“Performance Adrenaline”:

The Effects of Endorphins, Serotonin, Dopamine, and Adrenaline

On the Performing Singer

by

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ABSTRACT

The thrill of a live performance can enhance endorphin, serotonin, dopamine, and adrenaline levels in the body. This mixture of heightened chemical levels is a result of "performance adrenaline." This phenomenon can positively and/or negatively affect a performing singer. A singer's body is her instrument, and therefore, any bodily change can alter the singing voice. The uptake of these chemicals can especially influence a central aspect of singing: breath. "Performance adrenaline" can induce shallow or clavicular breathing, alter phonation, and affect vibrato. To optimize the positive effects and counteract the negative, diaphragmatic breathing, yoga, and beta-blockers are explored as viable management tools. When managed properly, the boost offered by "performance adrenaline" can aid the singer in performing and singing. After a review of medical and psychological studies that reveal the physiological and emotional effects of endorphins, serotonin, dopamine, and adrenaline, this paper will explore the biological changes specific to vocalists and methods to optimize these effects in performance.

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Preface

Performance anxiety is a tremendous concern for many performing musicians while others can thrive under the pressures of a live performance with few concerns about anxiety. For most musicians, the thrill of performing in front of a live audience offers opportunities for unexpected and exciting occurrences, both positive and negative. This excitement creates physiological changes, including an uptake of "performance adrenaline." This phenomenon of "performance adrenaline" is an enhanced performance caused by a concentration of endorphins (a neuropeptide), serotonin and dopamine (both neurotransmitters), and adrenaline (a neurotransmitter and hormone).[1]

Changes wrought by these powerful substances affect the performing singer's breath, which can impact the voice and performance. These chemical changes can thus fuel a singer's best performance, both vocally and emotionally. It can also jeopardize a potentially great performance if the singer does not adequately manage the physical changes created by the chemical increases. After a review of medical and psychological studies that reveal the physiological and emotional effects of endorphins, serotonin, dopamine, and adrenaline, this paper will explore the biological changes specific to vocalists and methods to optimize these effects in performance.

A singer experiences "performance adrenaline" when performing in front of an audience. The responsive energy from the audience, the thrill of not knowing what may happen during the live performance, and the desire to succeed all contribute to heightened

[1] Erich Vanecek, Thomas Biegl, and Johanna Gerngroß, "Psycho-physiologische Forschungsbeiträge zur Musikwirkung [Psycho-physiological Research of Music Effects]," *Musik-, Tanz- und Kunsttherapie* 17, no. 2 (2006): 96.

"performance adrenaline" levels. The musician is aware of being in the spotlight, and thus, his body undergoes biological changes. Endorphin, serotonin, dopamine, and adrenaline levels alter as a result of "performance adrenaline." Each chemical affects the body in a distinct manner and can be beneficial during performance. Performing singers are especially sensitive to these biological changes because the body is a singer's instrument, and any alteration to the body can influence the production of the singing voice.

"Performance adrenaline" specifically occurs when the singer perceives the stressful event of performing positively. As a result, the singer feels little to no anxiety, and the effects of "performance adrenaline" can positively affect the performance. This differs from performance anxiety in which the singer perceives the stress negatively and suffers from anxiety. The symptoms of performance anxiety are different from the effects of "performance adrenaline" and impact the singer in other distinct ways.[2] This paper will focus only on the effects of "performance adrenaline" and how they can impact the singer and the performance.

[2] Shirlee Emmons and Alma Thomas, "Voice Pedagogy: Understanding Performance Anxiety," *Journal of Singing – The Official Journal of the National Association of Teachers of Singing* 64, no. 4 (Mar 2008): 462.

Chapter One

A Pre-concert Cocktail: Endorphins, Serotonin, Dopamine, and Adrenaline

Introduction

A 2006 psycho-physiological study conducted by Erich Vanecek and his team investigated the effects of music on the singers' bodies. Teammate Thomas Biegl confirmed that the body undergoes chemical changes during a live performance. By testing the chemical levels of six singers before and after a live performance, the experiment pinpointed changes in serotonin, dopamine, endorphin, and adrenaline levels. According to the study, these alterations are associated with our well-being. Vanecek and colleagues not only proved the existence of "performance adrenaline," they also provided insight into physical changes during a live performance.[3]

This chapter will look closely at the chemicals - endorphins, serotonin, dopamine, and adrenaline. It will explain how each chemical works in the body and its functions. The next chapter will connect the effects of each chemical and how it influences a performing singer.

[3] Erich Vanecek, Thomas Biegl, and Johanna Gerngroß, "Psycho-physiologische Forschungsbeiträge zur Musikwirkung [Psycho-physiological Research of Music Effects]," *Musik-, Tanz- und Kunsttherapie* 17, no. 2 (2006): 96.

Endorphins

Endorphins were initially discovered in 1975 by a group of scientists led by John Hughes and Hans W. Kosterlitz. The team discovered an endogenous substance in the brain that attached to opioid receptor sites and created a chemical response. The scientists named this substance enkephalin. It was determined that enkephalin produced pain-relieving effects because it activated at the opioid receptor sites.[4] Other scientists continued to research this newly discovered substance. Most notably, biochemist Choh Li furthered the research in 1978 by discovering beta-endorphins in the brain.[5] With this new information, scientists were able to discover and classify endorphins, which are continuously researched today.

Endorphins are neurotransmitters, which are chemicals that transmit information within the nervous system. Over 300 known chemicals in the body are characterized as neurotransmitters.[6] These chemicals send, receive, modulate, and/or amplify messages within the brain and throughout the entire body.[7] As a neurotransmitter, endorphins primarily send pain-relieving signals throughout the body and produce effects similar to those of morphine.

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[4] J. Hughes et al., "Pharmacology Identification of Two Related Pentapeptides from the Brain with Potent Opiate Agonist Activity: Nature," *Pain* 2, no. 3 (Sep 1976): 329.

[5] Susan Heller Anderson, "Dr. Choh Hao Li, 74, Biochemist; Synthesized Hormone for Growth," *New York Times,* December 1, 1987: D27.

[6] "Neurotransmitter," in *The Columbia Encyclopedia*, New York: Colmubia University Press, 2013, accessed December 17, 2014, http://literati.credoreference.com.

[7] Ibid.

All chemicals that relieve pain are known as opioids. These chemicals work by binding to opioid receptors predominantly located in the central nervous system and the gastrointestinal tract. Opioids that are naturally produced in the body, such as endorphins, are specifically classified as endogenous opioids. Chemicals that are not naturally produced by the body but mimic the effects of endogenous opioids are known as just opioids or opiates. These non-biological substances function like naturally occurring endorphins and can be delivered through foods and drugs. Morphine and codeine, known for their pain-relieving properties, perform just like endorphins by activating opioid-receptors.[8] These and other painkilling drugs regulate pain in ways similar to endorphins, but pharmaceuticals can produce harmful side effects such as addiction.

As endorphins occur naturally in the body, they are safe to experience. The body produces endorphins when under stress to help the body function.[9] The release of endorphins in the body helps regulate pain; additionally, this chemical produces other effects. Endorphin increases may help regulate blood pressure, body temperature, respiration, eating, drinking, sexual activity, and memory. By regulating the perceived pain in addition to regulating other body functions, endorphins can be effective handling stress.

The effect of endorphins on regulating blood pressure is especially important. Endorphins create hypotensive effects, which lowers blood pressure. Endorphins work

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[8] Anthony L. Vaccarino and Abba J. Kastin, “Endogenous Opiates: 2000,” *Peptides* 22 (2001): 2257.

[9] Ibid, 2258.

specifically on the distal blood vessels, such as the arterioles and venules, and use peripheral vasodilators. These peripheral vasodilators widen the distal blood vessels and lower blood pressure. This lowered blood pressure allows the heart to more easily pump blood through the peripheral blood vessels and the rest of the body.[10] The increased endorphin levels will lower blood pressure, which will help the body manage stress.

Endorphins also affect the respiratory system. Endorphins, as well as other opioid peptides, target the medulla in the brain. The medulla contains the respiratory center as well as other involuntary functions. In the medulla, the endorphins produce respiratory depression. By depressing respiratory function, breathing can slow and be controlled.[11] This slowed breathing is especially important to singers. If the body's autonomic breathing is controlled, the singer can practice effective breathing for singing.

The experience of a live performance naturally produces endorphins in the performer. The effects of endorphins regulate pain, if needed, but the side effects can be more relevant to a performing singer. Endorphins can most significantly help the body regulate blood pressure, body temperature, respiration, and memory. Under the pressure of a live performance, the body's ability to function somewhat normally can be beneficial during this high stress situation for a performing singer.

[10] Fiorella Fontana et al., "Opioid Peptides Attenuate Blood Pressure Increase in Acute Respiratory Failure," *Peptides* 22, no. 4 (April 2001): 631.

[11] G. Feuerstein, "The Opioid System and Central Cardiovascular Control: Analysis of Controversies," *Peptides* 5, no. 2 (1985): 51.

