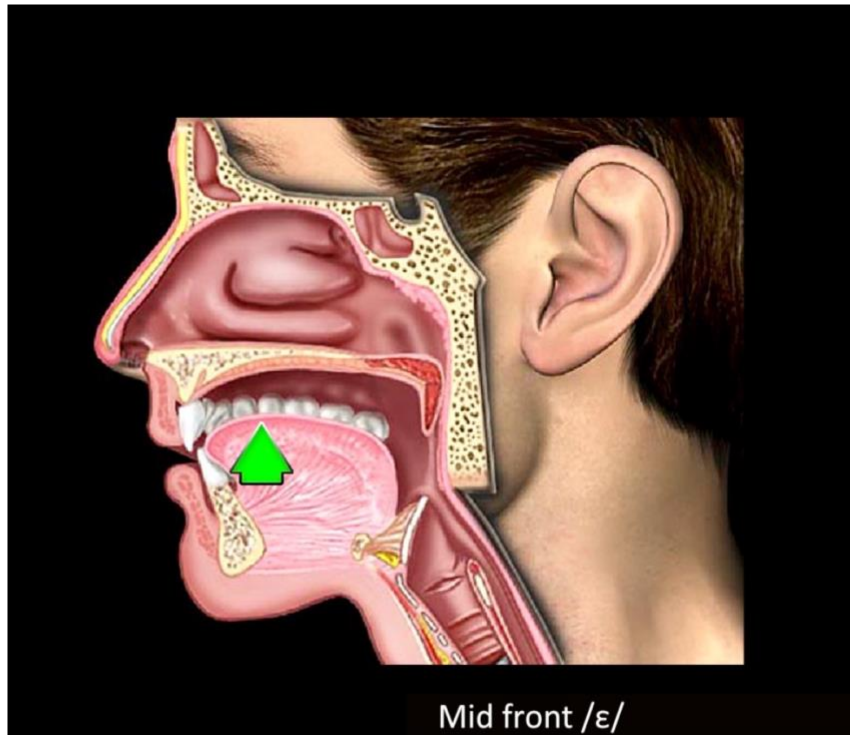


Figure 42: Mid front [ɛ]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

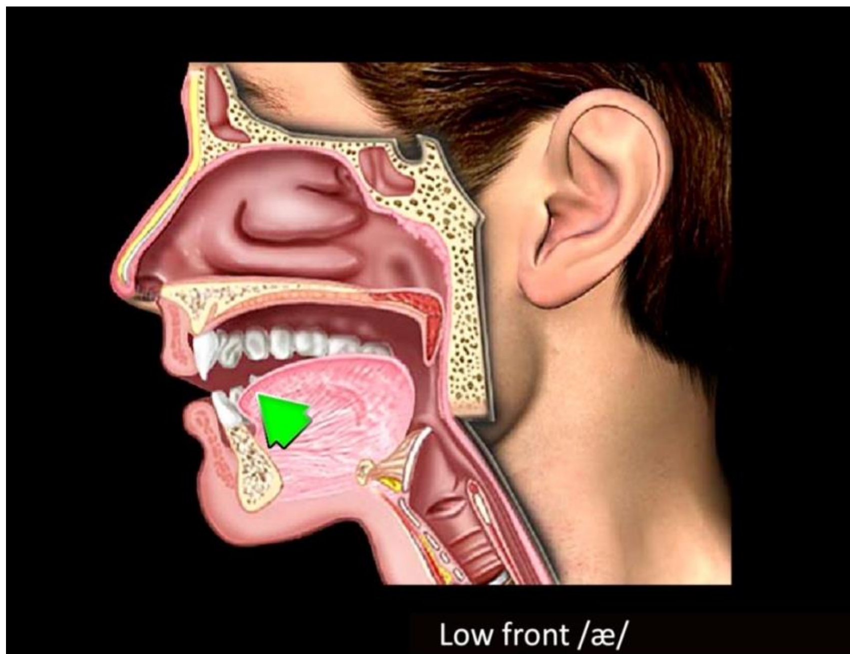


Figure 43: Low front [æ]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

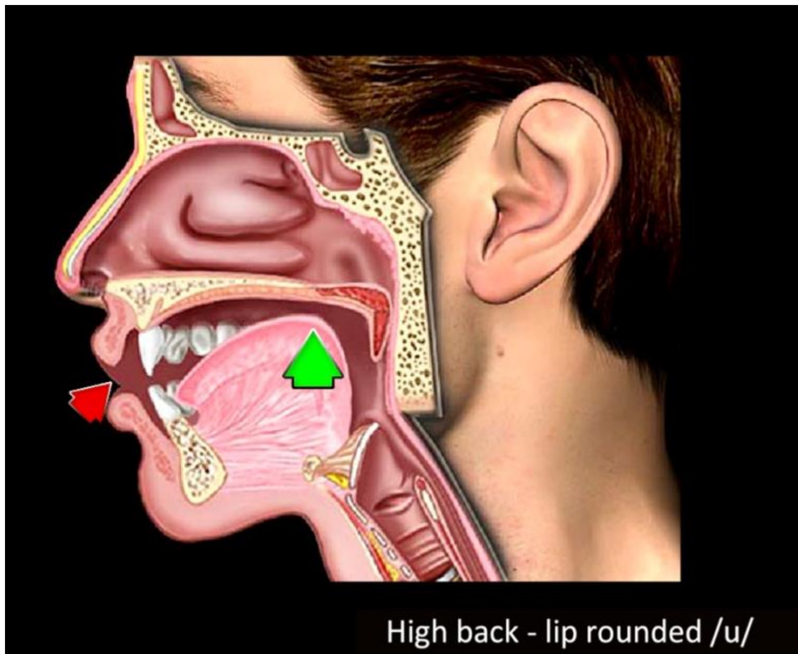


Figure 44: High back – lip rounded [u]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

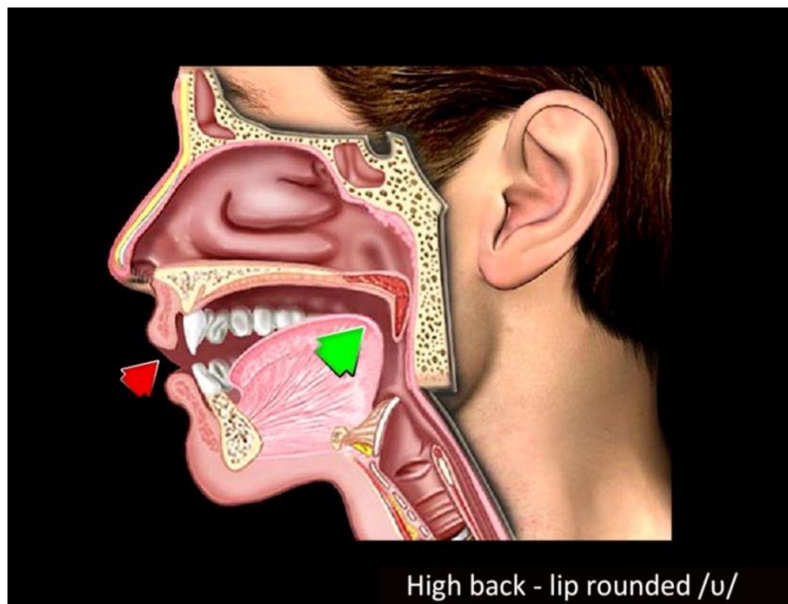


Figure 45: High back – lip rounded [ʊ]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

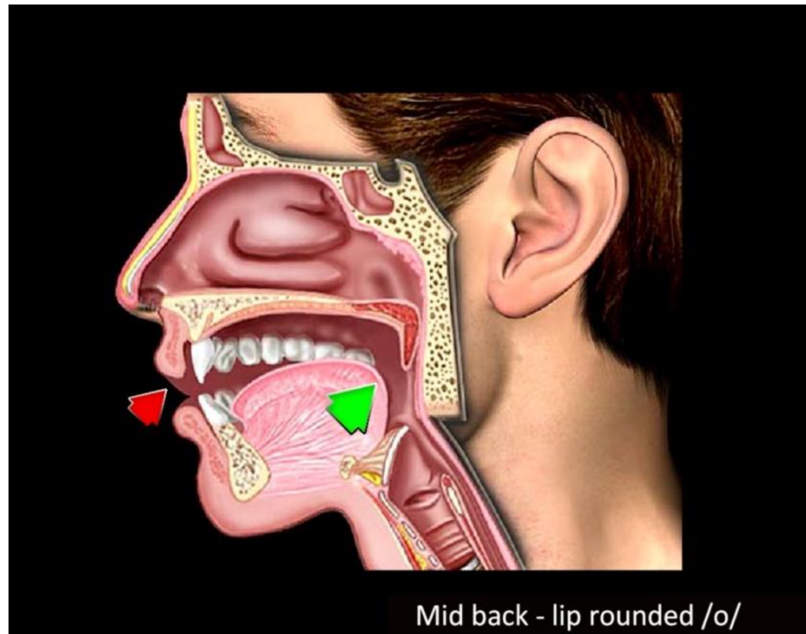


Figure 46: Mid back – lip rounded [o]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

In each of these diagrams, the green arrow shows the position of the tongue for the listed vowel. The tongue is either arched high, mid, or low, and front or back. Any combination of these tongue arch positions creates a different vowel sound. Additionally, in the diagrams depicting the [u], [ʊ], and [o] vowels, the red arrow indicates the rounding of the lips, and a slightly observable protrusion of the lips is indicated.

Studies of the rehabilitation of patients suffering from aphasia show that observation and focused study of these articulatory structures enhances mental imagery of the articulatory postures. This process encourages more efficient recall and activation of the synapses and motor sequences for the vocal-motor task of producing individual vowel sounds. We can apply basic principles of this therapy to the study of singing and foreign language diction as an effective way to practice articulation mentally, on the way to producing more authentic-sounding pronunciation in foreign languages.

Mental Imagery for Articulation

There are seemingly fewer well-known tools of mental imagery for use in the accurate positioning of the articulators. Some of the mental images used to improve articulation have already been mentioned in connection with the performance script and in the preceding section on detailed anatomical diagrams, and additional images will arise in the following sections on teacher-directed mental imagery and attentive listening for articulation. Let us pause here to review a few of the images associated with articulatory posture. It is important to note that the most successful incorporation of these mental images will follow physical use of these tools in practice. This will allow the singer to have a more accurate idea of what these mental images actually feel like and represent.

Most singers are familiar with the size and shape of a wine cork. Wine corks can serve various purposes in aiding efficient singing technique, but this section will focus specifically on the use of a mental representation of a wine cork to aid in learning appropriate articulatory posture. Picture a wine cork: a long cylinder, that is, a cylinder smaller in diameter than it is long. For the purpose of articulation, a singer should envision the smaller, flat, round side of the wine cork between the lips. This mental image immediately prompts the motor sequence of forming the correct posture for an [o]. I have already explained that certain vowels cause the jaw to lower and the lips to elongate slightly. A singer can simply imagine that they are loosening the lips and jaw to allow the wine cork to now hang from the mouth instead of being securely in the mouth. This mental image prompts the motor sequence to lower the jaw and elongate and relax the lips, which is part of the correct articulatory posture for [ɛ], [a], [ɔ], and [ʊ]. Note that the other part of the correct articulatory posture, and what deciphers each specific vowel, is the position of the tongue. However, the simple image of holding and changing the position of a

wine cork in the mouth effectively prompts the motor sequence for the lips and jaw to form the correct position of any specific vowel.

Here is another helpful image involving a wine cork: in this case, the tip of the tongue rests on the bottom edge of the wine cork that is resting in the lips. If the cork is just slightly inside the mouth (resting gently between the teeth), a singer can imagine that the tip of the tongue is gently touching the edge of the cork, positioning itself properly behind the front teeth without pressing or feeling like it is being held in that position. Recall that nearly all vowels are produced with the tip of the tongue resting at the bottom front teeth; this image can be helpful with vowel articulation.

It is also helpful to think of a wave when envisioning or mentally practicing articulation. The dorsum of the tongue arches forward, mid, or back and at varying heights depending on the vowel. The transition between vowels is often when tongue tension begins to cause noticeable problems in a singer's tone production. Picture a wave: typically waves grow higher and have a larger peak as they approach the shore (before they crash). After a wave crashes, it begins to return out to sea. When it returns out to sea, the wave is at a much lower level than it was during its approach to the shore. Note, however, that at no point does a wave stop moving or become stiff; waves always move in a fluid motion without rigidity. This image can help a singer picture the motion of the tongue for vowel changes, as the tongue moves forward and back in the mouth to create different vowels. Regardless of whether the tongue is moving forward with a high arch, [i], or backward with a mid-low arch, [o], the tongue always moves in a fluid motion. Even when the tongue arrives at the proper position to produce the next vowel, it is crucial that the tongue is not pressed into this position or held in this position with rigidity. The tongue should always have a sense of fluidity to it, like a wave.

Another image that can be used to assist in creating a mental image for specific vowels, specifically those with a high tongue arch, is the mental image of a chopstick. Picture a chopstick: a long rod typically made of wood, cylindrical in shape with a very small circumference and diameter. Imagine holding the chopstick perpendicular to the face, so that each point of the chopstick lines up with the ears. Next, imagine releasing the jaw enough to allow the chopstick to slide backwards between the top and bottom teeth so that it can rest about one or two teeth behind the bottom canines. To practice vowels with a high and forward tongue arch, such as [i], imagine raising the tongue over the chopstick and arching the tip of the tongue down behind the bottom front teeth. Although it is not easy to sing with a chopstick in the mouth, this mental image allows the singer to picture just how high the arch of their tongue needs to be for the [i] vowel.

Another simple concept (not an image as such) that prompts activation of motor sequences is "dumb jaw." Many singers are familiar with this phrase, which simply refers to a dropped and relaxed jaw position. Simply reciting the words "dumb jaw" internally when mentally practicing articulation fires the same motor neurons that are associated with the physical action of dropping the jaw.[119]

As previously explained, much of the known mental imagery for articulation has to do with creating accurate mental representations of specific articulatory postures with the aid of detailed anatomical diagrams or a detailed performance script that makes reference to the position of each articulator. Beyond the tools outlined in this section, there is additional mental imagery that can be used when properly directed and taught in the voice studio by an experienced teacher.

---

119 Helding, *The Musician's Mind*, 114.

Teacher-Directed Mental Imagery for Articulation

In the voice studio, teachers provide visual and verbal cues to help students experience new sensations pertaining to articulation in the moment. Additionally, students can take these visual and verbal cues and store them as mental images in the schema associated with specific articulatory postures. Although motor learning shows that concurrent feedback isn't particularly beneficial to long-term learning, succinct verbal and visual feedback directly preceding or following a student's performance in a lesson positively impacts long-term learning.

In the studio, numerous teachers use hand gestures next to the mouth to imitate the position and arch of the tongue. These are simple and relatively quick visual cues that allow students to refine the mental image that already exists for a specific vowel. If the tongue needs to be more arched and forward, the teacher simply arches the hand more, rolling it forward toward the front of the mouth. If the student is attentive and focused on the teacher's feedback during the lesson, then during mental practice of a particular vowel or phrase in any given language the student will likely be able to envision the teacher demonstrating the position of the tongue using the hand. It is also helpful for the purposes of subsequent mental practice if the student imitates the teacher's demonstration during the lesson. This imitation will consolidate the mental representation of the necessary tongue position. Not only will the student be able to visualize the teacher's demonstration, but they will also be able to visualize their own physical practice. By visualizing the teacher demonstrating, then visualizing themself demonstrating, the student has now activated the motor sequence being practiced twice, rather than just once.

Another effective tool used in voice studio instruction to enhance a student's mental representation of certain vowel shapes is the tracing of the lips. This method is often used in choral settings, as well. As in the previous example with the arching of the hand, this feedback

can be given while students are singing, but it is more effective directly before or after a student has just performed. This method of modeling involves teachers using their fingers to directly trace the shape of the lips for specific vowels. For example, if the vowel being sung is an [o], the teacher traces the shape of an [o] with one finger around the lips. This method involves being very specific regarding the size and shape of the tracing and of the lips. If the teacher wants to demonstrate an [o], but is tracing a wider shape than is necessary, this method is ineffective. Another example of this method is the demonstration of the [u] vowel. Although the shape of the lips is quite similar to the [o] vowel, the lips are in a slightly smaller position, so the teacher demonstrates this with lip tracing. Additionally, for the [u] vowel, the teacher can indicate to the student that this particular vowel has a more forward, ringing sensation. To show this visually, the teacher traces the round [u] shape of the lips but asks the student to imagine that the [u] vowel is tied to the pointer finger by a thin string. The teacher then pulls the thin string directly away from the mouth, indicating a more narrow, forward direction for this vowel than the previously mentioned [o] vowel.

Other methods for teacher-directed mental imagery include having the teacher directing the student to imagine small objects, such as a Hershey's kiss or a Werther's caramel, in the mouth on the tongue. Such teacher-directed imagery indirectly impacts the student's soft palate and tongue. To use the image of a caramel (or any other hard candy) on the tongue properly, the teacher should ask the student to imagine a caramel resting on the middle of the dorsum of the tongue. The teacher should then direct the student to imagine keeping the caramel stable on the tongue even as the tongue moves between vowels. This image encourages a more fluid and liquid tongue movement, rather than a movement that is abrupt and rigid. Using a Hershey's kiss, the teacher asks the student to imagine placing the Hershey's kiss on the mid-back of the dorsum

of the tongue. The ultimate goal in this image is to elevate the soft palate regardless of the position of the tongue so that the palate doesn't break the tip of the Hershey's kiss. These are both effective methods of mental imagery because nearly every student is familiar with Hershey's kisses and caramel candies (or other hard candies). This form of teacher-directed mental imagery incorporates the use of familiar sensations to aide in the formation of a more specific and detailed mental image of articulatory posture. If students can picture the mouth shape for a vowel, they will be more successful in both the mental and physical practice of said vowel.

Teacher-directed mental imagery for articulation is extremely helpful because it teaches the student not only how to properly form vowel sounds, but also how to envision the structure of the vowel sound. If students are able to envision specific articulatory postures, mental practice using more detailed mental images will have a greater impact on the motor sequences for articulation. Teachers are responsible not only for teaching the student how to sing, but how to practice, both physically and mentally.

Third-Person Observation for Articulation

Third-person observation to enhance articulation and retrain speech patterns has been used successfully for years in rehabilitation of patients who have suffered from strokes or patients with aphasia.[120] The principles of this technique can also be applied to articulation for the art of singing. Students of singing are often required to take diction classes or coachings with voice coaches who are highly trained and specialized in producing authentic articulation in various foreign languages. In these coachings, the instructor often offers detailed anatomical

120 Kendall et al., "Phoneme-Based Rehabilitation of Anomia in Aphasia," 8.

diagrams and various mental images as outlined above, but there is another significant benefit to these individual or classroom diction and articulation settings in the form of third-person observation. As with many motor tasks, third-person observation of a motor task has been shown to activate the mirror neuron system. The mirror neuron system sends electrochemical messages along the same neurons and motor sequence pathways as physical execution of the observed skill, provided that the skill under observation is already in the observer's motor repertoire.

When working on articulation for an aria in German, for example, a singer first writes in the IPA (International Phonetic Alphabet) symbols that were taught in diction class. Then, the singer practices these sounds, combining vowels and consonants to form the German sounds. The more the student practices, the more fluid the formation of the German language sounds become. However, many students believe that they are producing the correct foreign language sounds, when instead are producing a sound that is only close to the correct one. This is where third-person observation becomes most useful.

As an example, let us take a hypothetical non-native German speaker. A young singer often produces the German schwa, [ə], in the same manner as the schwa in spoken English. In many cases, this pronunciation is narrow, with a raised jaw and neutral, unrounded lips. However, in speaking proper Hochdeutsch, a speaker would pronounce the neutral vowel, [ə], with a lowered, released jaw, lips protruding slightly forward, and the corners of the lips slightly closer together, almost in the same position as the [ɛ] or [ʊ] vowels. When a young native English speaker observes (both visually and aurally) a native German speaker producing this neutral vowel, the motor/mirror neuron system activates in Broca's area because of the visual and aural external stimuli. Broca's area is associated with and active in articulation and speech formation. This activation recalls information from the schema associated with the German [ə]

vowel. The observer is likely to notice variations in the position of the singer's articulators from their own, which are important in helping refine the motor sequence pathway associated with the production of this vowel sound. As the observation continues, this motor sequence continues to fire in the brain, wrapping the neurons in more myelin and strengthening the pathway. It is likely that the next time the singer physically produces this vowel sound, it will be closer in articulatory posture and sound to the vowel produced by the native German speaker. Although the motor/mirror neuron system is activating the areas of the brain associated with articulation and speech production during this process, a singer is not actively aware of the activation; rather, they are only aware of the effects of said repeated activation. In other words, a person who is actively studying German language pronunciation will notice positive changes in articulation of accurate German sounds because of the activation of the motor/mirror neuron system even though they aren't aware of the brain activation while it is occurring.