Serotonin

Serotonin is a hormone and neurotransmitter naturally found in the body, as well as in other plants and animals. Italian doctor Vittorio Erspamer initially discovered serotonin in the early 1930s. Interested in the study of drugs from natural sources, Erspamer discovered a substance that caused smooth muscles to contract, which he named enteramine.[12]

In the late 1940s, biomedical researcher Irvine Page studied hypertension and arteriosclerosis, paying particular attention to the naturally occurring constricting factors in blood. When the blood coagulated, another substance appeared. Page recruited chemist Maurice Rapport and biochemist Arda Green to help with his research. Together, the three researchers isolated and characterized the substance produced during blood coagulation. They named this serum vasoconstrictor 'serotonin.'[13]

Researcher Betty Mack Twarog began examining connections between smooth muscle membranes and neurotransmitters in 1949. She found an unidentified neurotransmitter that seemed to fit the properties of the newly discovered serotonin, but it functioned as a neurotransmitter in the smooth muscle membrane. By studying Erspamer's writings, Twarog discovered that serotonin and enteramine were the same substance.[14]

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[12] Patricia Mack Whitaker-Azmitia, "The Discovery of Serotonin and Its Role in Neuroscience," *Neuropsychopharmacology* 21, no. 2 (Aug 1999): 2S.

[13] Ibid, 3S-4S.

[14] Ibid, 6S.

Convinced that the serotonin neurotransmitter would be present in the brain, Twarog began collaborating with Page in 1952. As a result, they discovered that serotonin was found in the brain and hypothesized that it functioned as a neurotransmitter. Dilworth Wayne Woolley continued the research to further confirm this hypothesis. By hypothesizing that serotonin played a role in mental illness and brain development, he helped confirm serotonin's presence in the brain as a neurotransmitter.[15]

Since serotonin was initially discovered in the early 1930s, new information continues to be revealed about the substance. Through the studies conducted from the 1930s-1960s, researchers have proven serotonin's significance in the central nervous system as well as regulating nearly all brain function. Additionally, serotonin is important to the function of all of the other major organ systems.[16]

Serotonin's importance in the central nervous system influences most human behavioral processes. The serotonin neurons in the central nervous system are positioned within the brain to contact most of the human brain circuits. Due to serotonin's access to most of the brain, it can alter mood, perception, reward, anger, aggression, appetite, memory, sexuality, attention, and other behavioral processes.[17]

Researchers continue to discover information about the substance that can be especially relevant to performing singers. As a neurotransmitter, serotonin increases the

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[15] Ibid, 7S.

[16] Miles Berger, John A. Gray, and Bryan L. Roth, "The Expanded Biology of Serotonin," *Annual Review of Medicine* 60, (2009): 356.

[17] Ibid.

attention to, recognition of, and emotional processing of others' facial expressions.[18] Another cognitive process connected to the serotonin transporter is enhanced memory. By studying patients with Alzheimer's disease, a disease whose primary recognized symptom is memory issues, researchers found the serotonin transporter expression to be decreased throughout the brain in these patients. Additionally, experiments involving pharmacological and genetic manipulations of the serotonin transporter proved increased memory performance in humans. There is still much to be revealed about serotonin's interactions with memory.[19]

Serotonin also plays a role in the cardiovascular system. Much like serotonin's wide-ranging effects in the brain, serotonin also alters the vascular system in various ways. Most prominently, serotonin can control vascular resistance and blood pressure as well as effect hemostasis and platelet function. Serotonin can cause vasoconstriction or vasodilation in various vascular beds in each vessel wall and surrounding smooth muscle tissue. As blood platelets lack the enzymes to synthesize serotonin, serotonin can cause platelet aggregation, vasoconstriction, and thus cause hemostasis, which interrupts blood flow. Due to this occurrence, serotonin causes most individuals to experience a decrease in blood pressure.[20]

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[18] Ai Koisumi et al., "Serotonin Transporter Gene-Linked Polymorphism Affects Detection of Facial Expressions," *PLoS One* 8, no. 3 (2013): 1, accessed November 17, 2013, doi: 10.1371/journal.pone.0059074.

[19] Alfredo Meneses et al., "Serotonin Transporter and Memory," *Neuropharmacology* 61, no. 3 (Sept 2011): 355.

[20] Berger, Gray, and Roth, "The Expanded Biology of Serotonin," 358.

Additionally, serotonin regulates some cardiac function. Studies suggest that serotonin helps improve cardiac function through various methods. Serotonin increases in failing cardiac ventricles, which may assist in ventricular remodeling. Serotonin may also help improve cardiac function during congestive heart failure. Consequently, serotonin plays a positive role in different aspects of cardiac function.[21]

Serotonin also affects the respiratory system. Through its function in the brainstem, serotonin helps control breathing and respiratory drive. Serotonin can control breathing by activating the rhythm-generating respiratory neurons in the brainstem. In addition to serotonin's effects on breathing, it also aids those with pulmonary artery hypertension, which is high blood pressure in the arteries that connect the lungs and heart. Serotonin can prevent increased pulmonary vascular resistance just as it helps control vascular resistance and blood pressure.[22]

Serotonin also stimulates the endocrine system, metabolism, and the gastrointestinal system. Serotonin plays an important role in regulating energy balance and glucose homeostasis. Serotonin also helps regulate overall metabolic rate and temperature control in the body. It can also control digestion through the GI system. Approximately 95% of total body serotonin is in the stomach, but serotonin is also important throughout the entire GI tract. Once food enters the GI tract, serotonin immediately assists in propelling the food's path through the body.[23]

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[21] Ibid, 359.

[22] Ibid, 358.

[23] Ibid, 360-1.

Similar to the work of endorphins, serotonin also aids in pain control. By accessing the central and peripheral nervous systems, serotonin sensitizes the signals created by inflamed tissue that are sent to the central nervous system. Serotonin neurons from the brainstem also help alter the perception of pain.[24]

Serotonin can be found in genitourinary function and the reproductive system, as well. It enhances genitourinary function by prolonging ejaculatory latency and delaying orgasms. Serotonin also aids in uterine contraction, which can help transport sperm to the oviduct. In addition, higher serotonin levels are found in pregnant women. The increased serotonin during pregnancy can be either helpful or hurtful for the woman and her baby depending on individual differences.[25]

Serotonin affects almost every system in the body and is especially relevant to performing singers because it affects the cardiovascular, nervous, digestive, and respiratory systems. Serotonin is always present in the body, and an increase in this substance can produce positive effects. For a performing singer, the increased level of serotonin can be beneficial during performance. Due to serotonin's capacity to control and regulate many bodily processes, it can help the body maintain a normal state while performing.

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[24] Ibid, 361.

[25] Ibid, 361-2.

Dopamine

Dopamine is a neurotransmitter that was officially characterized in the 1950s. When dopamine was initially discovered, it was thought to function as a converter of tyrosine, an amino acid used by cells to create proteins, to adrenaline and noradrenaline. In 1957, a team in Sweden led by Arvid Carlsson found that dopamine was a neurotransmitter, not an intermediary in the synthesis of adrenaline and noradrenaline.[26] Researchers currently continue to study and discover new insights about dopamine.[27] Though dopamine is only present in approximately 1% of the neurons in the brains, it has wide-reaching effects in the body. It can alter the body both physically and behaviorally.[28]

In the brain, there are many dopamine pathways through which the release of dopamine transmits information throughout the brain. There are only two major and important pathways for dopamine. The larger pathway is the nigrostriatal dopamine pathway, which contains about 70% of the dopamine in the brain.[29] This pathway is mainly involved in regulating motor function throughout the body, which includes all

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[26] Anders Björklund and Stephen B. Dunnett, "Fifty Years of Dopamine Research," *Trends in Neurosciences* 30, no. 5 (May 2007): 185.

[27] Paul Willner, "Dopamine," In *The International Encyclopedia of Depression*, New York: Springer Publishing Company, 2009, accessed December 18, 2014, http://literati.credoreference.com.

[28] Ian Creese and Lisa Taylor, "Dopamine," In *Encyclopedia of the Human Brain*, Oxford: Elsevier Science & Technology, 2002, accessed December 18, 2014, http://literati.credoreference.com.

[29] Ibid.

intentional movement.[30] The second is the mesocorticolimbic pathway. This pathway is related to the limbic system and affects behavioral functions, specifically motivation, reward, emotion, and cognitive processing.[31]

Dopamine affects motor control by way of the nigrostriatal pathway. This pathway connects the substantia nigria, which is a structure located in the midbrain, to the striatum, which is located in the subcortial part of the brain. The striatum receives information through this pathway and then transfers the information to the basal ganglia system. Basal ganglia are located at the base of the forebrain and are connected with several other brain areas. The basal ganglia motor loop is a system that is primarily involved with the production of movement. Through this complex system, dopamine greatly affects motor control and movement.[32]

Due to dopamine's influence on motor control, there is a connection between dopamine and Parkinson's disease. A primary marker of this disease is the loss of motor control. This symptom is caused by the degeneration of dopamine neurons in the substantia nigra, and thus, in the nigrostriatal pathway. This causes decreased dopamine neurotransmission to the striatum, and the regulation of motor control is reduced.[33]

Dopamine that travels through the mesocorticolimbic pathway plays a large role in cognition. Though this is the smaller of the two main dopamine pathways, it transfers

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[30] Willner, "Dopamine."

[31] Ibid.

[32] Filip Bergquist, Haydeh Niazi Shahabi, and Hans Nissbrandt, "Somatodendritic Dopamine Release in Rat Substantia Nigra Influences Motor Performance on the Accelerating Rod," *Brain Research* 973, no. 1 (May 2003): 81.