This process then repeats any time a singer watches a video or live performance of a singer performing in any language. There are many videos of singers performing art songs and arias available on the internet, and some of them can be used to help a singer learn to articulate more effectively in a foreign language. However, significant caution is warranted in using such resources, because with so many videos of varying quality it is all too easy to find a singer whose articulation is poor. The mirror neuron system is non-biased in regard to the quality of the articulation being observed. If the observer is watching a video where the performer uses poor articulation, the mirror neuron system will still activate and will continue to wrap myelin around the motor sequence for specific articulations. However, now the incorrect articulatory posture is being strengthened in the schema. Here teachers must intervene to make sure that the student can both see and hear the differences between proper and improper articulation. Although there are

many well-trained singers from various parts of the world publishing videos of performances on the internet, there is no substitute for listening to a foreign language piece sung by a native speaker of that language.

Third-person observation can be effective whether the observer is observing in person or whether they are watching a video recording. The most important element in the success of using third-person observation for mental practice of articulation is that the observer is able to clearly see the articulators of the performer. Third-person observation for mental practice of articulation also incorporates attentive listening, and attentive listening can also be used as a mental practice method without visual observation to enhance articulation.

Attentive Listening for Articulation

Attentive listening for mental practice of articulation requires that the listener first establish a sense of mindfulness and heightened awareness in a location free from distraction. Once the listener has found such a location and entered a state of mindfulness, they may use a variety of recordings for mental practice, such as performance recordings, studio recordings, recordings of rehearsals/lessons, recordings of diction coachings, and recordings of spoken text.

The following step-by-step guide provides a generalized routine to incorporate attentive listening for articulation into a successful mental practice routine.

1. Find a quiet room or place free from all distractions.
2. Briefly close your eyes, eliminating all extraneous stimuli.
3. Focus your attention on a specific ambient noise, attempting to make that noise the only thing you hear.
4. Once your mental state has been aroused and your awareness heightened, open your eyes briefly to turn on a recording. Try to only open your eyes enough to see the device that the music is coming from, keeping your eyes in a sort of haze.
5. Once you have started the music, close your eyes again. You should devote all your attention and energy to listening.

6. Once the singer begins singing, listen intently to the sounds.
7. First, focus on a specific phrase. Choose a phrase that you are familiar with so that you are better able to decipher the text.
8. As you are listening to articulation of the text, can you describe it? Are you able to imagine what shape their lips are in? Does it sound like their tongue is forward and high (bright sound) or back and down (dark sound)? Does the text sound legato or more staccato and choppy?
9. Pay close attention as the singer continues. Do you notice general qualities about the sounds they are articulating? Do they continue in a legato manner, or does the quality of delivery change? Do all the vowels sound equally bright or dark?
10. Does it sound like the singer is working hard to produce these sounds or does the articulation sound free and fluid?
11. Are there any general observations? Does the amount of articulation change as the range or tessitura changes? What about the shape of the mouth? The release of the jaw? Does it sound more elevated or lowered?
12. Listen as the singer continues through the entire piece. As you are listening, try to imagine what they are doing physically to produce the articulation so that it sounds authentic and free. Can you imagine how the lips are shaped? Are they relaxed? Are they rounded? Are they protruding forward or are they in a neutral position? Can you imagine how dropped or raised the jaw is? Can you imagine the amount of space between the teeth at both the front and back of the mouth? Can you imagine the position of the tongue? Is it arched high or low? Is it arched more forward or more back?
13. As you are creating a mental image of the singer's physical position for each specific sound, try to be as detailed as possible, imagining every specific detail.
14. Keep your eyes shut for a few seconds after the recording ends.
15. During the silence, allow yourself to focus intently on the sounds and articulation you just observed.
16. After you feel that you have formed the most detailed mental and aural image possible, open your eyes.

This attentive listening guide establishes a sense of mindfulness and attempts to place the mind in a state of arousal by eliminating extraneous stimuli. The remaining steps focus on guiding the listener in creating the most vivid and detailed mental and aural image possible so that it can be stored and associated with the motor sequences for articulation when needed for physical practice or performance. Because of the mirror neuron system, listening attentively to the articulation of a singer performing a piece of music in the listener's repertoire engages and

activates the actual motor sequences involved in physical execution. This engagement causes increased myelination of the neurons involved in this sequence, which will make physical practice of this skill more efficient.

Conclusion

Articulation is an involved and active system that relies heavily on the interaction and coordination of the lips, tongue, soft and hard palates, and teeth. It is crucial that a singer practice articulation physically on a regular basis to ensure muscle coordination and freedom. But a singer need not limit themselves to physical practice, and the addition of well-designed mental practice exercises such as mindfulness exercises, including detailed and language-specific performance scripts, can help in forming stronger mental representations to enhance physical execution of articulation. Detailed anatomical diagrams of the position of the articulators in various positions for differing vowels and various techniques of mental imagery can also support existing mental representations or schema for singing in foreign languages. And third-person observation of articulation and attentive listening activates the mirror neuron system, which effectively myelinates the neurons of the motor sequences for articulation, enhancing the fluency and ease of recall in later physical practice.

Ultimately, articulation is an important element of singing, particularly in the classical style. Not only can mental practice of articulation enhance more authentic language production, but proper articulatory positions also result in more freely produced, ringing resonance. The ability to effectively alter articulatory position relies heavily on mental practice. If the articulators are not in optimal position for a specific vowel, the resulting sound will likely lack ring. The incorrect position of the articulators is largely a result of an incorrect message being

sent from the brain through the neural pathways for articulation. For example, in Western classical styles, articulatory position for the [i] vowel requires a higher, more forward arch of the tongue. If the tongue does not fully arch forward, the vowel will be incorrect (more of an [I]), and the sound will lack ring. The incorrect position of the tongue is caused by poor messaging from the brain to the articulators. However, by using exercises and methods outlined here, a singer can create more detailed mental representations of accurate articulatory positions. They may then recall these representations, sending more accurate messages through more myelinated neural pathways, resulting in more accurate vowel production and a freer, more resonant tone.

Chapter Eight:

Mental Practice for Resonance

According to McCoy, resonance consists of "the intensification and enriching of a musical tone by supplementary vibration."[121] Intensification refers to the amplification of sound and enrichment refers to the change in timbre. The supplementary vibrations mentioned are the vibrations of something beyond the source, meaning vibrations that are caused as a result of vibration at the source (the vocal folds). These two components work cooperatively in the system of resonance, because the sound being produced by the vocal folds is amplified or enhanced throughout the vocal tract, which is what causes sympathetic vibrations. To put this another way, with Ragan, "resonances of the vocal tract turn the 'buzzing' sounds produced by the vocal folds into a beautiful and intelligible vocal quality."[122]

As sound waves travel through the vocal tract, some of the energy leaves the vocal tract through the mouth (producing a sung sound), while some of the energy returns to the vocal folds. These resonances that return back affect the vibration of the vocal folds, either strengthening or disrupting the vibratory pattern. When resonance is produced in an efficient and optimal manner during singing, it creates acoustic energy that helps the vocal folds vibrate more freely, leading in turn to easier singing.[123]

A singer can affect their resonance by altering the shape of the vocal tract by control of specific muscles. The vocal tract consists of the larynx, pharynx, mouth, and nose. The vocal tract also houses the articulators which, as previously discussed, are moveable and can be consciously controlled. Because the articulators lie within the vocal tract, they have a significant

---

121 McCoy, *Your Voice: An Inside View 3*, 47.
122 Ragan, *A Systematic Approach to Voice*, 195.
123 Ibid., 196.

effect on resonance and the quality of sound because of their ability to change the shape of the vocal tract.

Nearly all singers in classical and contemporary vocal styles aim to achieve vocal ring, or resonance, in their singing. If they achieve the desired resonance, they can produce high-intensity sounds with less vocal effort, leading to more sustainable singing. In classical singing, a singer most often achieves vocal ring by means of manipulating the *singer's formant clusters*, whereas in contemporary styles, they achieved it instead by means of *twang*. These terms are explained below.

The singer's formant cluster is created by grouping the third, fourth, and fifth vocal tract formants tightly together within a narrow frequency range. The location and position of the tongue, shape of the lips, and opening of the jaw are the most important factors in determining which formants are enhanced.[124] All of these articulators change the shape of the vocal tract, which causes changes in formant frequencies in turn. Specifically, the singer's formant cluster is achieved by narrowing the epilarynx (part of the space between the vocal folds and the epiglottis) and widening the pharynx. This narrowing of the epilarynx within the larger pharynx becomes a resonator within a resonator, which boosts the harmonics in the singer's formant.[125] In addition to the narrower epilarynx and the wider pharynx, the point of exit of the vocal tract (the lips) must be significantly smaller than the rest of the vocal tract. This configuration explains why students of classical singing often learn to think of the vocal tract being in the shape of a reverse megaphone. Finally, the singer's formant requires a neutral-low laryngeal position, which lengthens the vocal tract.

124 McCoy, *Your Voice: An Inside View 3*, 67.
125 Ragan, *A Systematic Approach to Voice*, 199.

In contemporary vocal styles, a singer achieves vocal ring through the use of twang. Twang can be produced nasally, where sound travels through the nasal cavity, or orally, where twang starts in the pharynx and is enhanced through the shape of the mouth and articulators. Specifically, as Ragan writes, "pharyngeal wall narrowing (supralaryngeal area) at the level of the middle constrictor" causes twang.[126] Twang also requires that the articulators, specifically the mouth/lips, to be in a more divergent position. In contemporary vocal styles, this is often thought of as a "megaphone position," precisely the opposite of the position necessary to achieve vocal ring in classical styles of singing. Additionally, the larynx must be in a neutral-high position, effectively shortening the vocal tract. The combination of the narrower pharynx, slightly higher larynx, and wider mouth create twang, enhancing vocal resonance in contemporary vocal styles. Many students find achieving ring in contemporary vocal styles to be much easier because the vocal production is similar to normal speech.

In classical singing and contemporary vocal styles alike, a singer tends to experience resonance in the form of sympathetic vibrations in the "mask," or specific facial tissue. Sensory feedback and physical sensations are thus extremely important to creating, finding, and supporting free resonance.

Additionally, it is important that teachers indicate to students that resonance and focus are not the same. Teachers must distinguish for students that it is not possible to physically "place" the voice in the mouth, nose, or pharynx, introducing the concept of focus in order to help students gain perceptual awareness of where their voices are actually resonating.

Focus, as Ragan writes, refers to a tone or vowel "in order to intensify the brilliance of a given sound."[127] In this technical sense, focus derives from scientific uses of the word, where it

126 Ibid., 201.
127 Ibid.

refers to the manner in which the convergence or divergence of waves of different wavelengths affect their intensity. Since the voice is a product of a series of sound waves, a singer can readily focus the sound waves generated by the vocal folds by imagining the convergence of waves. Focus is a kinesthetic sensation felt by a singer in the "mask" and it differs from resonance, which occurs in the pharynx. Teachers use kinesthetic instructions to help students sense a focused sound. If students are able to focus their sound correctly, they will hear a different resonance than when the focus is not optimal. The term focus helps to elicit mental illusions about the desired tone quality and are often used in voice studios to evoke changes in vocal quality.

Mindfulness Exercises

For the purpose of mental practice for resonance, a singer should begin by establishing a sense of heightened awareness and attentional focus. Unlike the mindfulness exercises presented in previous chapters, those below (drawn from Leigh-Post and Cornett, respectively) do not include a performance script or best-practice script, because resonance is a non-tangible component of singing, and so physical sensations cannot be accurately commented on or described. The sole purpose of the following mindfulness exercises is to establish a sense of focus so that all the subsequent mental practice proves more beneficial.

> If possible, remove your shoes and stand in a room that has windows or doors that may be opened to ambient sound.
>
> 1. Stand at rest, breathing comfortably. We will call this neutral.
> 2. Notice the spaces surrounding you, inside the room and beyond.
> 3. Listen to the sounds surrounding you, inside the room and beyond. What happens when you recall a favorite melody (inner sing)?
> 4. Stand on your dominant leg, placing the toe of your other foot just ahead of you or in a tree pose, if you like. Now shift your weight ever so slightly from what is equalized pressure between the ball and heel of your foot so that about 75% of your weight is on the ball of your foot. Do this

> without lifting the heel of your foot from the floor and maintain easy balance. Try shifting your weight toward the heel of your foot. What changes? What information alerts your conscious mind?[128]

> Find a quiet place where you will not be bothered. You may choose to sit or recline comfortably. If you are worried that you will fall asleep or miss an appointment, set a quiet alarm for 10, 15, or 20 minutes, depending on how long you wish to practice this activity. Close your eyes or direct your gaze downward, and allow your mind and body to settle. You may wish to focus your attention on your breathing for a minute or two as you gradually relax. Begin to imagine the best-possible scenario for an upcoming [practice session]. Include as many details as possible, and as many of your imagined senses as you wish. Remember to affirm all of the positive thoughts and feelings you want to experience before, during, and after this [practice]. Be realistic and optimistic![129]

Notice that neither of these exercises is specific to resonance; rather their inclusion as part of a routine of mental practice is to arouse the conscious mind. This state of mental arousal should lead directly into elements of mental practice specifically tailored to working on resonance.

Detailed Anatomical Diagrams for Resonance

To understand how resonance is achieved and to be able to create vivid mental images that enhance resonance, a singer should observe detailed diagrams of the entire vocal tract. To be effective, these diagrams must show all of the components that impact resonance, including all parts of the pharynx and the articulators. Figure 47 shows a side view of the head and neck. It is clearly labeled to indicate where the vocal folds, laryngopharynx, oropharynx, tongue, hard and soft palates, and nasopharynx are located. Although the lips are not labeled, they are also clearly visible in this diagram.

128 Leigh-Post, *Mind-Body Awareness for Singers*, 11.
129 Cornett, *The Mindful Musician*, 220.

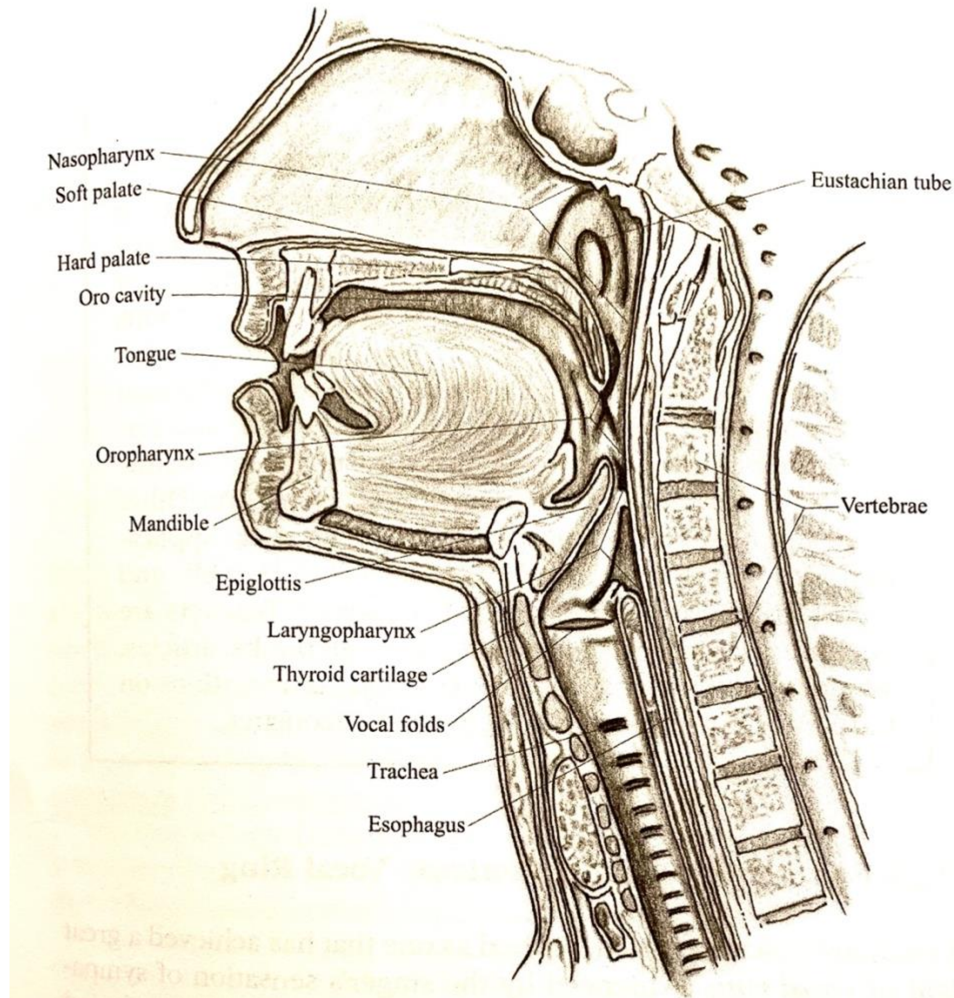


Figure 47: Side view of the head and neck showing cavities important to resonance. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 197.

Looking at this image, a singer should be able to visualize how vibrations are initiated at the level of the vocal folds and then see the path from the vocal folds through the laryngopharynx and into the oral cavity before the sound exits the vocal track by way of the mouth. A singer should also be able to imagine how the sound waves produced by the vibration of the vocal folds bounce off the walls of the laryngopharynx and oral cavity, enhancing and amplifying the sound so that the sound wave is much larger by the time the sound exits the mouth. This visualization

of a sound wave growing also doubles as a visual representation of how resonance works within the vocal tract.

Likewise, a singer of contemporary vocal styles can observe this image and see all of the things listed above, as well as where the sound enters into the nasopharynx. As I have already mentioned above, the nasopharynx plays a role in creating twang, or vocal ring, in some contemporary vocal styles. Therefore, a singer of contemporary vocal styles can imagine how the sound waves are enhanced as they travel from the vocal folds through the laryngopharynx into both the oral cavity and nasopharynx.

For another diagram that is slightly simpler but that still shows all of the necessary components for visualizing resonance, see Figure 48.

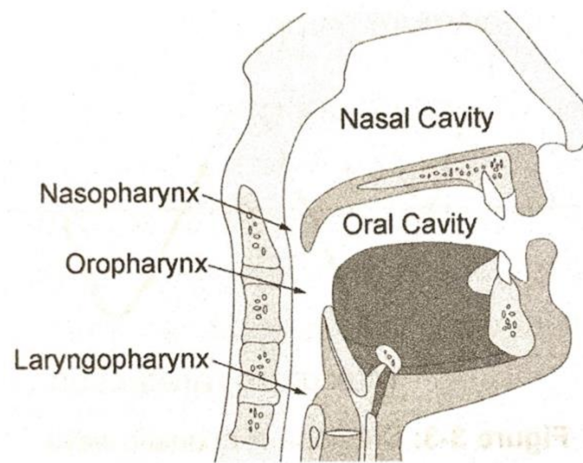


Figure 48: Free resonators of the vocal tract. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 49.

This diagram, although less detailed than the previous image, shows the major components of the vocal tract that are considered in producing free resonance. It should allow a singer to visualize the direction and enhancement of sound waves traveling from the vocal folds (not pictured)

through the vocal tract to either the oral cavity and/or nasopharynx, depending on the desired vocal aesthetic and style.

Because vocal aesthetic and style are important factors in resonance strategy, it is particularly important to recall the differences between achieving vocal ring in Western classical singing and contemporary vocal styles. One of the most significant differences involves the position and shape of the epilarynx, represented in Figure 49.

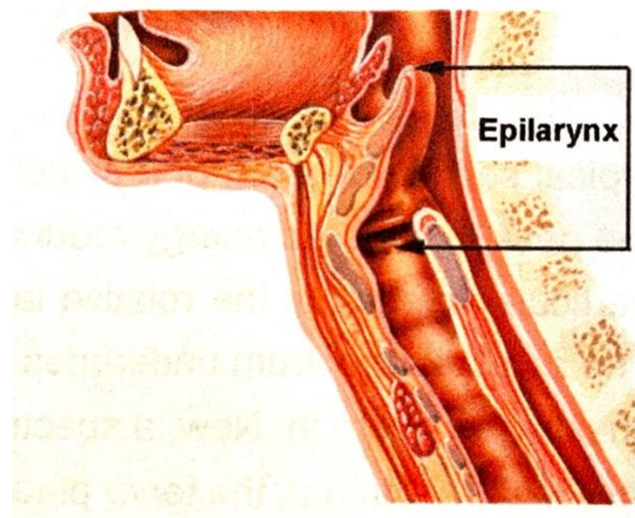


Figure 49: Laryngopharynx. Image reproduced from Scott McCoy, *Your Voice: An Inside View 3*, (Gahanna, OH: Inside View Press, 2019): 75.

In Western classical singing, the epilarynx narrows within the wider pharynx, creating a resonator within a resonator. This narrowing of the epilarynx along with a neutral-low laryngeal position enhances frequencies, creating more vocal ring. In contemporary vocal styles, however, the narrowing that occurs is not specific to the epilarynx; rather, it represents a narrowing of the entire pharynx. This means that while in Western classical singing, the majority of the pharynx is wider aside from the epilarynx, in contemporary vocal styles the entirety of the pharynx is narrowed. According to LeBorgne and Rosenberg, various modifications of the vocal tract affect harmonics and resonance depending on the desired aesthetic: "The three primary ways to alter

the inertive areas of the vocal tract are: (1) modify vocal tract length (altering laryngeal height, and/or jaw/lip/tongue position), (2) modify vocal tract shape (megaphone versus inverted megaphone), and (3) facilitate epilaryngeal narrowing."[130]

When observing Figure 49, a singer of the Western classical style is able to see exactly which part of the vocal tract should be narrowed to activate the singer's formant. In this way, a singer is more likely to be able to create or activate their formant clusters because they know exactly where and how to alter the vocal tract. Engagement of the middle constrictor muscle, which controls the narrowing of the epilarynx, can and should be taught in vocal pedagogy classes and voice studios. A singer who is able to visualize where the epilarynx is located within the pharynx will be more successful in actively engaging the middle constrictor to create the singer's formant cluster.

Figure 50 shows an endoscopic view of the larynx and surrounding structures in differing positions for both Western classical singing and contemporary vocal styles. In this image, the white line shows the position of the pharyngeal wall, which affects resonance and varies with the chosen vocal aesthetic.

130 Leborgne and Rosenberg, *The Vocal Athlete*, 307–308.

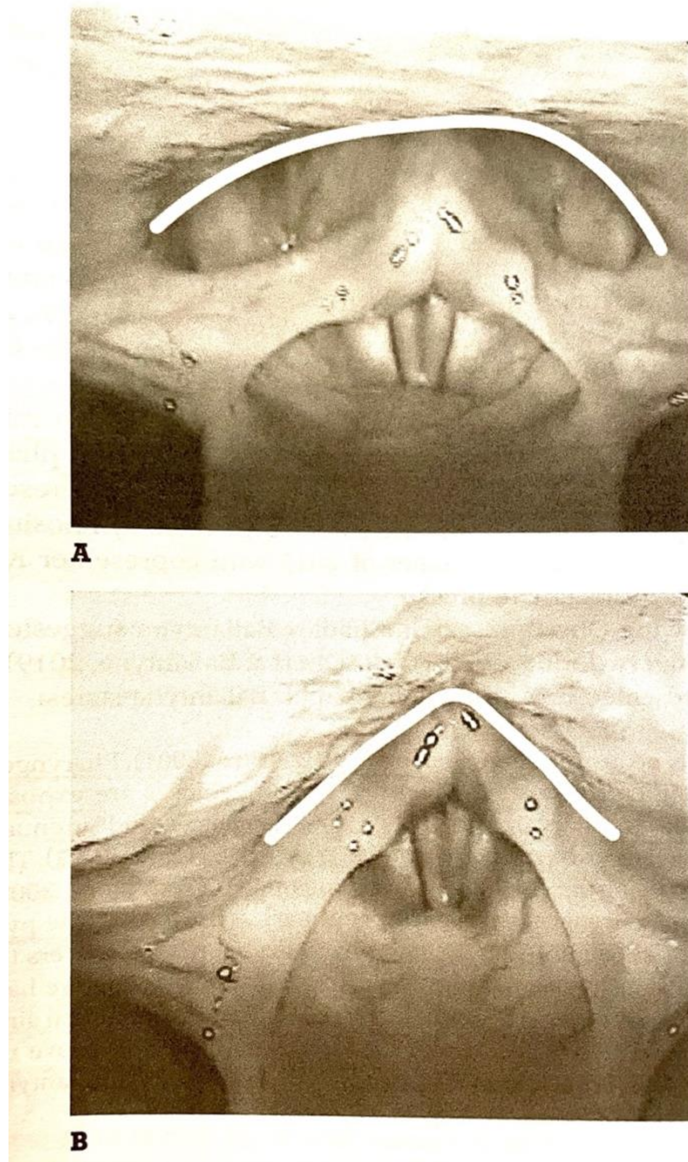


Figure 50: Endoscopic view of the larynx and surrounding structures. Image reproduced from Kari Ragan, *A Systematic Approach to Voice: The Art of Studio Application*, (San Diego, CA: Plural Publishing Inc, 2020): 202.

In the upper image of Figure 50 (A), the pharyngeal wall is wider, as shown by the arched white line. Also visible in this image are the open pyriform sinuses. The open sinuses and wider pharyngeal wall indicate that this is an endoscopic view of vocal production and resonance in a Western classical aesthetic. In the lower image (B), the pharyngeal wall is narrower, seemingly peaked at the back of the larynx. This narrow position of the pharyngeal wall (and thus of the

entire pharynx) indicates that this is the position for vocal production and ring in a twang aesthetic, common to contemporary vocal styles.

This diagram and others like it are important for observation because a singer has the ability to actively change the position and shape of the vocal tract to achieve different vocal aesthetics. These changes can also be physically felt. When mentally practicing, a singer should first decide the vocal aesthetic necessary for the piece or exercise they are practicing. Once the vocal aesthetic has been established, a singer must visualize the position of the vocal tract. Through visualization in this manner, they activate the motor sequences controlling the widening and narrowing of the pharynx and epilarynx. If a singer visualizes a narrower pharyngeal space for contemporary vocal styles, the associated motor sequence will fire and be wrapped in more myelin, and likewise for a wider pharynx and narrow epilarynx in a Western classical aesthetic.

Once a singer is able to produce accurate and vivid mental images of the structures of the vocal tract that impact resonance, it becomes important that a singer be able to visualize where they might experience sympathetic vibrations when actually singing. As mentioned earlier, the facial tissues where a singer might feel or experience sympathetic vibrations when optimal resonance and ring is achieved is called the mask, or the singer’s mask. The mask comprises the *maxilla* (the stationary bone at the top of the mouth), the *maxillary sinuses*, the *nasal bones* (bridge of the nose), and the lower part of the frontal bone where the *frontal sinuses* are located.

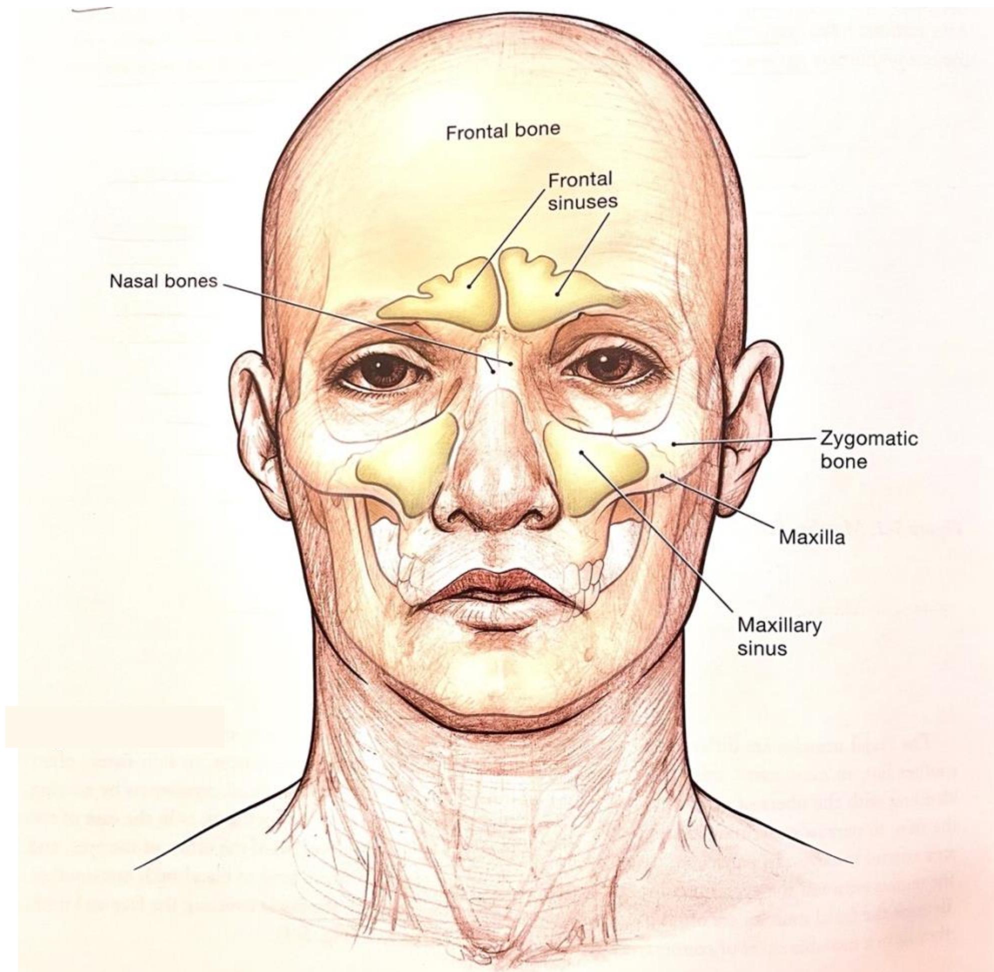


Figure 51: The mask. Image reproduced from Theodore Dimon, *Anatomy of the Voice: An Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*, (Berkeley, CA: North Atlantic Books, 2018): 74.

Although none of these structures is actively involved in resonance of the voice, the visualization of sound vibrating in these areas can effectively enhance resonance by means of a more focused sound. For the purposes of mental practice, a singer must visualize that the sound waves produced by the vibration of the vocal folds travel through the vocal tract and into the mask for optimal vocal ring. If a singer is able to visualize the mask as the focal point or destination of vocal ring, they are more likely to experience sympathetic vibrations in these locations when physically practicing.

Ultimately, the ability to visualize the production and enhancement of sound waves as they travel through the vocal tract accurately is the goal of using detailed anatomical diagrams for mental practice of resonance. Vivid visualization of the muscles contracting or relaxing to create a wider or narrower pharyngeal space strengthens the motor sequence for these physical actions, provided that the singer already possesses these motor skills. The more often a singer is able to recall vivid mental representations for resonance, the more efficient a singer will be in achieving optimal resonance when physically practicing or performing.

Mental Imagery for Resonance

As previously stated, resonance is an intangible component of singing that is influenced by physical conditions within the vocal tract. Because of the intangibility, much of resonance control relies on some form of mental imagery. When practicing, a singer often works to find the optimal vocal ring or resonance of every note. A number of mental images can be used to help a singer find optimal vocal ring for whatever vocal style they are performing.

Kinesthesia, which Kenneth Bozeman defines as "a person's sensory awareness of how body parts and situated, how joints are articulated, and how movements function," is the domain that comprises understanding and awareness of feeling within the body.[131] A singer can use what Bozeman calls "kinesthetic motivations" from past experience to generate mental images.[132] Kinesthetic motivations are ideas or thoughts that provide appropriate visualizations to a singer while allowing for freedom and flexibility for the vocal mechanism to move.[133] He writes:

> Voice teachers must … translate their knowledge … into accurate vocal mapping strategies and the most likely subjective kinesthetic perceptions of the singer—in

131 Kenneth Bozeman, *Kinesthetic Voice Pedagogy*, (Gahanna, OH: Inside View Press, 2017): 91.
132 Ibid., 14.
133 Ibid.

> other words, from the spatial arrangements that we know need to happen to what the student needs to think in order to generate those behaviors.[134]

One form of kinesthetic motivation when working on resonance is mapping of the tongue, bringing awareness to where the tongue resides in the mouth and to the various positions and shapes it take. Bozeman offers the following as another example of kinesthetic motivation:

> The vocal tract is divided into two "rooms" by a tube-narrowing bulge of the tongue dorsum toward a location somewhere along the palate. The "back room" is the vertical pharyngeal column, with the glottis as its floor and the soft palate as its ceiling. A narrowing caused by a tongue bulge toward the hard palate creates a dividing inner threshold into a "front room" formed by the oral space extending from that tongue bulge to the teeth and lips. The teeth and lips then form a "front door" to the outside world.[135]

This example is beneficial because it combines a kinesthetic motivation with a mental image, creating a detailed picture that a singer can visualize to impact proper focus.

A singer often visualizes resonance by localizing it to a specific place in the vocal tract or by highlighting the direction of sound traveling through the vocal tract. Some singers use the image of sound as a laser shooting through the frontal sinuses, which are located at the top of the bridge of the nose. While a singer might experience some sympathetic vibrations in this location, the sound itself is not actually exiting the body through the frontal sinuses. Nevertheless, the image of a narrow, focused laser beam gathered at one specific spot in the mask gives a singer a semi-tangible place to experience an intangible sensation. A singer who uses this analogy might describe the sound produced as clear, focused, and direct, words that indicate they have achieved resonance. While this image can be useful in physical practice, it can also contribute to "inner singing," or audiating. Even if a physical sound is not produced, the mental image of the sound leaving through the frontal sinuses like a laser beam will positively affect later physical practice.

---

134 Ibid., 27.
135 Ibid.

Another form of mental imagery that a singer can use to achieve resonance is that of a string traveling through the medial cleft, or the notch at the center of the top lip. A singer can imagine that the sound that is produced by the vocal folds is attached to this string. As the sound travels through the laryngopharynx into the oral cavity, the string pulls the sound through a very narrow point in the medial cleft, which is actually the center of the maxilla. Although it localizes resonance to a different physical location from the frontal sinuses, this image could similarly lead to a sound that is clear, direct, and focused. Like the laser beam image, this exercise can also contribute to mental as well as physical practice.

Many singers learn to visualize an "inside smile" to help lift the palate and therefore enhance their resonance. The use of an inside smile raises the soft palate, maxilla and zygomatic bone and directs sympathetic vibrations into the maxillary sinuses. Additional sympathetic vibrations might be felt in the bridge of the nose when singing through an inner smile. This image is easy to use when mentally practicing because virtually everyone knows what a smile feels like. When mentally running through repertoire, a singer can easily think about an inner smile while audiating, which will help prepare them to smile inside when physically singing, thereby enhancing their resonance.

Regardless of which method of mental imagery for resonance they choose, a singer should recognize that a more vivid mental image will refine more effectively the motor sequence for later physical recall. The use of vivid and detailed mental imagery affects physical execution of motor tasks by modifying and consolidating already existing memories in the brain.

Teacher-Directed Mental Imagery for Resonance

It is common for voice teachers to use directed mental imagery in the voice studio to elicit noticeable changes in a student's resonance. Teachers use a variety of visual and verbal cues to help students form more vivid mental representations for the desired sound for both immediate use and for later recall in physical and mental practice. It is important that teachers provide students with numerous tools and opportunities to enhance their mental representation for resonance so that when students are practicing on their own, mentally or physically, they are able to achieve similar results to those achieved in the studio. Referring back to the earlier section on feedback, it is important to remember that while some feedback during performance might produce immediate results, feedback offered a few moments before or after a performance is more easily processed in the brain and is more beneficial for long-term learning.

The importance of receiving visual cues from the voice teacher during a lesson is that students can associate the gesture of the teacher with a specific sound goal. This visual cue gets stored in the brain with all the other memories that already exist in the schema for this specific sound. The more a teacher provides visual cues, then, the more likely their student will be able to picture the teacher performing the visual cue even in their absence. The more a student is able to mentally recall the image of their teacher performing a visual cue, the more they are activating the motor sequence for the skill they are practicing (in this case, resonance). Ultimately, the more a student activates this motor sequence, the more efficient the physical production becomes.

A common visual cue performed in the voice studio involves the teacher tapping fingers on the maxilla near the maxillary sinuses. This visual cue indicates to students that they should attempt to guide the focus into the mask for more enhanced resonance. This gesture can be performed while the student is singing, but it serves to be more beneficial as a reminder to the

student directly before they sing. Offering the gesture directly before performance gives students a mental image of where sound should be "felt" and a goal of enhanced vocal ring. This gesture can also be used in the voice studio by teachers directing students to place fingers on their own mask. The teacher then asks them to send the sound "into" their fingertips. Although this is a physical action, this physical action enhances the mental image for resonance in the brain. After numerous performances of this action (directed by the teacher), students should be able to imagine what it feels like to have their fingertips on their mask and thus be able to guide their sound to meet their fingertips. Any time a student practices mentally following this physical activity, the student should be able to picture the fingertips on the mask and to imagine the sound waves traveling through the vocal tract to meet their fingertips.

Another common visual cue used in voice studios for resonance is a simple pointing gesture (sometimes it is more like a pulling gesture). For this visual cue, teachers begin by pointing a finger directly where they want a student to feel resonance (typically near one of the parts of the mask or the medial cleft). The teacher then moves the pointed finger in a smooth and direct forward motion, away from the face. This motion represents the direction of the sound traveling into the mask and then out into the room. Similar to the previous visual cue discussed, this gesture can be performed while a student is singing but is more beneficial as a reminder to a student directly before they sing. Demonstrating this gesture directly before performance gives a student a mental image of where they should feel the sense of focus and provides the goal of enhanced resonance with direction. This gesture can also be performed physically by a student in a lesson to help create a more vivid mental image for later recall. Any time a student practices mentally following this physical activity, they should be able to picture the pointing direction and know that this gesture means to focus their resonance in the mask. Furthermore, any time a

student is mentally practicing repertoire after the teacher has given this visual cue, they will likely picture their teacher performing the cue in their mind. This image activates the motor sequence for vocal ring and strengthens the neural pathways.

Voice teachers employ many other common visual cues for resonance, but they also use verbal cues to help form more detailed mental images that enhance vocal ring and resonance. Teachers often use such words as bright, reedy, clear, focused, and direct to describe vocal timbres with resonance. Conversely, teachers might use such words as hazy, fuzzy, hollow, or aspirate to describe a sound that lacks resonance. Additionally, some teachers use a variety of colors to enhance their students' mental representations for vocal ring.

Verbal cues, just like visual cues, offer a singer the greatest benefit when they receive them directly before a performance or a few moments after a performance has concluded. Verbal cues may be very simple: for example, even just asking a student to picture a sound that is brighter, or clear and focused can be very effective. The key to using this type of verbal cues is that a student must be given a few moments after receiving the cue so that they can adequately visualize the intended sound. This visualization need not include visualization of the anatomy and physiology of the system of resonance; rather it should simply take the form of the student audiating themself singing in a tone that is bright, clear, or focused. After a student sings, then, the teacher must allow a few moments for them to reflect on the sound they have just produced. After allowing for such reflection, the teacher then should ask the student for their feedback: what did you think of the sound you produced? Do you think you achieved a bright, clear, or focused sound? Was it resonant? After the student has answered these questions, the teacher should provide additional feedback. For the sake of consistency, the teacher should always try to use the same language in formulating verbal cues (this allows students to hear the word

repeatedly and associate it with the sound they are trying to achieve). By using the same words repeatedly and reflecting on the sound that is produced when imagining a sound that is associated with those words, a student forms more vivid mental images for resonance that will be combined with their existing mental images through memory consolidation. Thereafter, any time a student mentally practices, they can simply think of producing a sound that is bright, clear, and focused and the same neural pathways that are active during physical singing will be activated. The more a student thinks about producing a bright, clear, and focused sound, the more this specific neural pathway becomes wrapped in myelin, creating a more efficient and stronger pathway for the motor sequence associated with resonant singing.