[33] Ibid, 81-2.

information to both the prefrontal and limbic cortices in the brain. Dopamine alters cognition specifically by modulating the prefrontal cortex function. The dopamine enhances executive function, which is a term for cognitive control and the supervisory attentional system. Executive function regulates cognitive processes, which includes memory, reasoning, task flexibility, problem solving, and decision-making. Cognition is also imperative for attention, language comprehension, and expression.[34]

A dopamine increase typically releases in reaction to a change in environment. This new change activates dopamine and prepares the body to be adaptive. The stimulant can occur out of a positive change, such as reward, or a negative change, such as stress. By stimulating both the motor control and the limbic system, a person can prepare physically and emotionally for the upcoming event.[35]

Another positive effect of dopamine is its influence on regulating the immune system. The immune system is largely controlled by the central and peripheral sympathetic nervous systems. The brain regulates the immune system through many neurotransmitters interacting with immune effector cells that maintain the system's homeostasis. New research shows dopamine's involvement as a neurotransmitter helping

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[34] Shinichiro Nakajima et al., "The Potential Role of Dopamine D_3 Receptor Neurotransmission in Cognition," *European Neuropsychopharmacology* 23, no. 8 (Aug 2013): 800-1.

[35] "Dopamine Systems," in *The Concise Corsini Encyclopedia of Psychology and Behavioral Science*, Hoboken: Wiley, 2004, accessed December 19, 2014, http://literati.credoreference.com.

regulate the immune system. This additional effect of dopamine further supports its positive involvement in the human body.[36]

Though dopamine is only present in approximately 1% of the neurons in the brain, it greatly affects motor control and cognitive processes. As these are two significant areas of body function, dopamine is a necessary substance. An increase of dopamine during a live performance can improve these functions and aid the singer.

Adrenaline

Many researchers began to discover the adrenaline substance at approximately the same time. In 1886, William Bates discovered a chemical produced by the adrenal gland. In 1895, Napoleon Cybulski isolated and classified this substance as epinephrine. John Jacob Abel found adrenaline in 1897, and Jokichi Takamine also discovered it in 1900. Researchers began isolating and testing the substance to gather more information. This research still continues, but much has been discovered about adrenaline since 1886.[37]

Adrenaline, also known as epinephrine, is both a hormone and a neurotransmitter. When presented as a hormone, adrenaline is produced by the adrenal gland, which is located on top of the kidneys, and the adrenaline is sent through the bloodstream to

[36] Sujit Basu and Partha Sarathi Dasgupta, "Dopamine, a Neurotransmitter, Influences the Immune System," *Journal of Neuroimmunology* 102, no. 2 (Jan 2000): 113.

[37] M.R. Bennett, "One Hundred Years of Adrenaline: The Discovery of Autoreceptors," *Clinical Autonomic Research* 9, no. 3 (July 1999): 145.

various organs. When released, it binds to receptors on the organs and creates different effects within each.[38]

When functioning as a neurotransmitter, adrenaline is produced at nerve endings. As it is produced at the nerve endings, adrenaline generates the same physiological effects as being produced by the adrenal gland; however, the neurotransmitter's effects do not last as long as the effects of the hormones. Through the adrenal gland, adrenaline is transferred to the organs through the bloodstream, which produces longer lasting effects compared to functioning as a neurotransmitter.[39]

Adrenaline is continuously secreted to help maintain a stable and constant bodily system, which is also known as homeostasis. It is released in large quantities during a stressful event such as a "fight or flight" situation.[40] This sudden and possibly threatening change activates the sympathetic autonomic nervous system. The neurotransmitter acetylcholine releases and triggers the adrenal gland's adrenaline to be secreted into the blood. The bodily changes caused by the increase in adrenaline aid in gearing the body to make a fight or flight decision.[41]

As a result of the added adrenaline, the body undergoes many alterations. The rise in adrenaline increases heart rate and cardiac output in the body. Splanchnic

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[38] "Epinephrine (Adrenaline)," in *The 100 Most Important Chemical Compounds: A Reference Guide*, Santa Barbara: ABC-CLIO, 2007, accessed December 18, 2014, http://literati.credoreference.com.

[39] Ibid.

[40] Ibid.

[41] Gerd Gäde, "Flight or fight – The Need for Adipokinetic Hormones," *International Congress Series* 1275 (Dec 2004): 134-5.

vasoconstriction, vasoconstriction in the abdominal organs, occurs and blood flow increases through the skeletal muscles, which can temporarily improve muscle strength. The peripheral arteries and veins experience vasoconstriction while the other organs experience vasodilatation. The adrenaline increase also acts on blood vessels. Typically, in high adrenaline situations, the blood vessels narrow, which causes increased blood pressure. Respiratory rate increases and the smooth muscles in the alimentary tract are relaxed, which hinders food passage through this tract. High adrenaline levels also boost energy input to cells by enhancing lipid metabolism and conversion of glycogen to glucose, known as glycogenolysis.[42] This results in higher blood sugar levels.[43]

Adrenaline's many effects can be also used effectively for controlling severe allergic reactions, specifically anaphylaxis. During anaphylaxis, the blood vessels widen and decrease blood pressure. Venous return, which is blood flowing into the heart from other parts of the body, decreases. Vascular permeability increases, which causes loss of plasma in the blood. Additionally, the cardiac output decreases, which can ultimately damage the heart's muscle tissue.[44] An injection of adrenaline to a human experiencing anaphylactic shock will instantly improve breathing, stimulate the heart, and reduce swelling.

Whether adrenaline is activated during a stressful event or used to treat anaphylaxis, it causes many effects that help increase the body's energy and strength.

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[42] "Epinephrine (Adrenaline)."

[43] Gäde, "Flight or fight – The Need for Adipokinetic Hormones," 134-5.

[44] George D. Soufras and Nicholas G. Kounis, "Adreanline Administration for Anaphylaxis and the Risk of Takotsubo and Kounis Syndrome," *International Journal of Cardiology* 166, no. 2 (June 2013): 281.

The body can experience a live performance as if it were a stressful event. Habitual exposure to live performance stress may not create the same level of adrenaline as a life-threatening situation might; however, the adrenaline increase would affect the body in preparation for the performance.

Chapter Two

Effects of "Performance Adrenaline" on Performing Singers

Positive Effects of "Performance Adrenaline" on the Performing Singer

The many effects of endorphins, serotonin, dopamine, and adrenaline change the body in numerous ways both positive and negative. Due to the fact that a singer uses the body as an instrument, the changes can be viewed differently. In terms of how the chemicals of "performance adrenaline" affect a performing singer, many of the effects yield positive results.

Most of endorphins' effects are helpful to a performing singer. Endorphin release sends pain-relieving signals throughout the body, which can help neutralize pain that could distract the singer from performing. Endorphins also regulate blood pressure, body temperature, respiration, and memory, which all help the body remain at a normal balance, or homeostasis.[45] During a stressful live performance, keeping the body as balanced as possible can allow the singer to perform as if stress were not a factor.

Serotonin's effects are extensive because of its presence in the central nervous system. It influences most brain function and human behavioral processes, which can affect a singer's mental preparation.[46] This involves altering mood, perception, anger, attention, and other behaviors. One of serotonin's functions in the brain is to help the

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[45] Fiorella Fontana et al., "Opioid Peptides Attenuate Blood Pressure Increase in Acute Respiratory Failure," *Peptides* 22, no. 4 (April 2001): 631.

[46] Miles Berger, John A. Gray, and Bryan L. Roth, "The Expanded Biology of Serotonin," *Annual Review of Medicine* 60, (2009): 356.

emotional processing of others' facial expressions, which can allow more significant expressivity and reactions from the singer.[47] This heightened attention and awareness can translate to a fellow singer onstage and can help singers react to each other with clearer and more animated facial expressions.[48] Additionally, the increase of serotonin enhances memory, which can help a performing singer who may need to perform an extensive amount of music and staging from memory.[49]

Serotonin also helps stabilize blood pressure and heart rate, and it regulates breathing. Controlled breathing is especially important because stable breath is essential for singing.[50] Finally, serotonin alters the perception of pain and creates a pain-relieving effect, which can help a singer who has chronic pain or one who is injured due to staging or other accidents.[51]

Dopamine's involvement in motor control and cognition make it a beneficial substance during a live performance. Dopamine even has an influence on fine motor control, so facial expressions can be positively enhanced as well.[52] Successful motor

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[47] Ai Koisumi et al., "Serotonin Transporter Gene-Linked Polymorphism Affects Detection of Facial Expressions," *PLoS One* 8, no. 3 (2013): 1, accessed November 17, 2013, doi: 10.1371/journal.pone.0059074.

[48] Steven R. Livingstone, William Forde Thompson, and Frank A. Russo, "Facial Expressions and Emotional Singing: A Study of Perception and Production with Motion Capture and Electromyography," *Music Perception* 26, no. 5 (June 2009): 475.

[49] Alfredo Meneses et al., "Serotonin Transporter and Memory," *Neuropharmacology* 61, no. 3 (Sept 2011): 355.

[50] Berger, Gray, and Roth, "The Expanded Biology of Serotonin," 358-9.

[51] Ibid, 361.