Another form of verbal cueing from teachers is vocal demonstration. After verbal instruction and prior to a performance, teachers can demonstrate the "ideal" sound. Students aurally observe the sound, taking note of tone, timbre, resonance, etc. Just as when they are watching videos of other singers, a singer will find that both the aural and visual components of observing the teacher's demonstrations activate the mirror neuron system, thereby enhancing the motor sequence for the intended action. Additionally, teacher demonstrations allow students to observe physical positions and adjustments to the vocal tract, aiding in the formation of more vivid and more detailed mental images for vocal tract configuration.

The use of the color spectrum in the voice studio for resonance is unique because it gives students something visual to focus on without a visual representation. Most students are able to discern colors that they think are bright or crisp, like lime green or highlighter yellow, or colors that they associate with being more muted (or fuzzy), like pastel blues and pastel pinks. As a student is preparing to sing repertoire in a lesson, the teacher asks which color sounds bright. After the student answers (for the sake of this example, bright will be lime green), the teacher

then asks the student to make the sound lime green. Assuming that the teacher and student have already discussed what the characteristics of a bright sound are, this verbal cue immediately prompts the student to think about a sound that is clear, direct, and focused. After a few moments of imagining what lime green sounds like, the student sings the phrase. Following the conclusion of the performance, the teacher allows the student a few moments to reflect and analyze the sound just produced. After the student has had a few moments to reflect, the teacher allows the student to describe the quality of sound in regard to resonance and then provides additional feedback. Assuming "lime green singing" was successful, the student can continue to think about lime green in any future mental or physical practice. Lime green has now been added to the existing mental representation for a clear, focused sound.

In summary, regardless of whether the cues given by the teacher in a lesson are verbal or visual, the teacher must remember to provide the cues before a performance to allow the student to create a mental representation associated with the cue before singing. Furthermore, teachers must allow time after a performance for students to reflect, process internally, and then provide feedback before the teacher provides further feedback. If a specific cue is particularly successful, that cue should be used repeatedly to further strengthen the mental representation associated with the cue. The more students see or hear a specific cue that elicits a successful response, the more vividly they will be able remember that cue, effectively enhancing the motor sequence for resonance in all mental and physical practice in the future.

Attentive Listening for Resonance

As explained in Chapter 2, the mirror neuron system activates not only upon third-person observation of a task, but also upon receipt of aural stimulus when the stimulus already exists in

the observer's motor repertoire. For a singer, attentive listening collects information about style, interpretation, character, and musical components; it also provides trained singers at any level the opportunity to listen intently to resonance strategies of professional singers of the same voice type. For the sake of mental practice of resonance, listening to a piece of music sung by someone of a different voice type will not have the benefit of activating the mirror neuron system because the auditory stimuli do not exist in the singer's motor repertoire. If the goal of attentive listening is to effectively enhance resonance, then a tenor should listen to a tenor, a mezzo to a mezzo, and so on. Reasons for this have previously been laid out in Chapter 6.

In addition to activating the mirror neuron system, attentive listening also allows a singer to imagine the position and shape of the vocal tract of the singer they are listening to. This process in turn allows the observing singer to create visual and aural mental representations to store in the schema for resonance. The following guide walks a singer through an attentive listening routine designed to effectively enhance resonance.

1. Find a quiet room or place free from all distractions.
2. Briefly close your eyes, eliminating all extraneous stimuli.
3. Focus your attention on a specific ambient noise, attempting to make that noise the only thing you hear.
4. Once your mental state has been aroused and your awareness heightened, open your eyes briefly to turn on a recording. Try to only open your eyes enough to see the device that the music is coming from, keeping your eyes in a sort of haze.
5. Once you have started the music, close your eyes again. You should devote all your attention and energy to listening.
6. Once the singer begins singing, listen intently to the quality of the sounds.
7. How would you describe their singing? Is it resonant? Is it clear? Can you describe it using a color?
8. Does the sound they are producing match the style of the music? Are they using the correct resonance strategy?
9. As you continue listening, are you able to imagine how their vocal tract is set up to achieve their resonance strategy? Is the larynx neutral-low or neutral-high? Are the lips convergent (gathered and round) or divergent (wide)? Is the soft palate raised or lowered?

10. Pay close attention as the singer continues. Do you notice general qualities about the sounds they are making? Is the resonant consistent from word to word? Is it consistent throughout the range and register? Are they changing resonance strategies to affect certain words?
11. Are there any general observations? Does the resonance strategy change if the singer changes registers?
12. Listen as the singer continues through the entire piece. As you are listening, try to imagine what they are doing physically to produce the resonance so that it sounds free and stylistically appropriate. Can you imagine the shape of the pharynx? The epilarynx? How is the tongue positioned to achieve this resonance strategy? Does it sound like the sound is in the mask? Is the resonance strategy somewhere other than the mask?
13. As you are creating a mental image of the singer's physical position for their resonance strategy, try to be as detailed as possible, imagining every specific detail.
14. Keep your eyes shut for a few seconds after the recording ends.
15. During the silence, allow yourself to focus intently on the sound quality you just observed.
16. After you feel that you have formed the most detailed mental and aural image possible, open your eyes.

This step-by-step process establishes a sense of mindfulness and then asks numerous questions that aide in the formation of vivid and detailed visual and aural mental images for resonance. Every time a singer listens attentively, following the process above, to a performance by a singer of the same voice type, they are bound to activate and strengthen the motor sequence for resonance.

Conclusion

The ability to sing with sharper focus and ringing resonance is one of the ultimate goals of voice training for anyone studying classical singing. Resonance has the ability to increase vocal tract inertance, which ultimately facilitates and leads to more efficient oscillation of the vocal folds. Similarly, focus can affect the perceived vocal quality created by a singer. Incorporating mental practice into work on resonance presents unique challenges, because resonance is an intangible quality and skill. The most successful physical practice of resonance

and focus includes numerous forms of mental imagery. The addition of well-designed mental practice exercises such as mindfulness exercises, detailed anatomical diagrams of the position of the vocal tract to enhance resonance, mental imagery, and teacher-directed mental imagery allow students to refine their existing schema for resonance in various styles of singing. The addition of attentive listening activates the mirror neuron system, which effectively activates and myelinates the neurons of the motor sequences for resonance. All of these mental practice routines allow for more fluency and efficiency in recall of the motor sequences for resonance, thereby enhancing and facilitating physical execution.

Chapter Nine:

Mental Practice for Memorization

Although it is not a motor skill, memorization is one of the most common reasons why a singer already incorporates mental practice into their regular practice routines. Memorization simply refers to a singer's ability to commit information to memory for later recall. The pieces of information a singer typically commits to memory are the pitches, rhythms, texts, and translations of works they are trying to memorize. There exist several useful methods of mental practice for memorization, and all singers (whether they employ these methods already) will benefit from incorporating mental practice into their memorization routines.

To prepare for successful mental practice for the purpose of memorization, a singer should begin by entering a state of mindfulness. Below is an exercise from Cornett's *The Mindful Musician* that can help with this initial task. Cornett refers to this exercise as a "Present Moment Check-Up," because it helps focus the mind on the present moment and redirects focus back to the task at hand if the mind wanders.[136]

> Five to ten times a day, when you remember to do so, pause whatever you are doing and direct your awareness to the present moment for 20 seconds or more. Notice the world around you, including your internal experiences. Where are you, and what are you doing? What do you see and hear around you? What does your world smell like, right now? What were you thinking about, just before this? Was your mind focused in the past, the present, or the future? How does your body feel right now? What is your mood? Can you answer these questions without judgement, basking in the pure acceptance of right now?[137]

The most important part of this exercise is to focus on the present moment and to notice the world around you. What are you doing? What is the intent behind what you are doing? If a singer intends to memorize music through mental practice but they are distracted or find that their mind

136 Cornett, *The Mindful Musician*, 216.
137 Ibid., 216–217.

is wandering, they will have trouble committing the music to memory. Indeed, a singer might think they have the music memorized in the moment, but hours later, they likely won't be able to recall what they thought they had committed to memory. When a singer is able to focus on a specific intent of the task at hand, the mental practice for memorization will be much more successful and yield better long-term results.

Attentive Listening for Memorization

Many voice teachers tell their students not to learn their music by listening to recordings. Recordings may include musical, stylistic, and articulatory errors. Such errors may cause students to learn pieces incorrectly, forcing the teacher to remedy the inaccuracies. Nevertheless, attentive listening for memorization can be a highly beneficial tool when a student has already spent a significant amount of time learning a piece. Since memorization is not a motor skill, the mirror neuron system doesn't activate any motor sequences during attentive listening for memorization as it would for enhancement of any of the previously discussed motor skills. However, attentive listening to music already learned recalls memories from the schema for the piece of music being studied. As a singer listens and follows along mentally, the memories for the piece of music are altered and consolidated with the old memories, creating more accurate memories for later recall. In order to ensure that the singer is memorizing the music correctly, I recommend that the teacher approve any recordings the student consults, or that the teacher and student make physical notes of the places where there are inaccuracies in the recording so that the student is aware of them and doesn't commit them to memory.

An important part of attentive listening for memorization is covert singing, or the ability to mentally hear and "sing" a melody without physically producing sound.[138] Although memorization is not a motor task, the ability to sing covertly the music that one is attempting to memorize activates the premotor cortex, initializing the motor sequences for all systems involved in producing physical tone, even in its absence.[139] In other words, covert singing turns memorization into a motor skill (at least in part) by activating the motor pathways that are used in physical singing, solely by imagining singing. Studies also show that covert singing increases activation in the supplementary motor area (SMA) and the motor cortex. A study by Tanaka and Kirino demonstrating connectivity of the SMA and the motor cortex during covert singing suggests that there are motor pathways that transform imagined or covert singing into motor signals, forming or enhancing the already existing motor sequences.[140] The results of this study also suggest that "the SMA and motor cortex [work] cooperatively to dissociate body movements from the imagined performance."[141] This simply means that the SMA and motor cortex are able to separate body movements and covert singing, allowing a person to sing covertly and activate the SMA and motor network without physically engaging the body.

To maximize the benefits of attentive listening for memorization, a singer should pair the activity with covert singing. In other words, they should covertly sing along with whatever recordings they listen to by way of mental practice at memorization. To this end, students may also benefit from recording themselves performing from notation. This type of recording ensures that students have a recording that accurately matches the music they are studying. Additionally,

---

138 Schmidt and Lee, *Motor Control and Learning*, 311.
139 Wilson, "Finding Your Voice," 2125.
140 Shoji Tanaka and Eiji Kirino, "Dynamic Reconfiguration of the Supplementary Motor Area Network during Imagined Music Performance," *Frontiers in Human Neuroscience* 11 (December 2017): 5–6.
141 Ibid.

such recordings ensure that a singer is not attempting to manipulate their sound to mimic a recording of another singer, since the recording is of their performance.

After producing high-quality recordings alone or in collaboration with their teachers, students can proceed with the following attentive listening exercise to facilitate memorization.

1. Find a quiet room or place free from all distractions.
2. Briefly close your eyes, eliminating all extraneous stimuli.
3. Focus your attention on a specific ambient noise, attempting to make that noise the only thing you hear.
4. Once your mental state has been aroused and your awareness heightened, open your eyes briefly to turn on a recording.
5. Turn your visual attention to the sheet music in front of you but keep the remainder of your attention focused on the recording.
6. As the singer begins singing, attempt to sing along in your head, making no physical sounds or gestures (don't even mouth the words along).
7. After a complete sing through of a piece, stop the recording but keep your focus on the sheet music.
8. Choose a specific section, verse, or phrase to focus your attention on for the next sing-through.
9. Study this section, verse, or phrase intently for up to one minute.
10. Close your music.
11. Return the recording to the beginning of this specific section, press play, and close your eyes.
12. As the music begins, attempt to covertly sing along again, this time from memory.
13. Were you successful? How much of the passage were you able to covertly sing from memory?
14. Open your eyes, then open your music to this section and make notes of areas that were problematic, and then close your music again.
15. Return the recording to the beginning of this specific section, press play, and close your eyes.
16. As the music plays again, attempt to covertly sing along, this time focusing more attention to the areas that were problematic before.
17. Were you more successful this time through? Were you able to covertly sing the entire passage from memory?
18. Open your eyes. Open your music back to this section one more time, making notes in your music.

This exercise focuses on using covert singing and attentive listening in combination to enhance the speed and detail of music memorization in a small, specific section of a piece of music. This process should be repeated, breaking up the entirety of a piece into smaller sections. Once a

singer is successful in covertly singing each small section individually from memory, they can begin to piece sections together until they eventually are able to covertly sing the entire piece from memory.

Attentive listening can be an effective tool for memorization alone, without the incorporation of covert singing; however, the process will be significantly slower without the activation of the premotor cortex by covert singing. For this reason, a combination of covert singing and attentive listening is recommended to enhance the efficiency of memorization.

Mental Imagery for Memorization

The use of mental imagery for the purpose of memorization relies heavily on in-depth and detailed score study and analysis. Fine et al. polled a significant number of professional and student musicians, asking about the incorporation of mental practice into their normal practice routine. Nearly 70% of the musicians they polled stated that mental practice is a vital component of their practice, especially in the form of score study and analysis during the memorization phase.[142]

Techniques of score analysis range widely among musicians, but the process typically includes analysis of the key, time signature, melodic and harmonic elements, the language, instrumental cues, and any stage directions specified in the score. Timothy Hubbard observes that "reading a musical score exhibits activation in occipital areas that spreads to midline parietal and then to left temporal auditory association areas and right premotor areas," meaning that score

142 Philip A. Fine et al., "Performing Musicians' Understanding of the Terms 'Mental Practice' and 'Score Analysis'.," *Psychomusicology: Music, Mind, and Brain* 25, no. 1 (2015): 69–82.

study acts as a visual stimulus that prompts a series of electrochemical messages to be sent through the brain, eventually activating the appropriate motor sequences.[143]

Score study for memorization is fundamentally a mental imagery routine. A singer who spends significant time studying and analyzing the score is likely able to visualize the score when they are mentally practicing or physically singing. The more details the singer pays attention to during the score study phase, the more detailed and the more vivid the mental image of the score will be, which lends to stronger recall and activation of the associated memories. A singer should pay close attention to exact pitches and rhythms during score study, memorizing each individual note rather than the general melodic and rhythmic contour of a phrase or piece. A singer should also pay close attention to musical markings indicated by the composer (or the editor) in the score, committing those to memory as well, as appropriate. Stage directions may need to receive equal attention as the notes and rhythms on the page, likewise both the text in the original language and word for word translations where relevant.

When a singer is studying scores, they cannot expect to create vivid and detailed mental images with a quick glance or during a single score-study session. Score study for the purpose of memorization should be integrated often as a part of a singer's mental practice routine. The more a singer physically studies and observes every detail of a notated score, the more vivid their mental representations for these scores become. Although score study is effective solely with visual study and analysis, the addition of covert singing along with score study further strengthens mental representations by adding an aural representation to the memory as well.

---

143 Timothy L. Hubbard, "Neural Mechanisms of Musical Imagery," *The Oxford Handbook of Music and the Brain,* November 2018, 525.

Conclusion

Memorization in and of itself is not a motor skill. Memorization is intangible, meaning it cannot be touched or measured using physical means, and occurs at different rates for every person. A singer who incorporates mental practice for the purpose of memorization will experience quicker and more accurate results than those who solely memorize in their physical practice sessions. Attentive listening and score study can be performed in places that physical practice is not possible, effectively adding to the total time spent practicing or memorizing music. Furthermore, the use of covert singing with both attentive listening and score study is shown to turn visual and aural stimuli into motor signals, effectively activating the motor cortex and motor areas associated with the physical skills required to perform music and sing. Through a series of interconnected brain networks, mental practice for memorization can not only effectively speed up the memorization process, but it can also strengthen and enhance the motor skills necessary to perform vocal-motor tasks.

Chapter Ten:

Mental Practice for Character/Performance

Mental practice is a useful tool for any vocal artist who is attempting to create and develop a character in a specific moment, scene, or piece of music. The use of mental practice allows a singer to focus on the character's internal thoughts and motivations without the distraction of stage pieces, other singers, or physical movements. Without these distractions, a singer can imagine various interpretations, moods, or facets of a character without pressure from a teacher, director, or other cast mates.

Mental practice for character development and performance relies largely on mental imagery while in a state of mindfulness and heightened awareness. Before creating mental images of a character, explore one of the mindfulness exercises listed in previous chapters to tune out extraneous stimuli and heighten mental arousal.

After a singer has entered a state of mindfulness, they can begin to form mental images of the space in which they will be performing and how the character would act in that space. The following list is a series of probing questions intended to help the performer create the most vivid and detailed mental images possible.

1. If it is a recital or concert setting, visualize where the piano or instruments are located. Attempt to visualize the stage in its entirety – how much space is there to move around? What objects in the room or on the stage are available for use as props or focal points? Are there other people to interact with or are you alone?
2. After successfully creating a vivid and detailed mental image of the space, begin to visualize the character.
3. How old is your character? What year were they born?
4. What are physical characteristics or movement qualities associated with this age group? Does your character move slowly? Quickly? Do they walk well or are their limbs weaker? Do they have any tremors? Do they stand tall or do they hunch over?
5. Attempt to visualize yourself making specific movements with the answers to these questions in mind.

6. What is your character wearing? Are the clothes comfortable? Are the clothes bright colors? Dark? Period specific? Do they reflect the character's personality?
7. Does your character have any family? Siblings? A spouse? Parents? Pets? How does your character interact with these family members? Are the relationships positive or negative? Are they deep and meaningful or superficial?
8. What other relationships does your character have? Friends? Co-workers? How does your character interact with these people? Are the relationships positive or negative? Are they deep and meaningful or superficial?
9. Think about your character's arch throughout the story. Where do they begin and where do they end? How did they get from point A to point B? What experiences caused them to develop throughout the course of the story? Were these experiences positive or negative?
10. Imagine yourself in those experiences. How would you react? What would your physical gestures be? How would these experiences affect you emotionally? Does your character cry? Do they compartmentalize? Do they bottle things up inside?
11. What are other general personality traits of your character? Are they suave? Uptight? Confident? Relaxed?
12. What are physical traits associated with your character's personality type?

This list is not all-inclusive, rather merely a starting point for character development. More importantly, this list asks a series of questions that require performers to dive deeper into the essence of the characters they are portraying. Many of the questions above require performers to think deeply about their own experiences or observations of people they know who have experienced significant or specific events in their life. By thinking deeply about these experiences, the performer is able to envision the emotions and physical responses caused by the experience. The ability to envision visceral responses allows performers to incorporate those memories into their own character development, lending to more genuine performance.

Once they have successfully formed and developed a character, a singer can combine the use of mental imagery for performance with attentive listening to establish the character in the context of a specific song, scene, or show.

1. Be sure to work in real time, at actual performance tempo. Faster or slower tempi make it hard to relate mental practice to physical execution.
2. Work phrase by phrase or section by section, listening to a recording and deeply analyzing the text and how the text is set to music.

3. Is the text positive, negative, or neutral? Happy or sad? Does it have tones of excitement or tension?
4. Does the music match or contradict it? Is it in major or minor? Is the accompaniment thick and lush or sparce? Is the vocal melody disjunct or fluid?
5. Taking the musical components and the textual components together, how would your character deliver this line? What words would they emphasize? How would they inflect certain words or syllables? Does the phrase have to be sung perfectly in time or is there room for some rhythmic liberty?
6. Can you imagine the character's specific situation in this exact moment? What emotions are they feeling? Are these emotions deeply personal or surface level?
7. What physical gestures make sense based on the emotion of this passage? Are the gestures strong or weak? Quick or slow? Energetic or lethargic?
8. How would your character perform these specific gestures? Think about your character's personality, age, and relationship to anyone else who might be involved in the scene? Can you vividly picture your character performing these gestures while singing?
9. How can you relate your own personal experiences to this specific moment to bring your character to life?
10. Continue working phrase by phrase, understanding that your character might experience different emotions from one phrase to the next. Regardless, try to create vivid images of your character experiencing visceral emotions and performing genuine gestures.

When performers have successfully worked phrase by phrase through the entirety of a piece or scene, they should piece the phrases together, focusing on how the character transitions between emotions. Remember that during the previous practice routine, phrases without singing should still be imagined in real time, allowing the performer to be in the moment even during musical interludes.