[52] Yen Kuang Yang et al., "Correlation Between Fine Motor Activity and Striatal

function can be helpful for a staged performance such as an opera, musical, or even a recital. Some performers must deal with complex staging or dance routines while singing and acting. Enhanced motor control will improve the singer's coordination and overall movement whether it is dancing, acting, or just emoting.[53]

The many areas of cognition affected by dopamine will also assist a performing singer. By boosting reasoning, task flexibility, problem solving, decision-making, and attention, a performer can be prepared for anything that may occur onstage. During a live performance, incidents arise where costumes, sets, props, or other performers may not function as they did in rehearsal. The increased dopamine improves the performer's ability to think and act quickly to solve the problem. In addition, miscommunications with the accompanist or another cast member can be less jarring when the singer can quickly revert to an alternate scenario.[54]

Nakajima and colleagues found that dopamine receptors are associated with cognitive function including memory, attention, learning, processing speed, expression, and language comprehension among others. If the dopamine receptors were blocked, these cognitive functions would be impaired.[55]

Dopamine D_2 Receptor Density in Patients with Schizophrenia and Healthy Controls," *Psychiatry Research: Neuroimaging* 123, no. 3 (Jul 2003): 191.

[53] Filip Bergquist, Haydeh Niazi Shahabi, and Hans Nissbrandt, "Somatodendritic Dopamine Release in Rat Substantia Nigra Influences Motor Performance on the Accelerating Rod," *Brain Research* 973, no. 1 (May 2003): 81.

[54] Shinichiro Nakajima et al., "The Potential Role of Dopamine D_3 Receptor Neurotransmission in Cognition," *European Neuropsychopharmacology* 23, no. 8 (Aug 2013): 800-1.

[55] Ibid, 800.

Increased memory, language comprehension, and expression resulting from a surge in dopamine also aid a performing singer. With these enhancements, a singer can perform at his absolute best during a live performance. Dopamine's regulation of the immune system is another added bonus. Though increased dopamine will not cure an illness, it can temporarily relieve symptoms and help the singer feel healthy enough to perform.[56]

Adrenaline, when continuously secreted in small amounts, helps the body maintain a natural balance. When adrenaline is released in large amounts during a stressful event, it changes the body. Adrenaline rushes often occur during incidents such as car accidents and can provide a boost in energy and strength to save yourself or others. These effects of increased energy and improved muscle strength can be useful to a performing singer. Performances can be long and tiring, and the singer must have enough stamina to perform, sing, and act sometimes for many hours. The increased energy will allow her to perform vivaciously for the length of the performance. The improved muscle strength could aid a singer in staged performances. Whether the singer needs strength for moving props or executing a dance number, the improved muscle strength can help the singer perform these duties with ease.[57]

Each of these four biological chemicals has a distinct function; however, some share similar positive effects. Endorphins and serotonin share similar effects including

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[56] Sujit Basu and Partha Sarathi Dasgupta, "Dopamine, a Neurotransmitter, Influences the Immune System," *Journal of Neuroimmunology* 102, no. 2 (Jan 2000): 113.

[57] "Epinephrine (Adrenaline)," in *The 100 Most Important Chemical Compounds: A Reference Guide*, Santa Barbara: ABC-CLIO, 2007, accessed December 18, 2014, http://literati.credoreference.com.

regulating blood pressure, body temperature, and respiration, and aiding in pain relief. Endorphins, serotonin, and dopamine all help control and enhance memory. Additionally, serotonin and dopamine affect behavioral processes and cognition such as attention and expression. These shared positive effects enhance each other, and, thus, "performance adrenaline" should especially increase pain relief, blood pressure, body temperature, and respiration regulation, memory, and cognition.

Negative Effects of "Performance Adrenaline" on the Performing Singer

Whereas each chemical involved in "performance adrenaline" offers many positive effects, adrenaline is the only chemical that produces negative effects for a singer. In preparation for a stressful event, adrenaline increases heart rate, blood pressure, and respiratory rate.[58] These changes can disrupt the singer's body, and thus, the voice. Though endorphins, serotonin, and dopamine help regulate blood pressure, heart rate, and respiration and can possibly neutralize the adrenaline, each singer experiences a different chemical balance of "performance adrenaline." These significant bodily changes can potentially affect the singer's ability to perform.

Impact of Chemicals on Singing

The bodily changes that result from increased adrenaline can alter a singer's performance. To focus on how "performance adrenaline" affects a live performance, I

[58] Ibid.

have chosen to focus on one of the most important elements of singing: breath. The increased chemicals of "performance adrenaline" can positively and negatively impact the breath and, thus, the singing and the performance.

Breath

Optimum breath management is key for successful singing and phonation. Breathing for singing is very different from breathing for living and speaking. Any breathing cycle, whether for speaking and singing, is the cycling of inhalation and exhalation. Typically, when the body is at rest, the entire breathing cycle takes about four seconds with the inspiration taking one second and the expiration taking three.[59] The muscles used for the singing breathing cycle are more varied and complex than for speech because the diaphragm, the thoracic muscles, and the abdominal muscles are active.[60] Additionally, the frequency, intensity, and duration of the sound constantly change while singing, which places added demands and intricacies on the breathing mechanism.[61] Coordinating the breathing cycle with singing is more complex, but, with practice, it allows for better control of the singing breathing cycle.[62]

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[59] Richard Miller, *The Structure of Singing: System and Art in Vocal Technique* (New York: Schirmer Books, 1986), 20.

[60] Ibid.

[61] D. Ralph Appelman, *The Science of Vocal Pedagogy* (Bloomington: Indiana University Press, 1969), 10.

[62] Miller, *The Structure of Singing*, 20.

Both vocal pedagogy and scientific research provide evidence that breath is the power source for singing because breath is needed to produce sound, which is known as phonation.[63] Johan Sundberg (1936-) defines phonation as "sound generation by means of vocal fold vibrations."[64] This sound is produced by the vocal folds as the airstream passes through them.[65] Due to the breath's importance to phonation and singing, breathing has been a major source of attention for theorists and pedagogy experts such as Richard Miller (1926-2009), D. Ralph Appelman (1944-), and William Vennard (1909-1971). Their theories and writings on breath management for singing will be explored. Even though there are numerous ideas on breathing for singing, a singer must ultimately find the right technique to healthily support phonation.[66]

Vocal pedagogy expert Richard Miller utilizes science and the body's breathing mechanisms to support his breathing theory. By coordinating the laryngeal muscles with the entire body and the breathing mechanism, a singer can control the breath and the vocal sound.[67]

To better understand the breathing mechanism, each organ and muscle involved in the process will be briefly explained. The lungs are the primary organs of respiration.

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[63] Miller, *Training Soprano Voices* (London: Oxford University, 2000), 32.

[64] Johan Sundberg, *The Science of the Singing Voice* (DeKalb, IL: Northern Illinois University, 1987), 9.

[65] Ibid, 10.

[66] Cornelius L. Reid, *The Free Voice: A Guide to Natural Singing* (New York: Coleman-Ross Company, 1965), 160.

[67] Richard Miller, *National Schools of Singing: English, French, German, and Italian Techniques of Singing Revisited* (Lanham, MD: Scarecrow Press, 1997), 7.

They move and function based on the pressures and movements of neighboring muscles. The thoracic cage houses the lungs and consists of the sternum, ribs, and the thoracic vertebrae. The muscles located between the ribs are the intercostals. These internal and external muscles are responsible for expanding and contracting the ribcage. Situated beneath the ribcage is the diaphragm. It is a large, dome-shaped muscle that divides the thoracic cavity from the abdominal cavity. This muscle plays a significant role in the breathing process. It is primarily involved in inspiration, but it also aids in the breathing cycle's rhythmic movements. The muscles in the abdomen are also involved in the breathing cycle. They include the external and internal oblique muscles, the transversus abdominis, and the rectus abdominis. These muscles are used for overall posture and expiration.[68]

All of these muscles and organs are somehow involved in the breathing for singing process. The extent of which each is involved depends on the specific breathing technique used. Typically, the muscle or part of the breathing system with the dominant action determines the name and method of that style of breathing.[69] The coordination and balance of the mechanisms determines whether the style of breathing for singing is successful.[70]

Miller extensively researched the breathing techniques taught in the national schools of singing. After studying the German, English, French, and Italian schools, Miller found great discrepancy between the four schools. Each utilized a different

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[68] Ibid, 7-12.

[69] Ibid, 20.

[70] Ibid, 7.

muscle for the dominant breathing action.[71] Miller preferred the Italian school's notion of *appoggio* for breath management. *Appoggio*, translated "to lean upon," utilizes the muscular coordination between the sternum, costal muscles, diaphragm, and epigastrium, which is the area at the top of the abdominals just beneath the sternum. By allowing these breathing mechanisms to work together, the singer can generate the most efficient breath management for singing while maximizing the resonant sound.[72]

To practice the *appoggio* technique, the singer should elevate the sternum while the shoulders remain relaxed. As the sternum is connected to the ribcage, this higher position allows the ribs to expand. The diaphragm can ascend quicker with the ribs expanded. Once in position, the area between the sternum and the navel will expand outward with inhalation. This movement will occur while the abdominals and the ribs expand laterally. To optimize this technique, the sternum should remain high and the ribs expanded while singing. Good breath will be easier to manage if this position is retained throughout the breathing cycle, and the singer can easily refill with air and the ribs can expand again for each new inhalation.[73]

This *appoggio* style of breath management primarily uses the major muscles of the abdominal wall, which allows for a more expansive and deeper inspiration. By coordinating the abdominal muscles with the other mechanics of the breathing mechanism, the singer can optimize the breathing cycle. To develop this style of breath

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[71] Richard Miller, "Energy and Freedom in Singing," *Journal of Singing: The Official Journal of the National Association of Teachers of Singing* 53, no. 2 (Nov 1996): 20.

[72] Miller, *The Structure of Singing*, 23.

[73] Ibid, 24.

management, a singer should practice the technique to improve overall breath and increase breath duration.[74]

D. Ralph Appelman's breathing for singing theory primarily involves breath support. He defines breath support as "the act of constantly sustaining the vocalized sound with the breath pressure."[75] To achieve this, the inspiration and expiration should be coordinated with phonation. This sound should be sustained with a constant breath pressure or breath support. The "Point of Suspension" is another facet to aid breath support. This sensation is a balance of pressure between all of the thoracic muscles used for inhalation, such as the intercostals, and the abdominal muscles used for exhalation. This balance should allow for complete control over the voice and breath.[76]

To successfully achieve the "Point of Suspension," the singer will inhale with a thoracic breath. This inhalation expands the thoracic cage by opening the ribs and costal muscles. For the most efficient inhalation, the singer should maintain this expanded position even after inhalation. Abdominal breathing is then used for the exhalation. The abdominal muscles and the back muscles pull in to push the abdominal organs upward toward the diaphragm. These two opposing actions of thoracic expansion while pulling the abdominal organs upward create an inner pressure or resistance during phonation. It

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[74] Miller, *Training Soprano Voices*, 41.

[75] Appelman, *The Science of Vocal Pedagogy*, 11.

[76] Ibid.

creates a steady flow of breath pressure against the vocal chords. This method is most effective when there is no tension present in the throat or neck.[77]

Appelman notes four objectives of breathing for singing. The first is to unite and coordinate exhalation and phonation by establishing a point of suspension. The second is to use the muscles in the body to produce even sound during phonation. The third is to provide a sufficient amount of breath. Finally, the fourth is to relieve tension from the neck and throat. [78]

To achieve these objectives, Appelman suggests coordinating the breathing practice with singing. If the breath is taught without sound, the process of synthesizing phonation and breathing can be delayed. Breathing should be taught while singing so the singer can coordinate the breath flow with phonation, practice a controlled exhalation, and activate all of the muscles used during breathing and singing together.[79]

William Vennard similarly believes that breathing for singing without actually singing is a simple practice. He instructs that a teacher should use only one or two lessons to teach breathing without singing. Coordinating the breathing with the sound, however, is of more importance and more difficult to master. Vennard suggests initially explaining the process of breathing in detail to the student. A clear understanding of the body's respiration muscles and organs will help a singer better comprehend the breathing

[77] Ibid, 12-3.

[78] Ibid, 11.

[79] Ibid, 16.

process. Once learned, a singer can practice breathing throughout the day or as a warm-up to form the correct habits.[80]

To begin proper breathing, the vocal instrument needs the correct alignment and posture. The head, chest, and pelvis should be aligned one under the other in a relaxed yet supported position. Ideally, a singer should strive for a balance of muscular poise that allows the body to be correctly aligned, strong, and relaxed. Once a comfortable and strong posture is achieved, a singer can more easily access the correct breathing.[81]

According to Vennard, the most efficient breath is a combination of costal or rib breathing and diaphragmatic-abdominal or belly breathing.[82] Costal or rib breathing is characterized by the lateral expansion of the ribs. A singer can test his rib breathing by placing his hands on the bottom portion of the ribcage. Upon inhalation, the ribs should expand pushing the hands apart.[83]

Diaphragmatic-abdominal or belly breathing uses one of the most powerful muscles in the body: the diaphragm. When the diaphragm descends, it flattens, which lowers the floor of the chest. This allows the lungs more room and more breath can be inhaled. When the diaphragm descends it also presses down on the stomach and its contents. This is why the abdomen moves forward with inhalation. In diaphragmatic-

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[80] William Vennard, *Singing: The Mechanism and the Technic* (New York: Carl Fischer, 1967), 19.

[81] Ibid, 19-20.

[82] Ibid, 20.

[83] Ibid, 28.

abdominal breathing, the chest and shoulders should remain relaxed and motionless while the diaphragm descends and the abdomen moves outward for the deepest inhalation.[84]

To coordinate rib breathing with belly breathing, the singer should first understand the basics of muscular antagonism. Muscles always work with other muscles and usually work in opposition. When combining rib breathing and belly breathing, the external intercostals in between the ribs work to keep the ribs expanded while the abdominal muscles work to pull the ribs downward. This resistance creates a steadiness in the contraction of the diaphragm, which allows the diaphragm to steady the vocal tone. Many teachers claim that the diaphragm supports the tone, but, because of this muscular antagonism, the diaphragm actually steadies the tone.[85]

Another supporting system to the diaphragm is the epigastrium area. The epigastrium is the region at the top of the abdominal muscles just below the breastbone. A singer can feel the action of the diaphragm at this spot. When the diaphragm lowers and flattens, the epigastrium area will abruptly push forward. This movement proves the correct use and development of the diaphragm muscle. The stronger the diaphragm becomes, the stronger and more dramatic the epigastrium motion will be.[86]

The tightening of the abdominals also causes the epigastrium's movement. When the abdominals contract, the diaphragm tightens in resistance, and the epigastrium bounces outward. This initial abdominal contraction occurs at the start of phonation, and because of this, the epigastrium will move outward only at the beginning of a sung

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[84] Ibid, 28-9.

[85] Ibid, 29-30.

[86] Ibid, 28.

phrase. By the end of the phrase, the epigastrium will no longer bulge. The diaphragm and the abdominals tighten as a function of exhalation and also aid in controlling the breath.[87]

Vennard boils down his inhalation breathing theory as the motions "in, down, and out."[88] During exhalation, the abdominals retract causing the abdominals and diaphragm to return to their resting positions. By combining the elements of rib or costal breathing with diaphragmatic-abdominal or belly breathing, a singer can experience the most effective breathing. The coordination of these two types of breath allows for a deeper inhalation and more breath control.[89] According to Vennard, if a singer's breathing can be improved, then his singing can also be improved.[90]

Each pedagogue encourages similar styles of breathing for singing. While the language of one theorist may resonate better for a particular singer or teacher, the overall message is clear: the most effective breathing for singing involves a combination of diaphragmatic breathing and rib expansion. Miller, Appelman, and Vennard all utilized physiological knowledge to support their theories. They proved that the musculature involved in breathing for singing is extensive, and coordinating the lungs, diaphragm, abdominals, ribcage, and the rest of the body is needed to access the best breathing. Once the body and breathing are coordinated, then the singer can synchronize the breathing with phonation.

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[87] Ibid, 30.

[88] Ibid.

[89] Ibid, 28.

[90] Ibid, 18.

“Performance Adrenaline” and Breathing for Singing

The changes that occur due to “performance adrenaline,” such as regulating blood pressure, heart rate, and respiration, can affect breathing. Due to the many muscles and organs involved in breathing for singing, breathing can be more successful if the body and muscles function normally. Since breath is fundamental to singing and phonation, the ability to access deep, expansive breath during performance is imperative.

Live performance can affect proper and efficient breathing. Adrenaline increases heart rate and respiration rate. When heart rate and respiration rate increase, the body requires more oxygen. As a result, breath can become rapid and shallow to intake oxygen faster. This can activate clavicular breathing. This type of breathing is usually used by athletes and can be characterized as a “desperate” or “last resort” attempt to bring oxygen quickly into the body.[91] It is known as the “breath of exhaustion.”[92]

Heaving in the chest and clavicles, which are the collarbones, characterizes this style of breathing. Also known as thoracic breathing, this method raises the chest with inhalation, and, as a result, the abdomen usually pulls inward. The organs within the stomach are then pushed against the diaphragm, the diaphragm cannot move as far down, and a deep breath becomes impossible. Clavicular breathing can easily throw off the deep abdominal and rib breathing practiced outside of performance.[93]

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[91] Ibid, 27.

[92] Miller, *National Schools of Singing*, 19.

[93] Vennard, *Singing: The Mechanism and the Technic*, 28-9.

This shallow style of breathing may be necessary for an exhausted athlete to inhale oxygen quickly, however, it is one of the most inefficient methods of breathing. Clavicular breathing focuses on inspiration and provides no control over exhalation because the abdominals, which control exhalation, are not activated. Additionally, the muscles that are needed to heave the chest up and down are connected to the muscles in the throat. The constant and harsh up and down movements that are needed for clavicular breathing can create muscular tension in the throat, which can be problematic for healthy singing.[94]

A 2006 study tested the fatigue of inspiration muscles during exercise. In the experiment, healthy subjects became exhausted with endurance exercise, which induced rapid shallow breathing, also known as tachypnea. Rapid shallow breathing uses clavicular breathing to initiate its effects of decreased lung capacity and increased breathing frequency. The study tested the rib cage muscle fatigue and diaphragm fatigue during exercise, and the subjects were instructed to not change their normal breathing patterns.[95]

The study showed that the diaphragm was activated and fatigued in this clavicular style of breathing, but the diaphragm fatigue was able to increase the lung volume, and keep the breathing frequency constant. The rib cage muscle fatigue caused the rapid shallow breathing by decreasing lung volume and increasing breathing frequency in two-thirds of the subjects. The two subjects with the greatest amount of rib cage muscle

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[94] Ibid, 27.