Much of this mental imagery for character development and performance involves the imagination of physical gestures of the whole body, rather than just the vocal-motor system. Studies from rehabilitation, physical therapy, and surgery show that vivid mental images of physical gestures of limbs activate and engage the motor sequences involved in physical gestures just like in the vocal-motor system. The more performers are able to vividly visualize physical performance gestures, the more natural and effortless these gestures will be performed when the performer is on stage.

By pairing this vivid mental imagery practice of visceral and genuine emotional responses with attentive listening, performers are better able to create schemas that associate character and the physicality of performance with musical performance. Performers who actively engage in mental imagery and attentive listening practice will experience a quicker character development that will lead to more intentional and natural character choices on stage. This mental practice also allows for a deeper integration of personal experiences, which can contribute to more genuine-seeming performance.

Conclusions

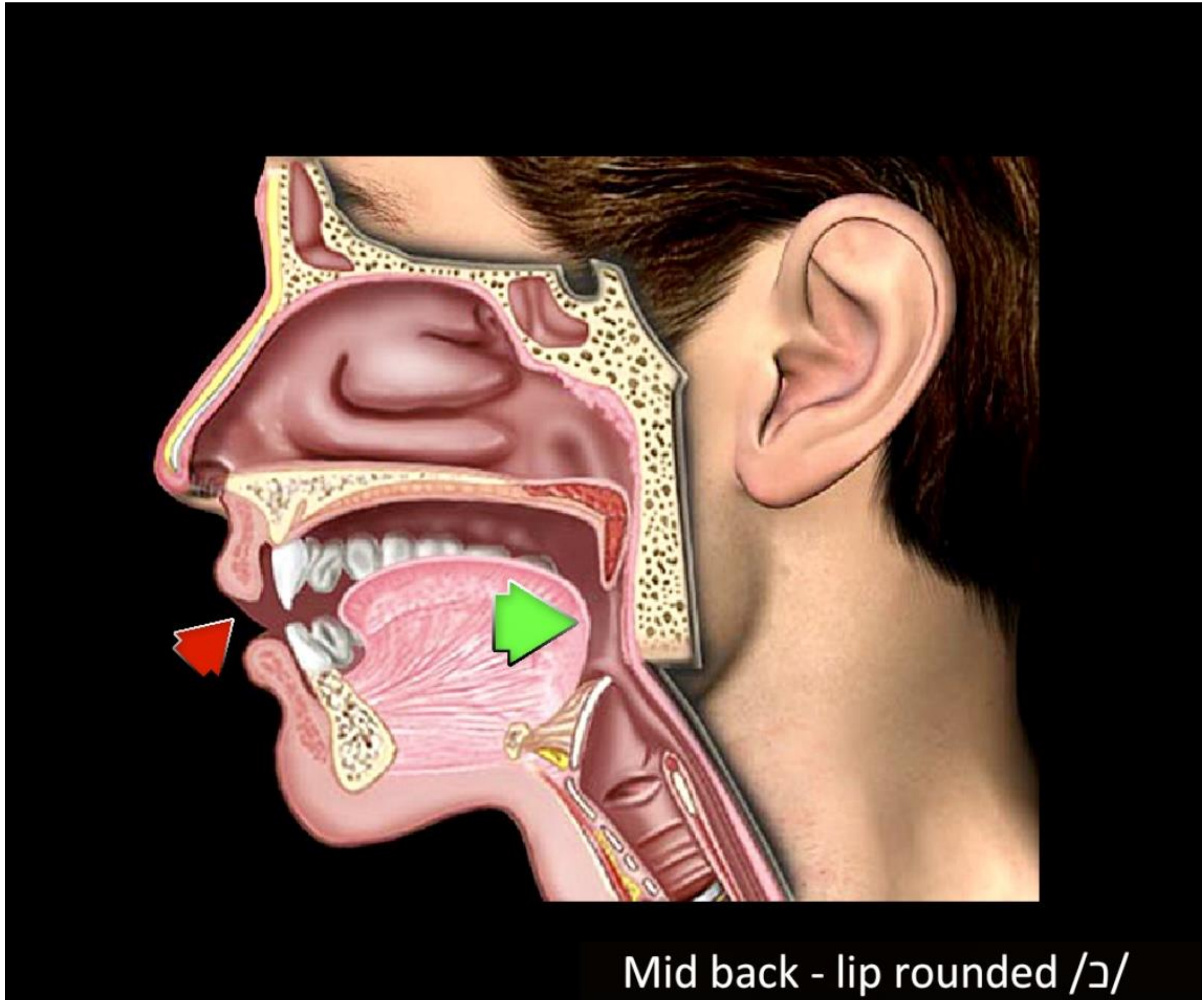
There is significant research about the cognitive effects of mental practice on motor learning in various fields of medicine and sports; until now, however, nobody has explored applying the principles of mental practice to music in general, or singing, in particular. This dissertation offers evidence of the efficacy of mental practice and identifies numerous practice routines and methods to incorporate mental practice into a singer's practice for enhancement of fine vocal-motor skills. The exercises provided here, adapting elements from therapeutic settings, feature strategies that are useful not only in a student's individual practice, but also in a voice studio or private lesson setting.

In a musical context, the efficacy of mental practice must be measured qualitatively, and desired outcomes will vary with the goals and experiences of the singers and teachers involved in the process. Every singer will have different levels of success with mental practice depending on their vocal-motor skill levels and their comfort using mental practice routines. Many voice teachers are concerned not only to teach their students how to sing, but also how to practice and now, thanks to the cognitive revolution, their goals may include teaching students how to practice mentally as well as physically. It is a voice teacher's duty to be informed and to understand how students learn and develop motor skills through physical and mental practice. The training of voice teachers is unregulated, and it varies based on the educational background and experience of the teacher (music education, vocal performance, choral conducting, etc.), with the result that, in many cases, voice teachers have little (or no) training in educational strategies or pedagogical methods.

In gathering, presenting, and synthesizing information about the efficacy of mental practice for motor skill acquisition in this dissertation, I have aimed to create a training manual

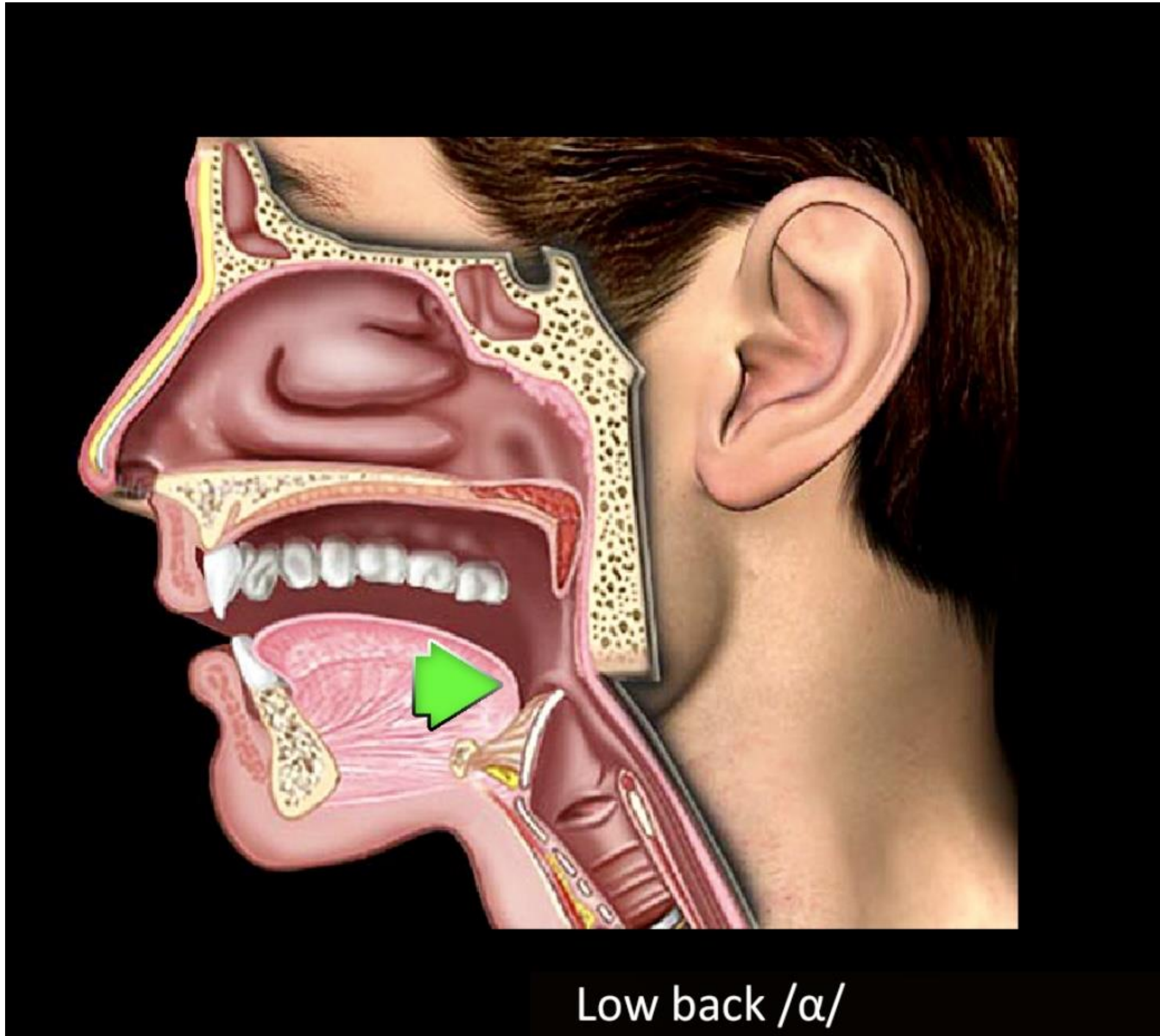
for teachers, guiding them in how to teach students to practice and how to incorporate mental practice successfully in their studios. It should also serve as a resource for singers of all levels who want to try incorporating a variety of mental practice methods into their existing routines. A singer will find here the tools to refine their vocal-motor functions in all five systems of singing, to improve their skill at memorization, and to develop their overall performance.

Appendix I



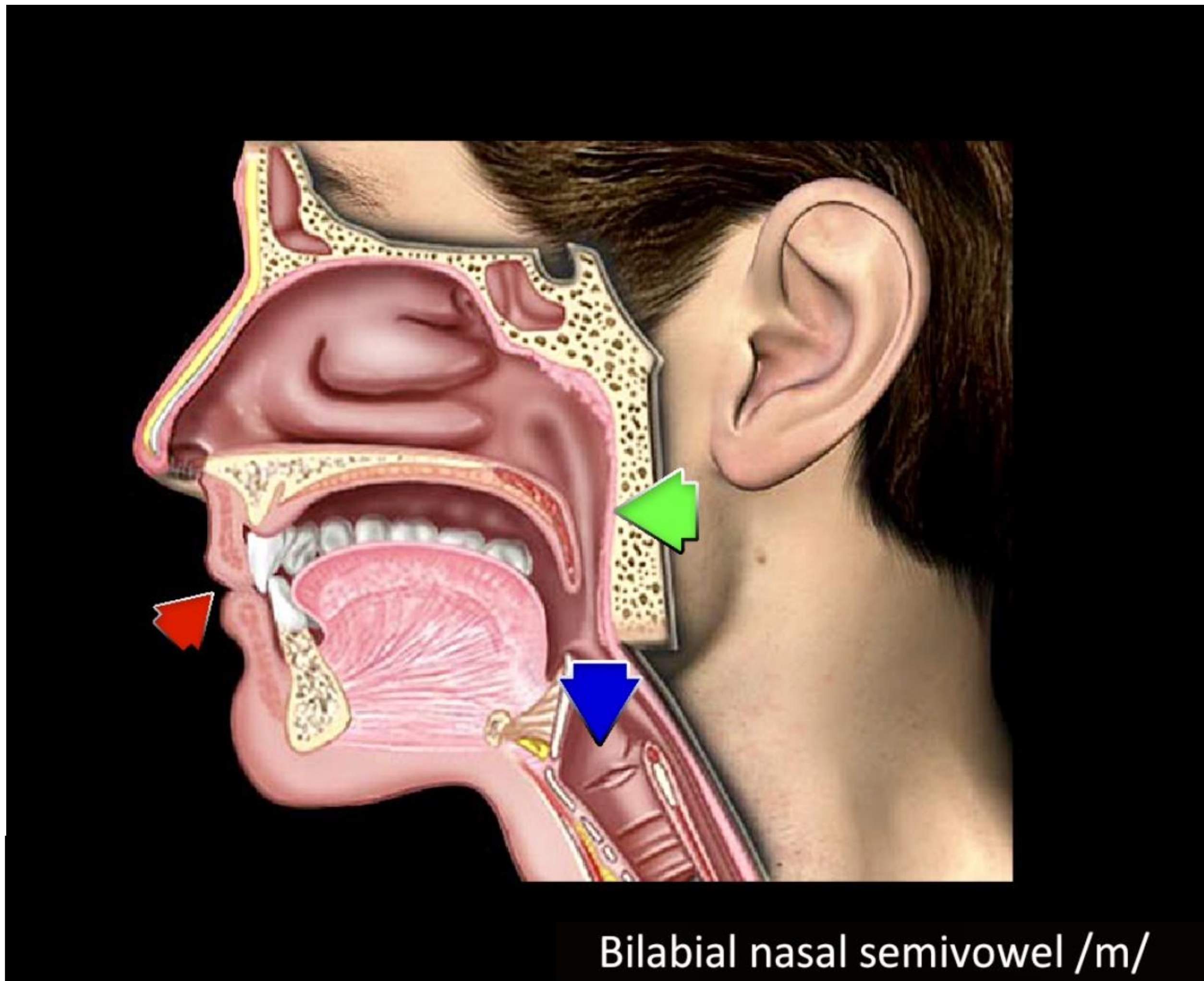
Mid back – lip rounded [ɔ]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

Appendix II



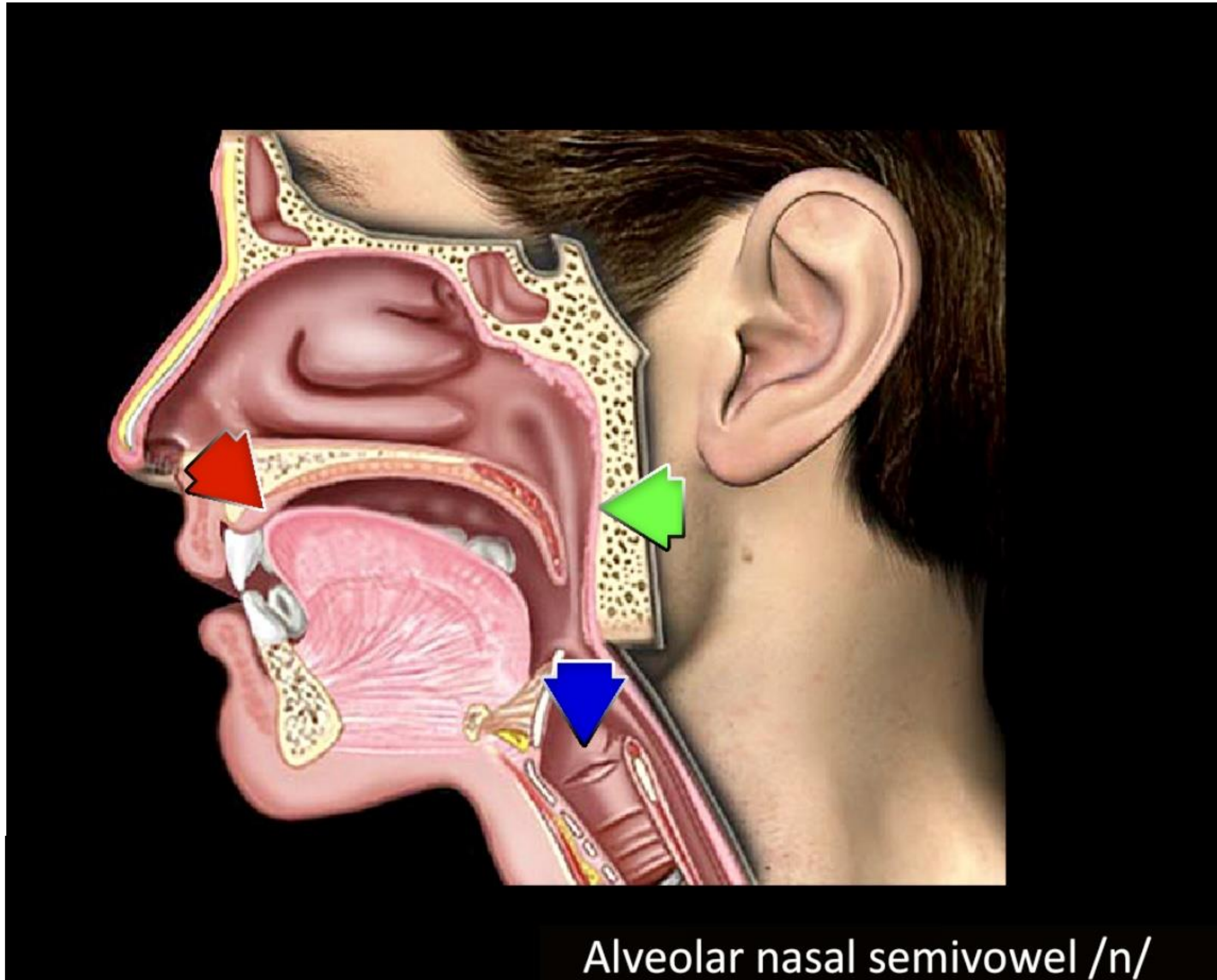
Low back – lip rounded [ɑ]. Image reproduced from *Vowels Front Back*, (Blue Tree Publishing, Inc., 2020).

Appendix III



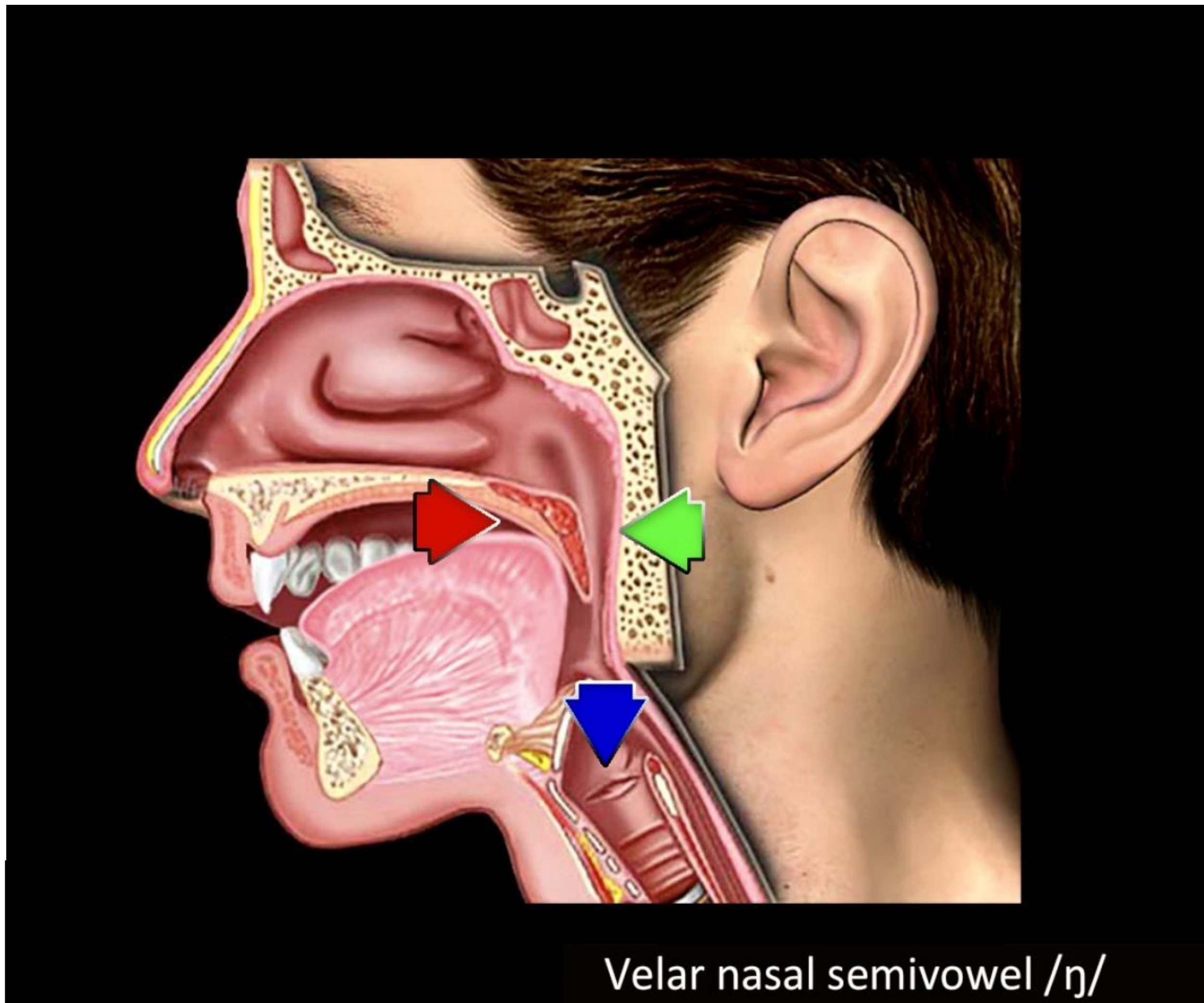
Bilabial nasal semivowel [m]. Image reproduced from *Semivowels*, (Blue Tree Publishing, Inc., 2020).