[95] Samuel Verges, Dominic Notter, and Christina M. Spengler, "Influence of Diaphragm and Rib Cage Muscle Fatigue on Breathing During Endurance Exercise," *Respiratory Physiology & Neurobiology* 154, no. 3 (Dec 2006): 432.

fatigue displayed the most pronounced rapid shallow breathing.[96] From this study, it can be deduced that a clavicular style of breathing will increase breathing frequency and decrease lung capacity. The more a person depends on rib cage and chest involvement in breathing, the more the breathing frequency will increase and the more the lung capacity will decrease.

A 1993 study researched the effects of exercise specifically on diaphragmatic fatigue. During whole body endurance exercise, the diaphragm fatigued due to the breathing. After the first five to ten minutes of exercise, the diaphragmatic fatigue reached a plateau and remained at that level for the remainder of the exercise. Despite this plateau, the breathing frequency and the pressure in the esophagus continued to rise. This information showed that the diaphragmatic contribution to breathing decreased over time and caused the other respiratory muscles, such as the intercostals, to work harder. The subjects who decreased or minimized the use of the diaphragm during the exercise showed less diaphragm fatigue post-exercise.[97]

Another study in 2007 tested the fatigue of respiration muscles and showed similar results. The study compared the fatigue conditions in inspiratory and expiratory muscles with the muscles in the calf. The most consistently fatigued muscles were the inspiratory muscles and the calf muscles. The study noted that the diaphragm is less active during heavy exercise, and, therefore, does not fatigue as much as the inspiration muscles or the calf muscles. Interestingly, the fatigue rates were the highest in the

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[96] Ibid, 439.

[97] Bruce D. Johnson et al., "Exercise-Induced Diaphragmatic Fatigue in Healthy Humans," *Journal of Physiology* 460 (1993): 403.

inspiratory muscles. The muscles most notably fatigued were the internal and external intercostals and the sternomastoid, which is one of the largest neck muscles.[98] This further confirms that clavicular breathing utilizes and exhausts the inspiration muscles in the rib cage more than any other muscle in the body.

To further study the effects of clavicular style breathing on the body, a 2000 study researched the effects of respiration on exercise performance. By testing highly fit cyclists, Harms and his team experimented with inspiratory unloading and loading. A feedback-controlled proportional-assist ventilator helped the subjects unload by reducing inspiration muscle work. This ventilator helped the subjects reduce their inspiration effort and relax the breathing.[99] To increase or load the inspiratory work, the team added ventilation loads, which added resistance to increase inspiratory muscle work.[100] The study discovered that with increased inspiration muscle work, the subjects could not exercise as long before reaching exhaustion. The subjects who experienced a reduced inspiratory workload were able to exercise longer before reaching exhaustion.[101] This study showed the exhausting effects of clavicular breathing and the lack of endurance that accompanies it.

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[98] Renana Perlovitch et al., "Inspiratory Muscles Experience Fatigue Faster than the Calf Muscles During Treadmill Marching," *Respiratory Physiology & Neurobiology* 156, no. 1 (Apr 2007): 65.

[99] Craig A. Harms et al., "Effects of Respiratory Muscle Work on Exercise Performance," *Journal of Applied Physiology* 89, no. 1 (Jul 2000): 131.

[100] Ibid, 132.

[101] Ibid, 134.

Clavicular breathing is one of the most inefficient and exhausting breathing styles. When used, it decreases lung capacity, diaphragm use, and endurance, and increases breathing frequency. The increased heart rate caused by adrenaline can also increase respiration rate to intake more oxygen. This can result in using clavicular breathing to intake oxygen faster. The continued use of clavicular breathing will greatly fatigue the rib cage and inspiration muscles while inefficiently using the breath. This will make it more difficult for a singer to access deep breathing. Clavicular breathing should be avoided despite the body's instincts to overcome the increased heart rate and respiration rate from adrenaline.

Breath can easily be affected by adrenaline. In preparation for this, a singer should mentally plan for less effective breathing during performance. Vennard suggests that a singer should not plan on singing impressively long phrases in public even if she can negotiate them in private. If a passage is difficult while practicing, the effects of a live performance can make the passage and breathing even more challenging. To prepare for this, a singer should practice taking a breath in an acceptable spot in the middle of the phrase. If the singer does not prepare herself in this way, she may be forced to breathe in a more obvious place in the music. Mentally preparing for extra breaths, as Vennard suggests, can be an easy and useful solution for singers.[102]

Another primary change in the body caused by the adrenaline chemical is the increase in energy. Miller asserts a balance in energy is beneficial to successful singing breath. Referring to singing breath support as breath energy, Miller says that singers

[102] Vennard, *Singing: The Mechanism and the Technic*, 34.

should find the proper balance between freedom and energy to optimize breath.[103] To find this balance, the singer should discover the perfect amount of breath energy to support phonation. The singer should sustain this balance between breath energy and phonation to utilize the increased energy from adrenaline.

If a singer is unable to maintain the proper balance between breath and phonation, named “balanced phonation” by Miller, the singing may be affected.[104] The adrenaline chemical can disturb the balance by increasing heart rate, cardiac output, blood pressure, and respiratory rate. If a singer creates an excessive amount of airflow that is not used for phonation, then a breathy phonation sound can be produced. By experiencing a higher respiration rate from adrenaline, this issue could easily occur during a live performance. Some singers attempt to counteract the higher airflow by increasing resistance at the glottis with a firm glottal closure. This method can create a pressed phonation sound, which is also undesirable. Though the singer may experience increased respiration due to adrenaline, he should aim to maintain a balanced phonation to produce the best sound.[105]

Another element of vocal production that can be altered by breath is vibrato. This musical phenomenon has been extensively researched; however, it is important to understand that there are different styles of vibrato depending on the type of music. The

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[103] Miller, “Energy and Freedom in Singing,” 27.

[104] Ibid.

[105] Ibid.

researchers' writings that I will discuss have focused on the vibrato in Western operatic singing.[106]

An initial leading expert in the study of vibrato was psychologist and musician, Carl Seashore (1866-1949). Seashore researched and published his findings on vibrato in the 1930s. He described an artistic vibrato as a periodic oscillation in pitch that oscillates at approximately a half tone or semitone. He considered the best vibrato to undulate at an average rate of six or seven cycles per second, and his research showed that approximately 50 percent of musicians sang within this rate.[107]

Researchers following Seashore agreed with his early findings. Pedagogues such as William Vennard (1909-1971), Johan Sundberg (1936-), Richard Miller (1926-2009), and others all believe good vibrato to oscillate within a range of five to eight pulsations per second.[108] If the undulations are faster than eight per second, the sound is described as a tremolo or bleat. If slower than five, the voice will sound like a wobble. The speed of pulsation can distinguish an aesthetically pleasing vibrato from an unpleasant sound.[109]

In terms of the pitch variant, recent pedagogues agree that the pitch should ideally oscillate at less than a semitone. Some, such as Appelman, believe that the variation in pitch should not exceed a quartertone from the pitch center. If the oscillation in pitch is

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[106] Sundberg, *The Science of the Singing Voice*, 163.

[107] Carl E. Seashore, "The Natural History of the Vibrato," *National Academy of Sciences* 17, no. 12 (Dec 1931): 624.

[108] Shirlee Emmons, "Vibrato, Wobble, Tremolo, and Bleat…. Do You Have a Problem?" accessed January 28, 2015, http://www.shirlee-emmons.com/vibrato.html.

[109] Miller, *The Structure of Singing*, 182.

larger, the pitch center can sound insecure.[110] Despite the slightly different interpretations of good vibrato's pitch variant, the ultimate purpose of vibrato is to give an aesthetically pleasing sound in flexibility, tenderness, and richness to the tone.[111]

The physiology of vibrato is less specific. Many ideas about the physical aspects of vibrato have been confirmed through studies, such as the definite relationships between particular muscles and vibrato. These include the correlation between vibrato rate and the oscillations in the musculature of the thorax. Another confirmed physical aspect of vibrato is that the synergy within the laryngeal musculature is responsible for the fluctuation in the vocal folds.[112] Though these among other physical relationships have been identified, there is no one precise conclusion to the cause of vibrato.[113] Despite the vibrato mystery, all vocal pedagogues agree that both breath management and the laryngeal mechanism are primarily involved. Appelman states that vibrato is directly related to breath management and can be controlled by respiratory and laryngeal muscles. The slight changes in body pressures, which are produced in the breathing mechanisms, affect and help produce vibrato. An even breath pressure should create an even vibrato sound. If a singer does not have proper breath and even breath pressure, the vibrato can become uncontrollable and uneven.[114]

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110 Appelman, *The Science of Vocal Pedagogy*, 24.