Appendix IV



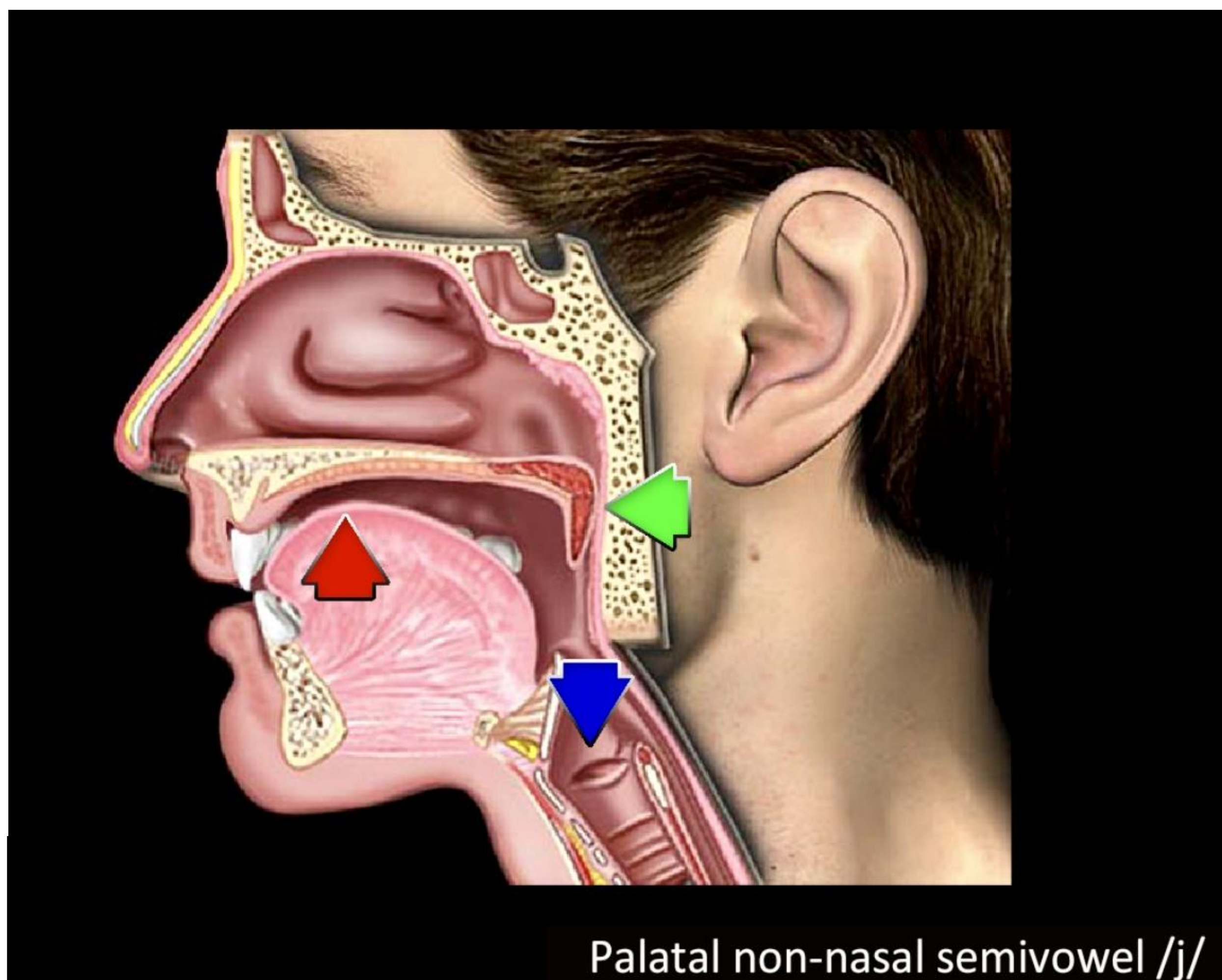
Alveolar nasal semivowel [n]. Image reproduced from *Semivowels*, (Blue Tree Publishing, Inc., 2020).

Appendix V



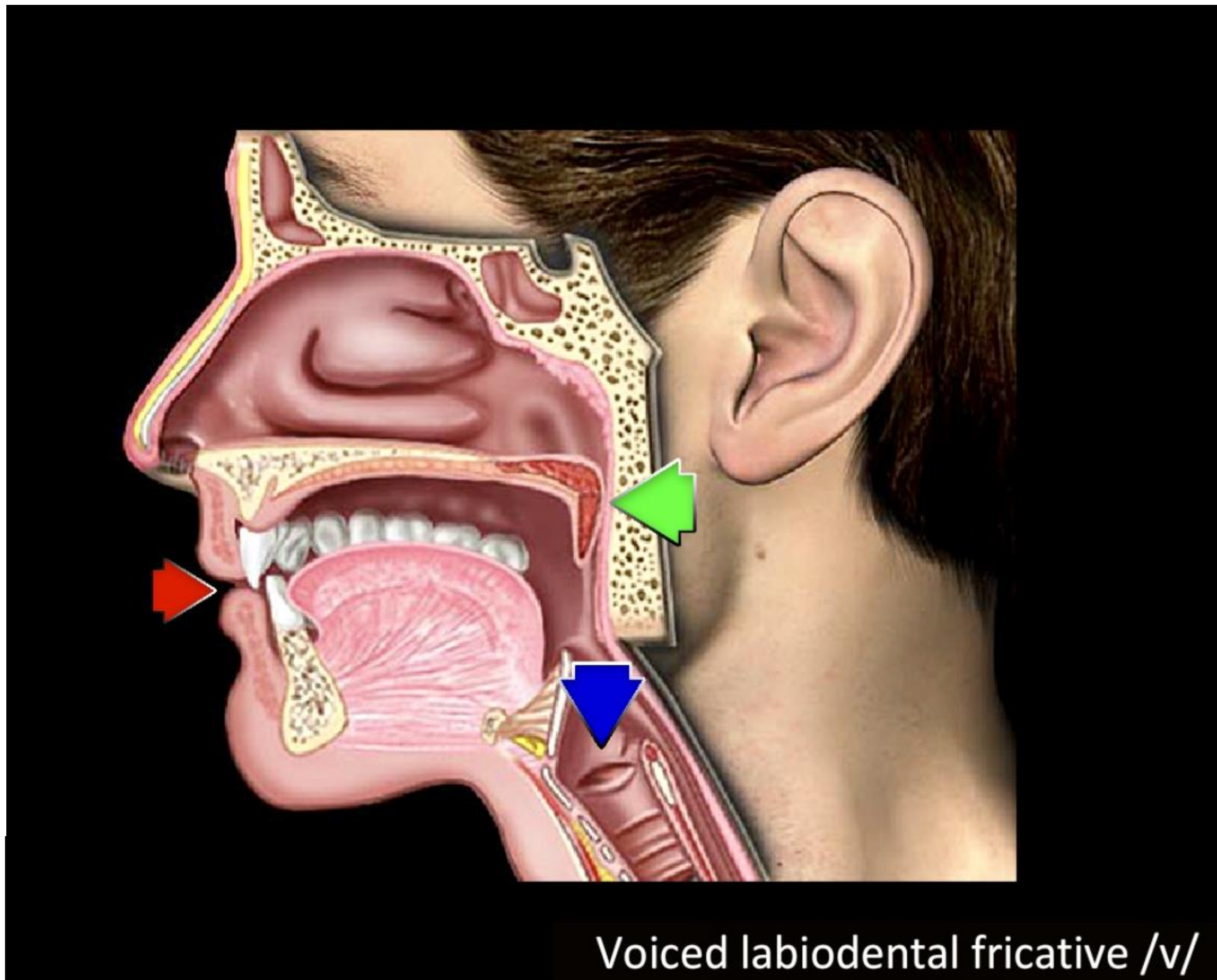
Velar nasal semivowel [ŋ]. Image reproduced from *Semivowels,* (Blue Tree Publishing, Inc., 2020).

Appendix VI



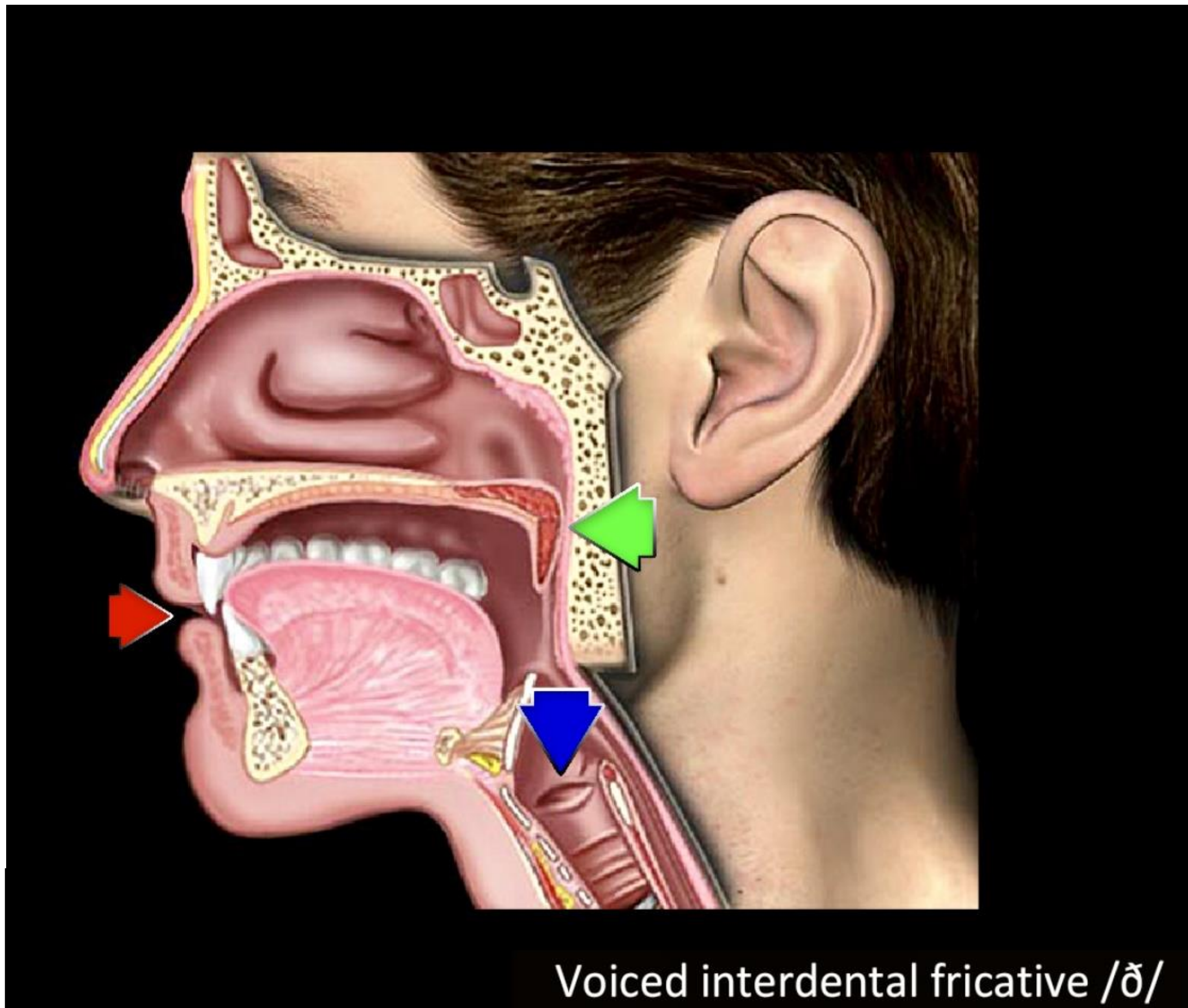
Palatal non-nasal semivowel [j]. Image reproduced from *Semivowels*, (Blue Tree Publishing, Inc., 2020).

Appendix VII



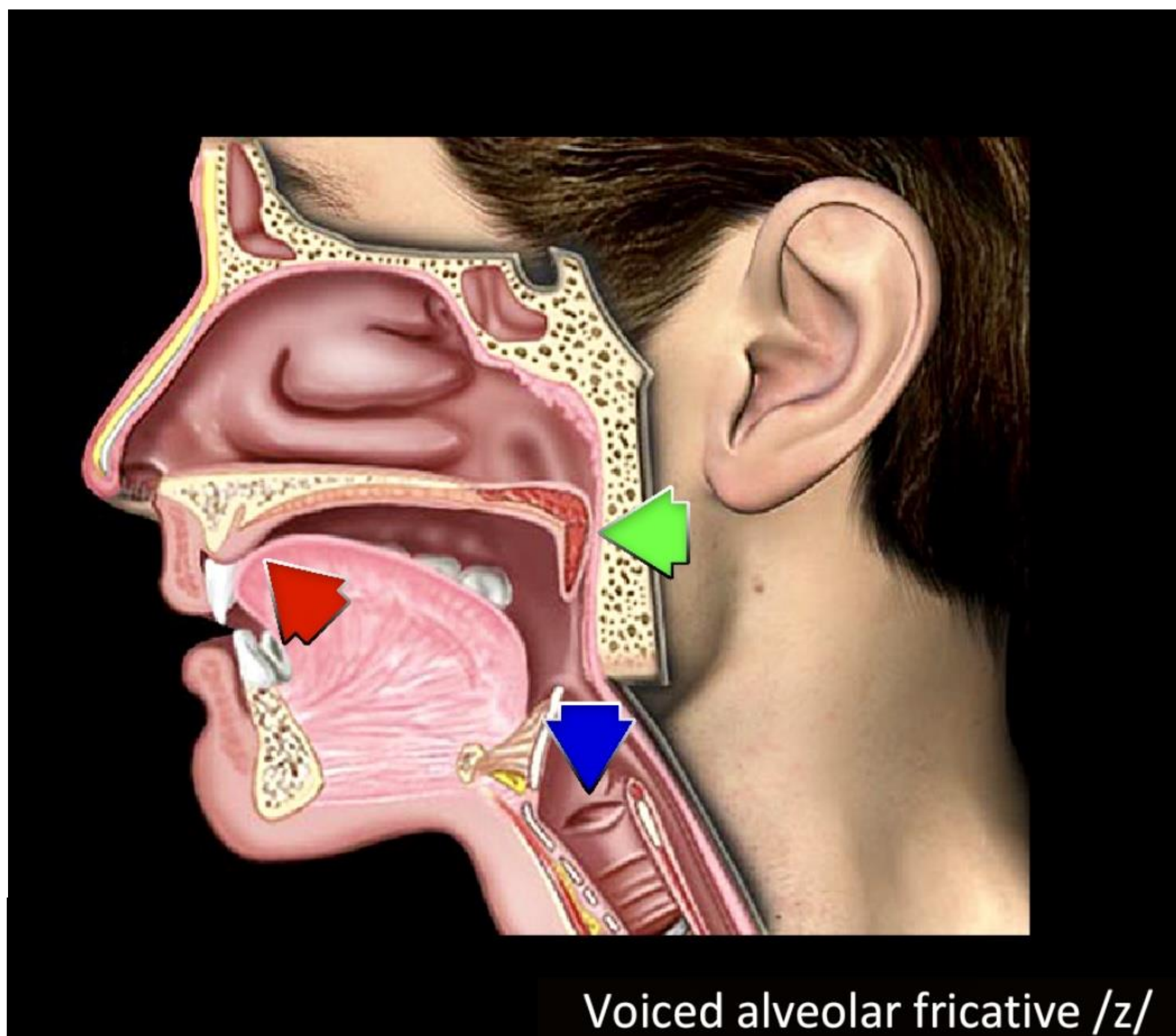
Voiced labiodental fricative [v]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix VIII



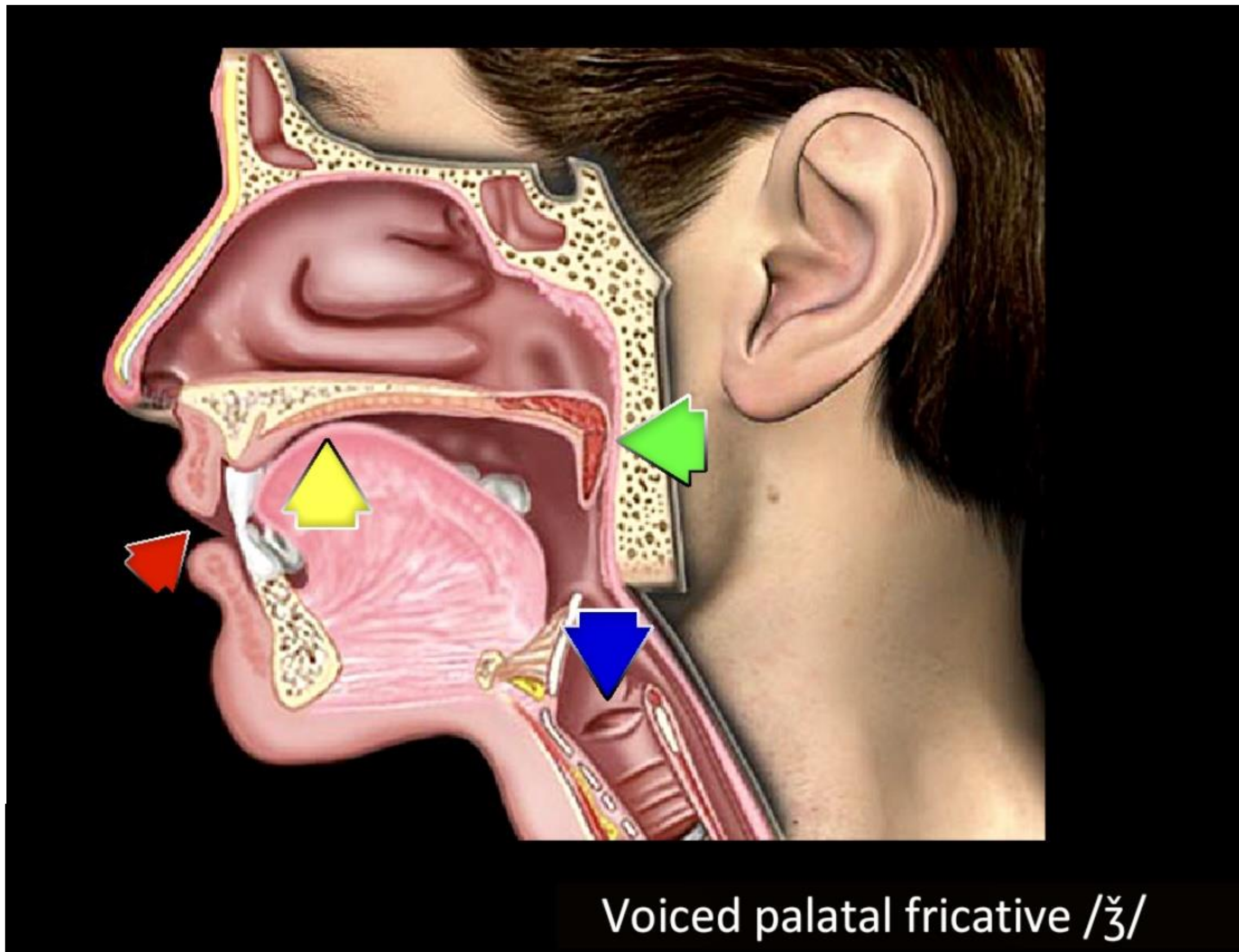
Voiced interdetnal fricative [ð]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix IX



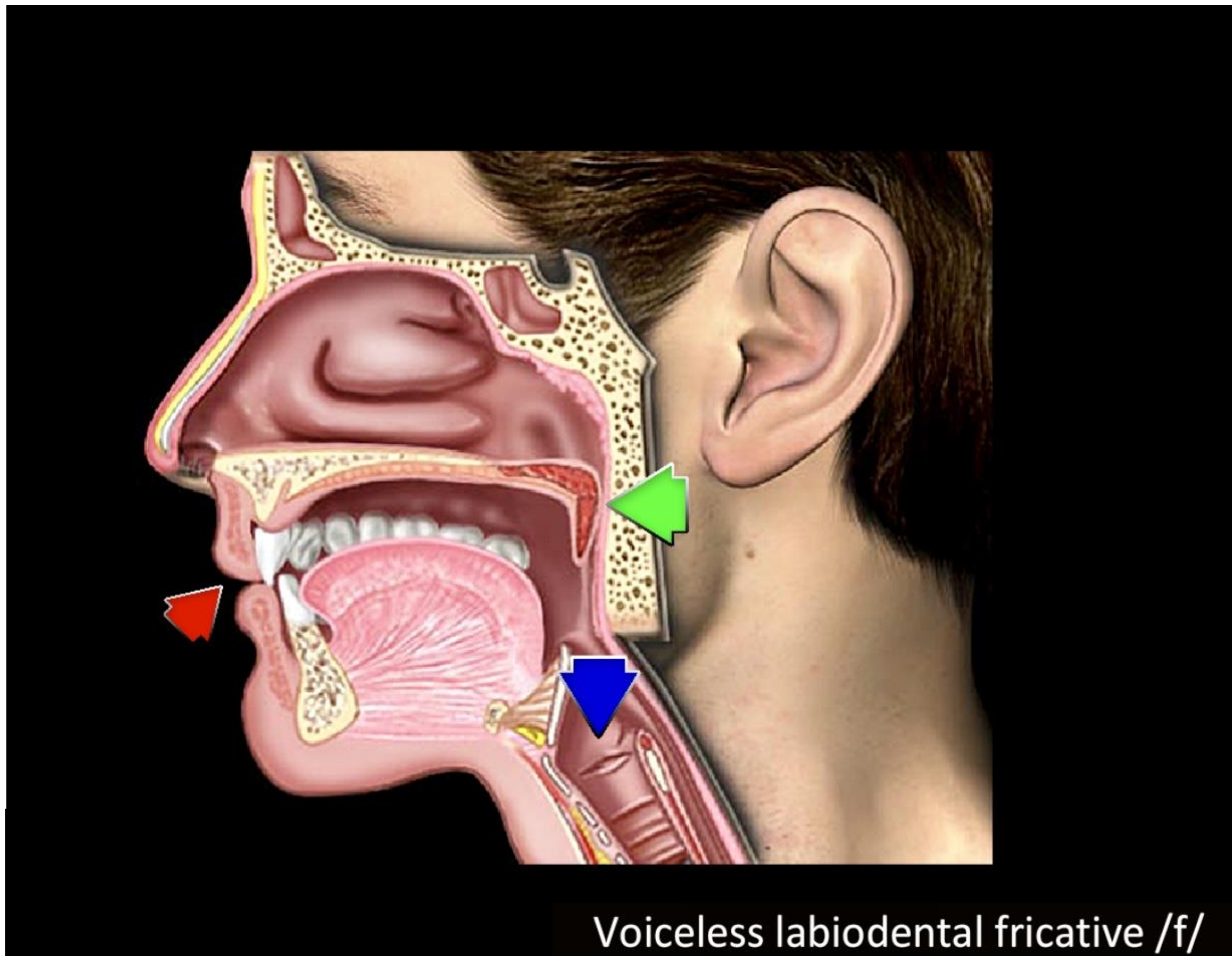
Voiced alveolar fricative [z]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix X



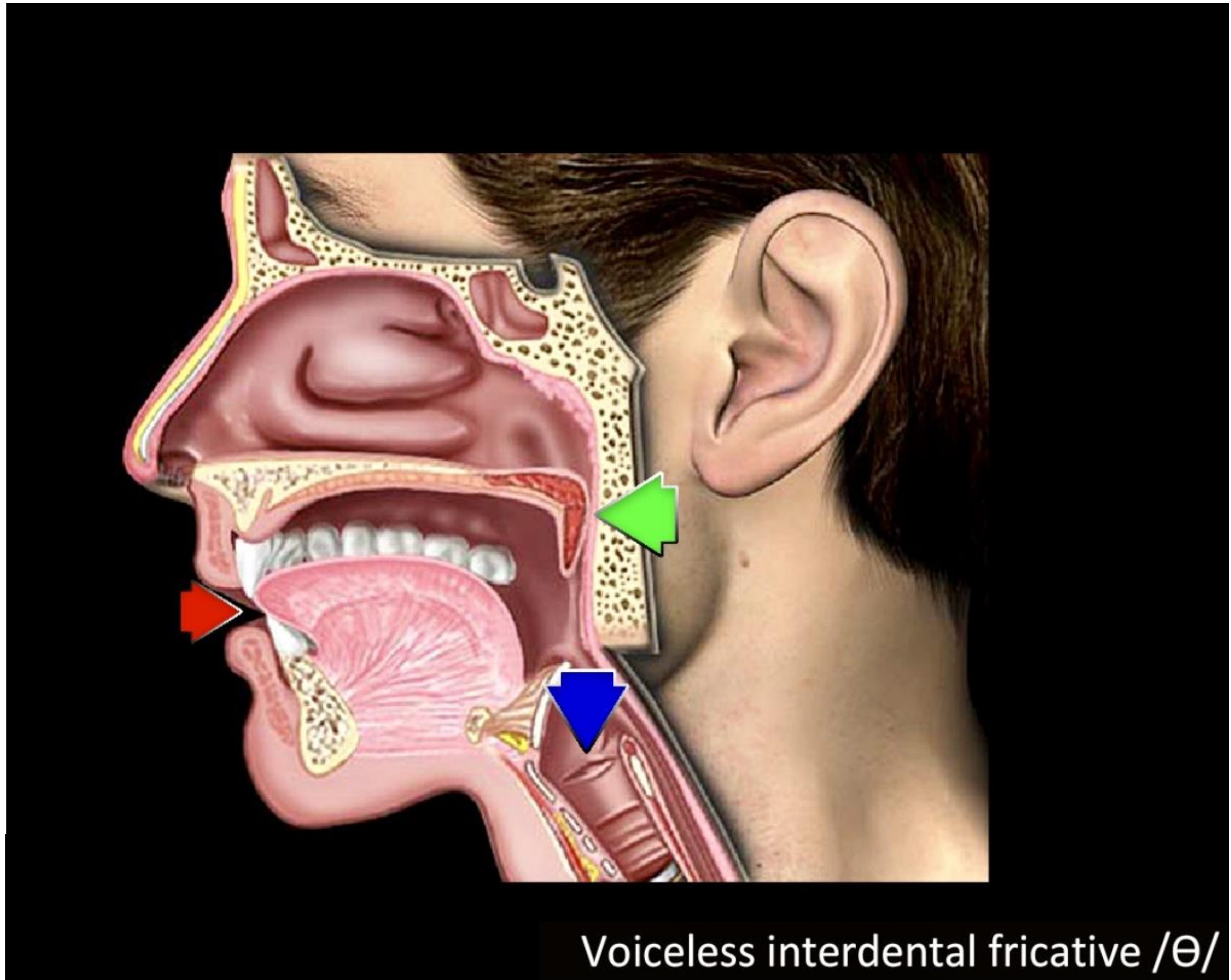
Voiced palatal fricative [ʒ]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix XI



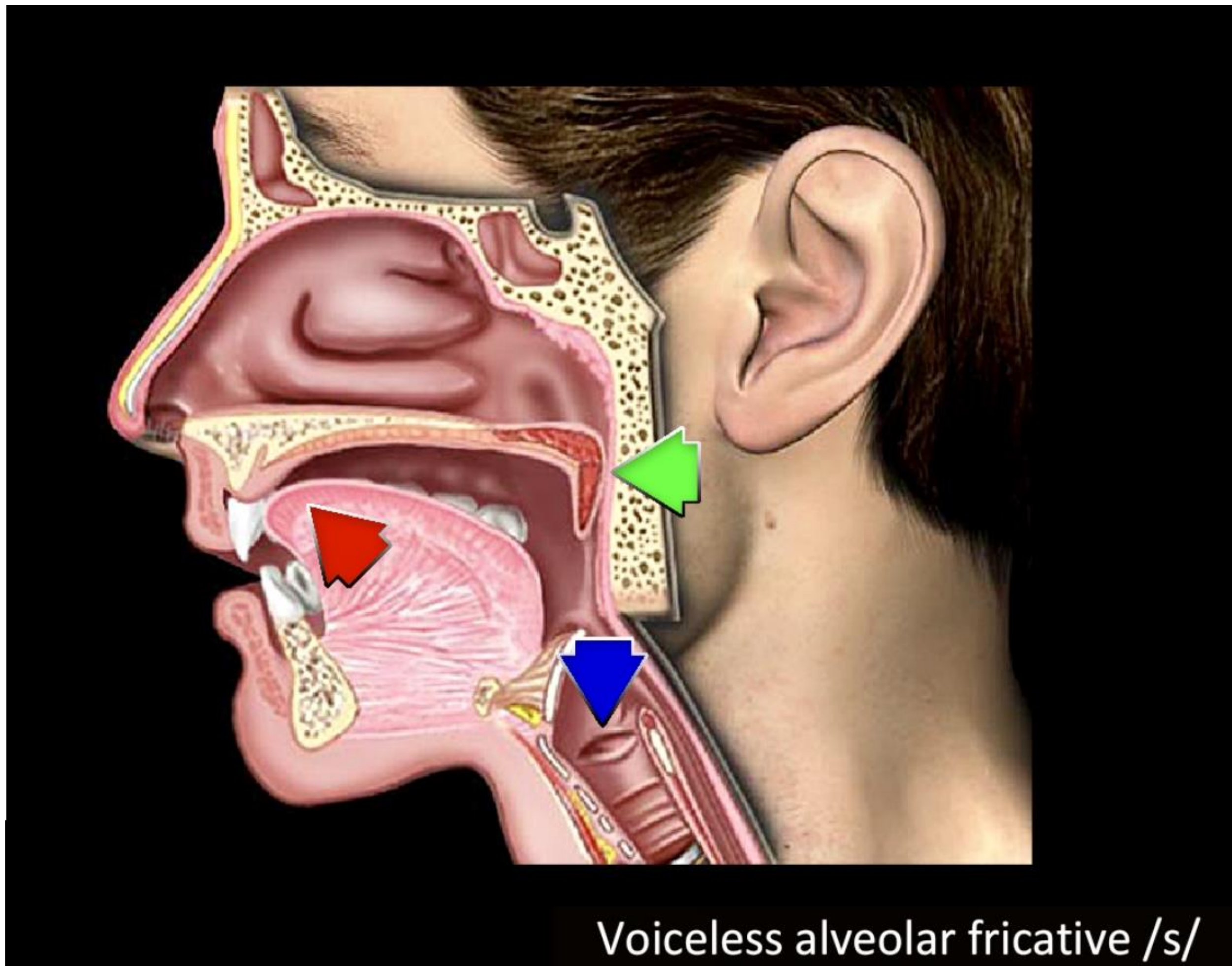
Voiceless labiodental fricative [f]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix XII



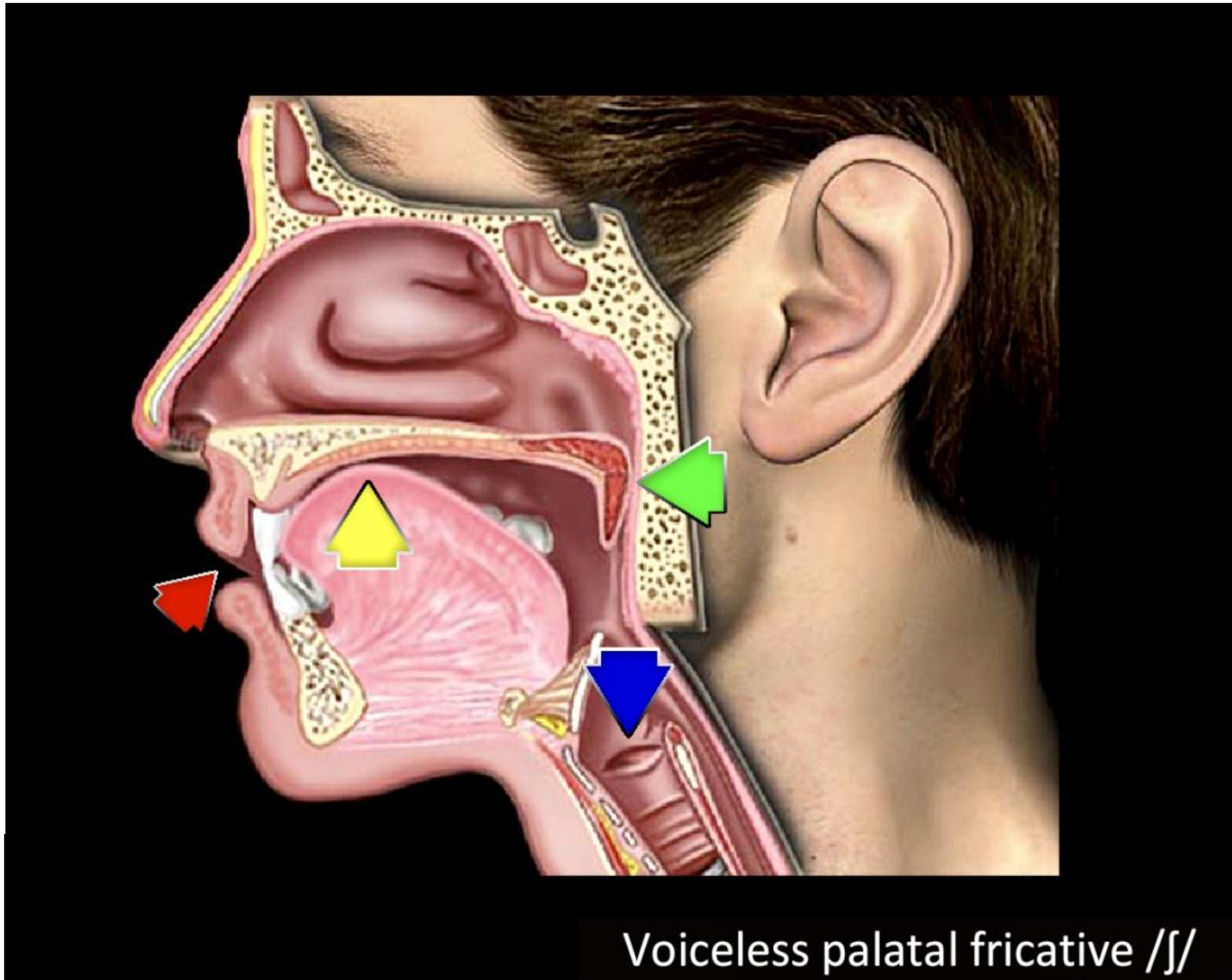
Voiceless interdental fricative [θ]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix XIII



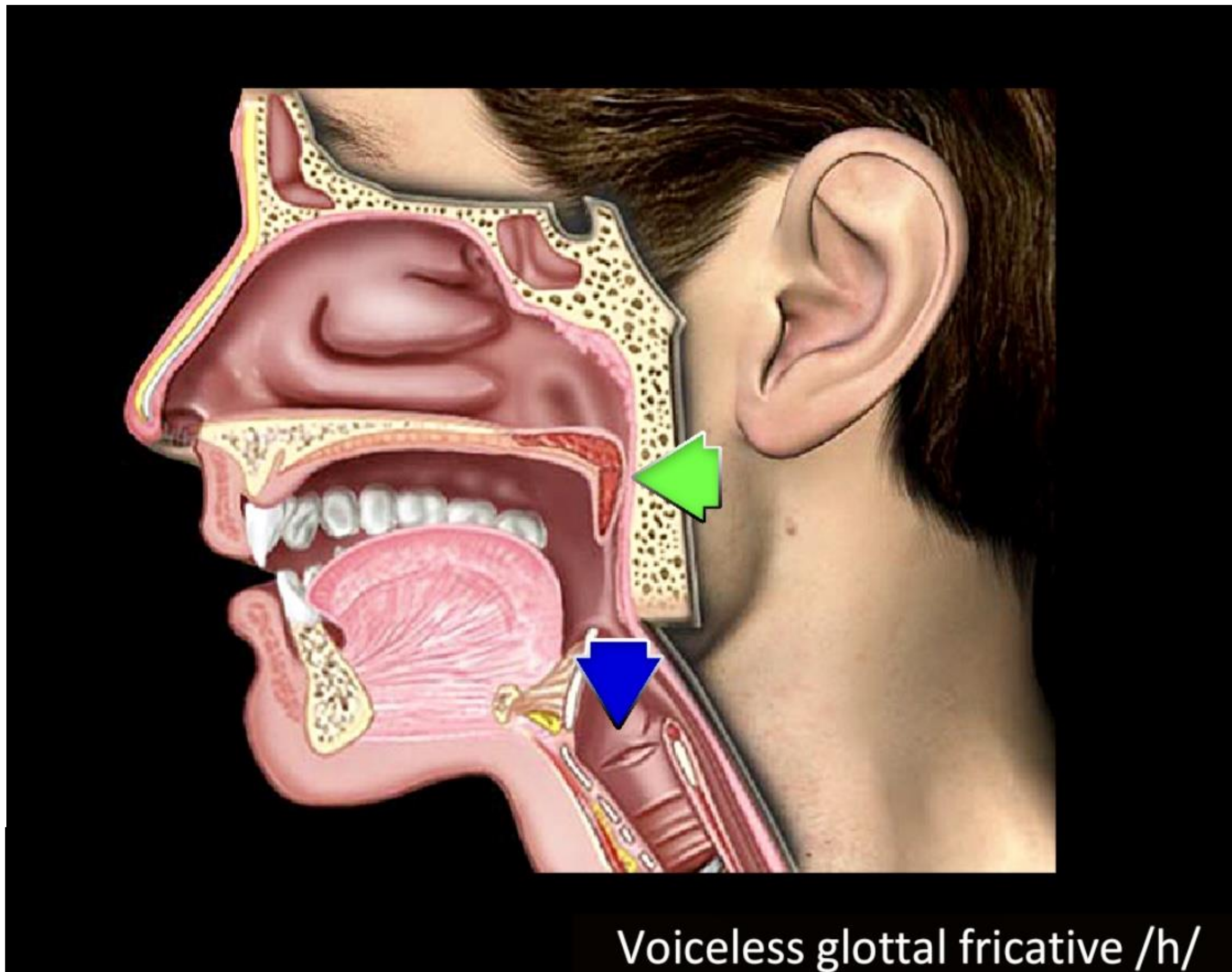
Voiceless alveolar fricative [s]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix XIV



Voiceless palatal fricative [ʃ]. Image reproduced from *Fricatives*, (Blue Tree Publishing, Inc., 2020).

Appendix XV



Voiceless glottal fricative [h]. Image reproduced from *Fricatives,* (Blue Tree Publishing, Inc., 2020).

Bibliography

Appelman, D. Ralph. *The Science of Vocal Pedagogy: Theory and Application*. Bloomington, IN: Indiana University Press, 1986.

Baddeley, Alan, and Graham Hitch. "Working Memory." *The Cognitive Neuroscience of Working Memory*, 2007, 1–20.

Bernardi, Nicolò F, De Buglio, Matteo, Trimarchi, Pietro D, Chielli, Alfonso, and Bricolo, Emanuela. "Mental Practice Promotes Motor Anticipation: Evidence from Skilled Music Performance." *Frontiers in Human Neuroscience* 7 (2013): 1–12.

Bernardi, Nicolò Francesco, Schories, Alexander, Jabusch, Hans-Christian, Colombo, Barbara, and Altenmüller, Eckart. "Mental Practice in Music Memorization: An Ecological-Empirical Study." *Music Perception* 30, no. 3 (2013): 275–90.