111 Carl E. Seashore, "The Vibrato: (1) What is it?" *Music Educators Journal* 23, no. 4 (1937): 31.

112 Miller, *The Structure of Singing*, 183.

113 Miller, *National Schools of Singing*, 93.

114 Appelman, *The Science of Vocal Pedagogy*, 23-4.

The balance between airflow and subglottic pressure during phonation is important to maintain an even vibrato. The velocity and amount of airflow that passes through the glottis influences the speed and consistency of the vibrato sound.[115] Good vibrato depends on this successful equilibrium of airflow and subglottic pressure. If the airflow exceeds the subglottic pressure, the sound lacks vibrato and is considered straight-tone. If the subglottic pressure exceeds the airflow, then the vibrato becomes uneven, and the oscillating pitch surpasses a semitone, which results in a wobble sound. To achieve the most aesthetically pleasing vibrato, the airflow and subglottic pressure should remain equal.[116] Therefore, good vibrato is sounded when the breath and phonation are balanced, and, thus, good vibrato is an indicator of healthy singing.[117]

Vocal vibrato is essential to good vocal production and a good performance. As good vibrato has a somewhat narrow definition, performing this specific act is challenging especially with increased "performance adrenaline" chemicals. The increased energy from adrenaline can influence the success of the vibrato. As energy affects breath, energy similarly affects vibrato. The balance of breath energy and phonation is important for both breathing and vibrato. With vibrato, the airflow and subglottic pressure should specifically be balanced.[118] By studying the aerodynamics of

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[115] Adam Kirkpatrick, "Teaching Methods for Correcting Problematic Vibratos: Using Sustained Dynamic Exercises to Discover and Foster Healthy Vibrato," *Journal of Singing – The Official Journal of the National Association of Teachers of Singing* 64, no. 5 (May 2008): 552-3.

[116] Ibid, 555.

[117] Ibid, 556.

[118] Ibid, 552.

vibrato and straight-tone, researchers John Large and Shigenobu Iwata found that the airflow rate to produce vibrato is usually 10% higher than for straight tone throughout all vocal registers.[119] If a singer tends to have lower breath energy, and thus, a slow or uneven vibrato rate or no vibrato at all, adrenaline can increase energy and the success of the vibrato.

Though breath energy or support tends to be the main issue for singers struggling with vibrato, simply increasing airflow does not address the issue. The main issue of creating vibrato is balancing the amount of airflow and subglottic pressure during phonation. Though this cannot usually be controlled consciously, exercises suited for the singer can encourage the control and awareness of vibrato.[120]

The "performance adrenaline" chemicals endorphins, serotonin, and dopamine can contribute to the success of vibrato. In order to maintain the even oscillation of five to eight cycles per second at a semi-tone or less, the overall body must feel balanced. Endorphins, serotonin, and dopamine all help stabilize this balance by regulating body functions such as blood pressure, respiration rate, and heart rate. Each singer must find her own balance to achieve an aesthetically pleasing vibrato rate.

Conversely, the effects of the adrenaline chemical can negatively alter vibrato. The increased heart rate, blood pressure, and respiratory rate caused by adrenaline can disturb the balance between subglottic pressure and airflow. If these heightened biomarkers, specifically the respiratory rate, cause the airflow and subglottic pressure to

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[119] Neisha Carter, J. Arden Hopkin, and Christopher Dromey, "Volitional Control of Vibrato in Trained Singers," *Journal of Singing – The Official Journal of the National Association of Teachers of Singing* 67, no. 1 (Sep 2010): 13.

[120] Kirkpatrick, "Teaching Methods for Correcting Problematic Vibratos," 556.

increase too much, the oscillations of the vibrato will become faster than the recommended five to eight cycles per second. This will cause the air to pass through the glottis at a high velocity against high resistance from the increased subglottic pressure. These increases will result in a high-intensity tremor of the laryngeal muscles and will create a bleating sound in the vibrato that is not aesthetically pleasing to Western ears.[121]

"Performance adrenaline" has both positive and negative effects on vibrato. Ultimately, the singer should find the balance between airflow and subglottic pressure to create the most pleasing vibrato sound. In addition to balancing these elements, the singer should aim to produce a consistent and even oscillation to produce a pleasant vibrato.

Breath is one of the most important elements in singing because it influences many different facets of the singing voice. If the breath is inefficient, the singing voice can be affected in many ways. "Performance adrenaline" can alter this efficiency either positively or negatively. If the singer can access the expansive breath management for singing practiced outside of performance, then the singing voice and overall performance will be successful.

[121] Ibid, 555-6.

Chapter Three

Optimizing Positive Effects and Counteracting Negative Effects

Introduction

Performing singers should be able to take advantage of the positive effects of "performance adrenaline" while counteracting the negative ones. A singer can experience the positive effects without any knowledge of the naturally occurring changes; however, the negative effects require more attention. Due to the fact that adrenaline increases energy, heart rate, blood pressure, and respiration, the performer should be aware of the changes so they do not hinder the singer's best performance.

There are many methods a singer can use to control the increased heart rate, blood pressure, and respiration. I have chosen to focus on the methods of diaphragmatic breathing, yoga, and beta-blockers. Each singer should discover the most effective technique or combination of techniques to handle the negative effects of "performance adrenaline."

Diaphragmatic Breathing

One successful technique for relaxing the body is deep breathing. This type of breathing goes by many names, but for the purposes of this paper, I will refer to it as diaphragmatic breathing. It is named for its efficient use of the diaphragm, which is the large muscle situated beneath the lungs that assists respiration. The earlier discussion of breathing pertained to breathing for singing. This return to diaphragmatic breathing is used for relaxation and utilizes only the diaphragm.

Most individuals naturally use thoracic or clavicular breathing during states of rest, in which breathing is limited to the upper half of the body. As previously mentioned, this style of breathing does not utilize the diaphragm. As the diaphragm is positioned under the lungs, clavicular breathing will decrease the possible lung capacity and increase respiration rate.[122]

Diaphragmatic breathing allows for a much deeper breath. Upon inhalation, the diaphragm moves downward allowing the lungs to fully expand and pressing on the abdominal contents. This causes the abdominal contents to temporarily move outward and the belly to expand. The thorax then increases in size and air to equalize the pressure from the abdomen. This breathing process allows for a more complete and expansive breath. Upon exhalation, the diaphragm moves upward and pushes air out of the lungs. The abdomen moves inward, and the diaphragm and abdomen return to normal resting states.[123]

Successful diaphragmatic breathing results in deep and prolonged inhalation and exhalation. As this breathing cycle continues, more oxygen enters the body while more carbon dioxide exits and causes the breathing rate to gradually slow. This expanded and rhythmic breathing helps relax the body and mind.

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[122] Margo Ann Kreger, "The Relationship Between an Individual's Locus of Control and the Perceived Benefits from Using Diaphragmatic Breathing to Control Chronic Pain," MS thesis, Rush University, 1994.

[123] Paul Kiesgen, "Voice Pedagogy: Breathing," *Journal of Singing: The Official Journal of the National Association of Teachers of Singing* 62, no. 2 (Nov 2005): 169.

The best breath management styles for singing involve some form of diaphragmatic breathing. The breathing methods encouraged by Miller, Appelman, and Vennard previously mentioned all utilize the diaphragm in this manner and in combination with rib expansion. Diaphragmatic breathing focuses only on using the diaphragm for a deep breath. As most singers are experienced in some form of diaphragmatic breathing, they can benefit from this relaxing breathing practice. Nevertheless, diaphragmatic breathing is a useful relaxation technique for both singers and non-singers.[124]

The bodily changes that occur during diaphragmatic breathing are extensive and powerful. Various studies have investigated the effects of diaphragmatic breathing and have proven that it induces calmness, helps with chronic pain, improves mental alertness, controls body temperature, and reduces stress.[125] Additionally, numerous reports show the beneficial influences of diaphragmatic breathing on blood pressure control.[126] In a study conducted in 2003, young adults had their blood pressure and heart rate tested before and after three diaphragmatic breaths. The subjects had no previous diaphragmatic breathing experience, but were taught how to access this style of breathing for the study. After only three diaphragmatic breaths, the systolic and diastolic blood pressures consistently and significantly dropped in all subjects. Though this style of

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[124] Earl E. Armstrong, "The Effect of Biofeedback and Verbal Feedback on the Training and Maintenance of Diaphragmatic Breathing," MS thesis, University of North Texas, 2003.

[125] Kreger, "The Relationship Between."

[126] Kinga Howorka et al., "Effects of Guided Breathing on Blood Pressure and Heart Rate Variability in Hypertensive Diabetic Patients," *Autonomic Neuroscience* 179, no. 1-2 (Dec 2013): 136.

breathing had a profound effect on blood pressure, the effects on heart rate were inconclusive.[127]

Studies have continued to test diaphragmatic breathing's impact on heart rate, but the results remain inconsistent. Nevertheless, diaphragmatic breathing consistently lowers blood pressure. This effect is significant for performing singers because adrenaline can increase blood pressure. Though diaphragmatic breathing may not affect heart rate, it will lower blood pressure and encourage deeper, calmer breaths for singing. In addition, diaphragmatic breathing can help control increased respiration rate. By concentrating on taking diaphragmatic breaths, a singer suffering from an increased respiration rate can return it back to its normal rhythm.[128] Diaphragmatic breathing is a favored relaxation technique for singers and non-singers because is it effective, simple, quick to learn, non-invasive, and can be practiced anywhere.[129]

Yoga

A singer's physical well-being impacts both the voice and performance. The vocal instrument is located inside the body; thus, a singer's body should be mentally and physically healthy to perform well. Vennard claims that any exercise that improves the

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[127] John S. Lee et al., "Effects of Diaphragmatic Breathing on Ambulatory Blood Pressure and Heart Rate," *Biomedicine & Pharmacotherapy* 57, no. 1 (Oct 2003): 88.