Bozeman, Kenneth. *Kinesthetic Voice Pedagogy: Motivating Acoustic Efficiency*. Gahanna, OH: Inside View Press, 2017.

Buccino, G, Binkofski, F, Fink, G. R, Fadiga, L, Fogassi, L, Gallese, V, Seitz, R. J, Zilles, K, Rizzolatti, G, and Freund, H.–J. "Action Observation Activates Premotor and Parietal Areas in a Somatotopic Manner: An FMRI Study." *The European Journal of Neuroscience* 13, no. 2 (2001): 400–04.

Byrne, Andrew. *The Singing Athlete: Brain-Based Training for Your Voice*. United States: Andrew Byrne Studio Incorporated, 2020.

Calvo-Merino, B, Glaser, D.E, Grèzes, J, Passingham, R.E, and Haggard, P. "Action Observation and Acquired Motor Skills: An FMRI Study with Expert Dancers." *Cerebral Cortex (New York, N.Y. 1991)* 15, no. 8 (2005): 1243–249.

Catmur, Caroline, Walsh, Vincent, and Heyes, Cecilia. "Sensorimotor Learning Configures the Human Mirror System." *Current Biology* 17, no. 17 (2007): 1527–531.

Collet, Christian, Guillot, Aymeric, and Louis, Magali. "Neurophysiological Substrates of Motor Imagery Ability." In *The Neurophysiological Foundations of Mental and Motor Imagery, The Neurophysiological Foundations of Mental and Motor Imagery*, 2010–01–14. Oxford: Oxford University Press, 2010.

Colorni, Evelina. *Singers' Italian: A Manual of Diction and Phonetics*. New York, NY: Schirmer Books, 1976.

Cornett, Vanessa. *The Mindful Musician: Mental Skills for Peak Performance*. New York, NY: Oxford University Press, 2019.

Coyle, Daniel. 2009. *The Talent Code: Greatness Isn't Born. It's Grown*. London: Arrow.

Curcic-Blake, Branislava, Ford, Judith M, Hubl, Daniela, Orlov, Natasza D, Sommer, Iris E, Waters, Flavie, Allen, Paul, Jari, Renaud, Woouff, Peter W, David, Olivier, Mulert, Christoph, Woodward, Todd S, and Aleman, Ane. "Interaction of Language, Auditory and Memory Brain Networks in Auditory Verbal Hallucinations." *Progress in Neurobiology* 148 (2017): 1–20.

Dimon, Theodore, and G. David Brown. *Anatomy of the Voice: an Illustrated Guide for Singers, Vocal Coaches, and Speech Therapists*. Berkeley, CA: North Atlantic Books, 2018.

Doidge, Norman. *The Brain That Changes Itself: Stories of Personal Triumph from the Frontiers of Brain Science*. New York: Viking, 2007.

Donnan, Thomas M. *French Lyric Diction*. Lanham, MD: University Press of America, 1994.

Duke, Robert A, Simmons, Amy L, and Cash, Carla Davis. "It's Not How Much; It's How: Characteristics of Practice Behavior and Retention of Performance Skills." *Journal of Research in Music Education* 56, no. 4 (2009): 310–21.

Fine, Philip A, Wise, Karen J, Goldemberg, Ricardo, and Bravo, Anabela. "Performing Musicians' Understanding of the Terms "Mental Practice" and "Score Analysis"." *Psychomusicology* 25, no. 1 (2015): 69–82.

Fuster, Joaquín M. "Network Memory." Trends in Neurosciences (Regular Ed.) 20, no. 10 (1997): 451–59.

Gallese, Vittorio, Fadiga, Luciano, Fogassi, Leonardo, and Rizzolatti, Giacomo. "Action Recognition in the Premotor Cortex." *Brain (London, England: 1878)* 119, no. 2 (1996): 593–609.

Gardner, Howard. *Art, Mind, and Brain: A Cognitive Approach to Creativity*. New York: Basic Books, 1982.

Gazzola, V, Rizzolatti, G, Wicker, B, and Keysers, C. "The Anthropomorphic Brain: The Mirror Neuron System Responds to Human and Robotic Actions." *NeuroImage (Orlando, Fla.)* 35, no. 4 (2007): 1674–684.

Grèzes, J, Armony, J.L, Rowe, J, and Passingham, R.E. "Activations Related to “mirror” and “canonical” Neurones in the Human Brain: An FMRI Study." *NeuroImage (Orlando, Fla.)* 18, no. 4 (2003): 928–37.

Hagoort, Peter. *Human Language: From Genes and Brains to Behavior.* Cambridge, Massachusetts: MIT Press, 2019.

Halwani, Gus F, Loui, Psyche, Rüber, Theodor, and Schlaug, Gottfried. "Effects of Practice and Experience on the Arcuate Fasciculus: Comparing Singers, Instrumentalists, and Non-musicians." *Frontiers in Psychology* 2 (2011): 156.

Harris, Robert, and De Jong, Bauke M. "Cerebral Activations Related to Audition-driven Performance Imagery in Professional Musicians." *PloS One* 9, no. 4 (2014): 1–10.

Helding, Lynn. "Motor Learning and Voice Training: Locus of Attention." *Journal of Singing* 72, no. 1 (2015): 87–91.

Helding, Lynn. *The Musician's Mind: Teaching, Learning, and Performance in the Age of Brain Science*. Lanham, MD: Rowman & Littlefield Publishing Group, 2020.

Helding, Lynn. "Singing with Your Whole Brain: The Mind-body Problem." *Journal of Singing* 71, no. 2 (2014): 227–31.

Helding, Lynn. "Teaching Voice with the Brain in Mind." *Journal of Singing* 70, no. 3 (2014): 349–54.

Hinshaw, Karin E. "The Effects of Mental Practice on Motor Skill Performance: Critical Evaluation and Meta-Analysis." *Imagination, Cognition and Personality* 11, no. 1 (1991): 3–35.

Hoch, Matthew, and Sandage, Mary J. "Exercise Science Principles and the Vocal Warm-up: Implications for Singing Voice Pedagogy." *Journal of Voice* 32, no. 1 (2017): 79–84.

Hodges, Donald, and Thaut, Michael. *The Oxford Handbook of Music and the Brain*. Oxford: Oxford University Press, Incorporated, 2019.

Hubbard, Timothy L. "Neural Mechanisms of Musical Imagery." In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 521–545. Oxford Library of Psychology. Oxford University Press, 2019.

Jacobson, Edmund. "ELECTRICAL MEASUREMENTS OF NEUROMUSCULAR STATES DURING MENTAL ACTIVITIES." *The American Journal of Physiology* 91, no. 2 (1930): 567–608.

Jäncke, Lutz. "Music and Memory." In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 237–262. Oxford Library of Psychology. Oxford University Press, 2019.

Jeannerod, M. "The Representing Brain: Neural Correlates of Motor Intention and Imagery." *The Behavioral and Brain Sciences* 17, no. 2 (1994): 187–202.

Johnston, Amanda. *English and German Diction for Singers: A Comparative Approach*. Lanham, MD: Rowman & Littlefield Publishers, Incorporated, 2016.

Kendall, Diane L, Rosenbek, John C, Heilman, Kenneth M, Conway, Tim, Klenberg, Karen, Gonzalez Rothi, Leslie J, and Nadeau, Stephen E. "Phoneme-based Rehabilitation of Anomia in Aphasia." *Brain and Language* 105, no. 1 (2008): 1–17.

Kleber, B, Veit, R, Birbaumer, N, Gruzelier, J, and Lotze, M. "The Brain of Opera Singers: Experience-Dependent Changes in Functional Activation." *Cerebral Cortex (New York, N.Y. 1991)* 20, no. 5 (2009): 1144–152.

Knott, Alistair. *Sensorimotor Cognition and Natural Language Syntax*. Cambridge, Mass.: MIT Press, 2012.

Koelsch, Stefan. *Brain and Music*. 1st ed. Chichester, West Sussex; Hoboken, NJ: Wiley-Blackwell, 2012.

Lachter, Joel. "Consciousness in Natural Language and Motor Learning." *The Behavioral and Brain Sciences* 17, no. 3 (1994): 409–10.

LeBorgne, Wendy DeLeo, and Rosenberg, Marci Daniels. *The Vocal Athlete*. Second ed. San Diego, CA: Plural Publishing, 2019.

Leigh-Post, Karen. *Mind-body Awareness for Singers : Unleashing Optimal Performance*. San Diego, CA: Plural Publishing, 2014.

Leisman, Gerry, Ahmed Moustafa, and Tal Shafir. "Thinking, Walking, Talking: Integratory Motor and Cognitive Brain Function," *Frontiers in Public Health* 4, no. 94 (May 2016): 1–15.

Levitin, Daniel J. *This Is Your Brain on Music: The Science of a Human Obsession*. New York, N.Y.: Dutton, 2006.

Logothetis, Nikos K. "What We Can Do and What We Cannot Do with fMRI." *Nature (London)* 453, no. 7197 (2008): 869–78.

Loui, Psyche, and Guetta, Rachel E. "Music and Attention, Executive Function, and Creativity." In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 263–284. Oxford Library of Psychology. Oxford University Press, 2019.

Luo, Cheng, Guo, Zhi-wei, Lai, Yong-xiu, Liao, Wei, Liu, Qiang, Kendrick, Keith M, Yao, De-zhong, and Li, Hong. "Musical Training Induces Functional Plasticity in Perceptual and Motor Networks: Insights from Resting-State FMRI." *PloS* One 7, no. 5 (2012): 1–10.

MacIntyre, Tadhg E, Moran, Aidan P, Collet, Christian, and Guillot, Aymeric. "An Emerging Paradigm: A Strength-based Approach to Exploring Mental Imagery." *Frontiers in Human Neuroscience* 7 (2013): 1–12.

MacIntyre, Tadhg E, Madan, Christopher R, Moran, Aidan P, Collet, Christian, and Guillot, Aymeric. "Motor Imagery, Performance and Motor Rehabilitation." *Progress in Brain Research* 240 (2018): 141–59.

Malouin, Francine and Carol Richards. “Mental Practice for Relearning Locomotor Skills,” *Physical Therapy* 90, no. 2 (February 2010): 240–250.

Massen, Cristina, and Prinz, Wolfgang. "Activation of Action Rules in Action Observation." *Journal of Experimental Psychology. Learning, Memory, and Cognition* 33, no. 6 (2007): 1118–130.

Maxfield, Lynn. "Slow Practice: How to Do More Than Just Practice Slowly." *Journal of Singing* 75, no. 1 (2018): 69–73.

McCoy, Scott Jeffrey, Halstead, Lucinda, and Helding, Lynn. *Your Voice: An inside View*. Third ed. Gahanna, Ohio: Inside View Press, 2019.

McGuigan, F. J. "A Neuromuscular Model of Mind With Clinical and Educational Applications." *The Journal of Mind and Behavior* 18, no. 4 (1997): 351–70.

McKinney, James C. *Diagnosis and Correction of Vocal Faults: A Manual for Teachers of Singing and for Choir Directors*. Nashville, TN: Waveland Press, 1994.

Meister, I.G., T. Krings, H. Fptys. B. Boroojerdi, M. Müller, R. Töpper, and A. Thron. “Playing piano in the mind—an fMRI study on music imagery and performance in pianists,” *Cognitive Brain Research* 19 (December 2003): 219–228.

Mielke, Susan, and Comeau, Gilles. "Developing a Literature-based Glossary and Taxonomy for the Study of Mental Practice in Music Performance." *Musicae Scientiae* 23, no. 2 (2019): 196–211.

Montero, Barbara Gail. *Thought in Action: Expertise and the Conscious Mind*. First ed. Oxford, United Kingdom: Oxford University Press, 2016.

Moorcroft, Lynda. “DIRECTIONAL IMAGERY IN VOICE PRODUCTION .” *The inaugural International Conference on Music Communication Science*, December 5, 2007, 103–6.

Moran, Aidan, Campbell, Mark, and Toner, John. "Exploring the Cognitive Mechanisms of Expertise in Sport: Progress and Prospects." *Psychology of Sport and Exercise* 42 (2019): 8–15.

Moran, Aidan, Guillot, Aymeric, MacIntyre, Tadhg, and Collet, Christian. "Re-imagining Motor Imagery: Building Bridges between Cognitive Neuroscience and Sport Psychology." *The British Journal of Psychology* 103, no. 2 (2012): 224–47.

Mukamel, Roy, Ekstrom, Arne D, Kaplan, Jonas, Iacoboni, Marco, and Fried, Itzhak. "Single-Neuron Responses in Humans during Execution and Observation of Actions." *Current Biology* 20, no. 8 (2010): 750–56.

Obeid, Rita. "Exploring the Relationship between Sequence Learning, Motor Coordination, and Language Development." Order No. 10273333, City University of New York, 2017.

Page, Stephen J, and Harnish, Stacy. "Thinking about Better Speech: Mental Practice for Stroke-induced Motor Speech Impairments." *Aphasiology* 26, no. 2 (2012): 127–42.

Pascual-Leone, Alvaro. "The Brain That Plays Music and Is Changed by It." *Annals of the New York Academy of Sciences* 930, no. 1 (2001): 315–29.

Penhune, Virginia B. "Musical Expertise and Brain Structure: The Causes and Consequences of Training." In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 419–438. Oxford Library of Psychology. Oxford University Press, 2019.

Penhune, Virginia B, Chen, Joyce L, and Zatorre, Robert J. "When the Brain Plays Music: Auditory-motor Interactions in Music Perception and Production." *Nature Reviews. Neuroscience* 8, no. 7 (2007): 547–58.

Prather, J. F, Nowicki, S, Peters, S, and Mooney, R. "Precise Auditory-vocal Mirroring in Neurons for Learned Vocal Communication." *Nature (London)* 451, no. 7176 (2008): 305–10.

Press, Clare, Gillmeister, Helge, and Heyes, Cecilia. "Sensorimotor Experience Enhances Automatic Imitation of Robotic Action." *Proceedings of the Royal Society. B, Biological Sciences* 274, no. 1625 (2007): 2509–514.

Pruitt, Tim, Andrea Halpern, and Peter Pfordresher. "Covert singing in anticipatory auditory imagery," *Psychophysiology* 56, no. 3 (October 2018): 1–10.

Ragan, Kari. *A Systematic Approach to Voice: The Art of Studio Application*. San Diego, CA: Plural Publishing, 2020.

Ragan, Kari. "Vocal Health for the Performing Artist." *University of Washington Vocal Pedagogy*. Lecture, February 2, 2021.

Ranganathan, Vinoth, Blodek Siemionow, Jing Liu, Vinod Sahgal, and Guang Yue. "From mental power to muscle power—gaining strength by using the mind," *Neuropsychologia* 42 (November 2003): 944–956.

Repetto, Claudia, Colombo, Barbara, and Riva, Giuseppe. "Is Motor Simulation Involved During Foreign Language Learning? A Virtual Reality Experiment." *SAGE Open* 5, no. 4 (2015): 1–8.

Rizzolatti, Giacomo, and Craighero, Laila. "The Mirror-neuron System." *Annual Review of Neuroscience* 27, no. 1 (2004): 169–92.

Rizzolatti, Giacomo, Fogassi, Leonardo, and Gallese, Vittorio. "Neurophysiological Mechanisms Underlying the Understanding and Imitation of Action." *Nature Reviews. Neuroscience* 2, no. 9 (2001): 661–70.

Rizzolatti, Giacomo, Fadiga, Luciano, Gallese, Vittorio, and Fogassi, Leonardo. "Premotor Cortex and the Recognition of Motor Actions.*" Brain Research. Cognitive Brain Research* 3, no. 2 (1996): 131–41.

Russo, Frank. "Multisensory Processing in Music." In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 212–236. Oxford Library of Psychology. Oxford University Press, 2019.

Saladin, Kenneth S., Sullivan, Stephen J., and Gan, Christina A. *Anatomy & Physiology: The Unity of Form and Function*. Seventh ed. New York: McGraw-Hill Education, 2015.

Sanders, Charles W, Sadoski, Mark, Bramson, Rachel, Wiprud, Robert, and Van Walsum, Kim. "Comparing the Effects of Physical Practice and Mental Imagery Rehearsal on Learning Basic Surgical Skills by Medical Students." *American Journal of Obstetrics and Gynecology* 191, no. 5 (2004): 1811–814.

Schlaug, Gottfried. "Brain Structures of Musicians: Executive Functions and Morphological Implications." In *Music, Motor Control and the Brain*, 2006-07-27. Oxford: Oxford University Press, 2006.

Schmidt, Richard A., and Lee, Timothy Donald. *Motor Control and Learning: A Behavioral Emphasis*. 3rd ed. Champaign, IL: Human Kinetics, 1999.

Schön, Daniele, and Morillon, Benjamin. “Music and Language.” In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 391–418. Oxford Library of Psychology. Oxford University Press, 2019.

Schreiner, Christoph E, and Winer, Jeffery A. "Auditory Cortex Mapmaking: Principles, Projections, and Plasticity." *Neuron (Cambridge, Mass.)* 56, no. 2 (2007): 356–65.

Schuster, Corina, Hilfiker, Roger, Amft, Oliver, Scheidhauer, Anne, Andrews, Brian, Butler, Jenny, Kischka, Udo, and Ettlin, Thierry. "Best Practice for Motor Imagery: A Systematic Literature Review on Motor Imagery Training Elements in Five Different Disciplines." *BMC Medicine* 9, no. 1 (2011): 1–35.

Tanaka, Shoji and Eiji Kirino. “Dynamic Reconfiguration of the Supplementary Motor Area Network during Imagined Music Performance,” *Frontiers in Public Health* 11, no. 606 (December 2017): 1–8.

Thaut, Michael H, and Braun Janzen, Thenille. "Cerebral Organization of Music Processing." In *The Oxford Handbook of Music and the Brain*, edited by Michael H. Thaut and Donald A. Hodges, 89–121. Oxford Library of Psychology. Oxford University Press, 2019.

Theiler, Anne M, and Lippman, Louis G. "Effects of Mental Practice and Modeling on Guitar and Vocal Performance." *The Journal of General Psychology* 122, no. 4 (1995): 329–43.

Titze, Ingo R. "The Human Instrument." *Scientific American* 298, no. 1 (2008): 94–101.

Toner, John, Montero, Barbara Gail, and Moran, Aidan. "Considering the Role of Cognitive Control in Expert Performance." *Phenomenology and the Cognitive Sciences* 14, no. 4 (2015): 1127–144.

Toner, John, and Moran, Aidan. "Enhancing Performance Proficiency at the Expert Level: Considering the Role of ‘somaesthetic Awareness’." *Psychology of Sport and Exercise* 16 (2015): 110–17.

Toner, John, and Moran, Aidan. "Exploring the Orthogonal Relationship between Controlled and Automated Processes in Skilled Action." *Review of Philosophy and Psychology*, 2020, Review of Philosophy and Psychology, 2020-08-22.

Toner, John, Montero, Barbara Gail, and Moran, Aidan. "The Perils of Automaticity." *Review of General Psychology* 19, no. 4 (2015): 431–42.

"UCLA Researchers Make First Direct Recording of Mirror Neurons in Human Brain." *NewsRx Health & Science*, 2010, 128.

Verdolini, Katherine. "On the Voice: Learning Science Applied to Voice Training: The Value of Being 'In the Moment'." *The Choral Journal* 42, no. 7 (2002): 47–51.

Viskontas, Indre. *How Music Can Make You Better*. San Francisco, CA: Chronicle Books, 2019.

Welberg, Leonie. "Mirror Neurons Singing in the Brain." *Nature Reviews. Neuroscience* 9, no. 3 (2008): 163.

Welberg, Leonie. "Learning to Reflect." *Nature Reviews. Neuroscience* 8, no. 10 (2007): 737.

Welch, Graham F. "Improvability of Poor Pitch Singing: Experiments in Feedback." Dissertation, University of London, 1983.

Wiestler, Tobias, and Diedrichsen, Jörn. "Skill Learning Strengthens Cortical Representations of Motor Sequences." *ELife* 2 (2013): 1–20.

Wilson, Sarah J, Abbott, David F, Lusher, Dean, Gentle, Ellen C, and Jackson, Graeme D. "Finding Your Voice: A Singing Lesson from Functional Imaging." *Human Brain Mapping* 32, no. 12 (2011): 2115–130.

Zhao, Xiaoguang, and Zhu, Lei. "Schema Theory and College English Reading Teaching." English Language Teaching (Toronto) 5, no. 11 (2012): 111–117.