[128] Shirlee Emmons and Alma Thomas, *Power Performance for Singers: Transcending the Barriers* (London: Oxford University Press, 1998), 69.

[129] Kitty Consolo, Sally Fusner, and Sharon Staib, "Effects of Diaphragmatic Breathing on Stress Levels of Nursing Students," *Teaching and Learning in Nursing* 3, (2008): 68.

body will be beneficial for singing. Strengthening the abdominals, which are the "foundation of breath control," will make for better singing overall.[130] Additionally, being in a state of optimal health directly affects a singer's ability to perform, which includes handling the effects of "performance adrenaline" and the pressures of a live performance. It is common knowledge that a healthy lifestyle positively impacts blood pressure and heart rate, but "performance adrenaline" can still affect those in good physical condition by increasing these vitals.[131]

Yoga is a form of exercise rooted in Indian philosophy that helps maintain a healthy body both mentally and physically. There are various styles of yoga; however, the ultimate goal in yoga is to quiet the mind to achieve a union of mind, body, and spirit. To accomplish this union, yoga offers exercise, intentional breathing, and relaxation by combining physical postures, breath control, and meditation.[132]

These practices can be especially helpful for a performing singer. The breathing practices taught in yoga are similar to those for singing. The primary breathing technique taught in yoga is the "Complete Yogic Breath."[133] This three-part breath begins the inhalation with the abdominal muscles relaxing downward and outward. Next, the lower

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130 William Vennard, *Singing: The Mechanism and the Technic* (New York: Carl Fischer, 1967), 35.

131 Emmons and Thomas, *Power Performance*, 65.

132 Holger Cramer et al., "Effects of Yoga on Cardiovascular Disease Risk Factors: A Systematic Review and Meta-analysis," *International Journal of Cardiology* 173, no. 2 (May 2014): 170-1.

133 Judith Carman, "Yoga and Singing: Natural Partners," *Journal of Singing – The Official Journal of the National Association of Teachers of Singing* 60, no. 5 (May 2004): 436.

ribs spread outward. These two movements are similar to breathing for singing and fill the lungs approximately eighty percent. The yogic breath continues by inhaling into the upper chest and filling the remaining twenty percent of the lungs' capacity. This third step is not used in breathing for singing because the increased air in the chest puts pressure on the throat and vocal mechanism. The exhalation occurs in the same order by contracting the abdominals, lowering the ribs, and expelling air out from the upper chest. More advanced yogic breathing techniques are taught as a student progresses to further strengthen breathing muscles and focus on breath. The "Complete Yogic Breath" is an effective technique that teaches expansive breathing while strengthening the breathing muscles.[134]

The controlled breathing techniques are coordinated with the physical movements and postures in yoga. The breath measures the timing of the movements and poses while making ample oxygen available to muscles and organs. By grounding the yoga movements in the breath, the breath's strength, flexibility, and focus increases.[135]

The more advanced forms of yoga use meditation as a method to achieve mental well-being. Silent meditation and guided meditation are two techniques to quiet and focus the mind. In silent meditation, the practitioner develops the skill of sitting in complete silence. This technique requires attention, desire, and dedication in order to turn attention away from the outside world and silence the mind. To do this, yoga aficionados focus the mind's attention to the middle of the forehead called the mind's

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[134] Ibid, 437.

[135] Ibid, 436.

eye.[136] Repeated and dedicated practice of this method allows, the practitioner to achieve inner self-knowledge and mental relaxation.[137]

Guided meditation is verbally guided by the instructor. There are four widely practiced forms of guided meditation. The first is "Soft-Belly Mindful Breathing Meditation." This meditation focuses the mind on belly breathing. The second guided meditation is "A Simple Mindfulness Meditation – Focusing on the Breathing and Noting." This method focuses the mind on breathing through the nostrils while noting or naming the thoughts and feelings that surface.[138] The third is "A Guided Mindfulness Meditation." This meditation also focuses the mind on breathing through the nostrils while acknowledging thoughts.[139] In this method, the practitioner recognizes the thoughts or feelings, and then lets them go. The final form of guided meditation is "A Guided Loving Kindness Meditation." This form uses the phrase "May I be free from suffering, may I be at peace," or a similar affirmation, to open the mind and heart. This meditation evokes compassion and love for oneself and others. In each form of guided meditation, the breath is the central focus. It is used to ground the practitioner in the present moment and help her release unwanted thoughts or feelings.[140]

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[136] Kay Mouradian, "Meditation the Yoga Way," *Armenian Reporter*, February 9, 2008.

[137] Carman, "Yoga and Singing," 439.

[138] Ibid.

[139] The breathing section in Chapter Two deliberately does not discuss nostril versus throat breathing for singing. The choice is an individual matter of taste, and the discussion is beyond the scope of this paper.

[140] Ibid, 440.

Many practice yoga to achieve physical and mental well-being. In more recent years, physicians and therapists have recommended yoga as a supplemental therapy to patients. According to a 2008 study, 14 million adult Americans reported that a physician or therapist encouraged yoga for health improvement.[141] As yoga is beneficial to the body and mind, its effects on body function and vitals have been extensively studied. The many benefits include reduction of stress, depression, blood pressure, heart rate, and respiratory rate.

A study from 2003 researched multiple styles of yoga with varying types of practitioners. The results showed the positive effects of yoga were comparable or more effective than other forms of exercise or physical movement. The study most prominently noted the benefits of decreased blood pressure, heart rate, and respiration rate from yoga.[142]

The benefits of yoga directly relate to the negative effects of "performance adrenaline." Yoga lowers the three main effects associated with "performance adrenaline": raised blood pressure, heart rate, and respiration rate. While a singer cannot practice yoga while onstage, she can prepare immediately before a performance or during an intermission by practicing yogic principles. A quick pose, breath concentration, or meditation offstage can help combat "performance adrenaline" issues that may occur.

In addition to counteracting the negative effects of "performance adrenaline," yoga can benefit singers in other ways. Yoga's breathing practices are useful to singers because the yogic breathing techniques are closely related to the singing breathing

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[141] Cramer et al., "Effects of Yoga," 170.

[142] Ibid, 178.

techniques. By practicing yoga, a singer can further strengthen the breathing muscles to produce a more expansive and efficient singing breath. Since these breathing techniques are used in a variety of positions and poses, the ability to access abdominal breath in any position is also improved. Additionally, the overall enhanced breath flexibility is important because each musical phrase requires a different length of breath, and a singer must be able to adapt the breath to each phrase length.[143]

A 2004 study by Kasiganesan Harinath and his team researched the effects of yoga and meditation on cardiorespiratory performance. Healthy subjects practiced yoga and meditation for three months to test the cardiovascular changes. After the three months, the team discovered that yoga improved cardiorespiratory performance by enhancing cardiovascular efficiency and improved the breathing rate and ventilatory function of the lungs. The strengthening of the respiratory muscles primarily used in yogic breathing caused these improved functions. Additionally, the study showed that yoga improved the subjects' psychological well-being and homeostatic control of the body.[144]

Yoga provides additional physical benefits that could benefit a singer. Physically, yoga strengthens the body. Moving into and holding unusual poses while breathing fortifies the joints and muscles to improve physical condition. It also improves physical

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[143] Carman, *Yoga and Singing: Natural Partners*, 436.

[144] Kasiganesan Harinath et al., "Effects of Hatha Yoga and Omkar Meditation on Cardiorespiratory Performance, Psychologic Profile, and Melatonin Secretion," *Journal of Alternative and Complementary Medicine* 10, no. 2 (2004): 266.

posture and alignment in addition to increasing strength and flexibility throughout the body.[145]

Mentally, yoga and meditation provide training for increased concentration and attention. The goal of these practices is to quiet the mind and open the heart. The different styles of guided and silent meditation make breath the central focus. These techniques practice the ability to be constantly aware of and concentrate on the breath. By focusing on the breath, the nervous system and mind can be calmed. This is especially beneficial to those who experience performance anxiety. The mind is trained to focus on breath instead of any distractions or negative thoughts during the performance.[146]

A 2006 preliminary study tested the effects of a yoga lifestyle on musicians. The study gathered musicians, both instrumentalists and singers, from an intensive two-month summer fellowship program. The subjects practiced regular yoga and meditation sessions throughout the two months.[147] Based on a psychological questionnaire given at the end of the two months, the performance anxiety scores were significantly decreased compared to the questionnaire completed at the beginning of the program. The decreased performance anxiety was the greatest improvement indicated by the tests.[148]

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[145] Ibid, 440.

[146] Ibid.

[147] Sat Bir S. Khalsa and Stephen Cope, "Effects of a Yoga Lifestyle Intervention on Performance-related Characteristics of Musicians: A Preliminary Study," *Medical Science Monitor* 12, no. 8 (2006): CR325.

[148] Ibid, CR328.

Yoga is a wonderful exercise to enhance the body and mind for live performances. Though other forms of physical exercise are useful to a performing singer, yoga is one of the safest exercises and can also be used immediately before a live performance. Yoga strengthens the mind, body, and breath while counteracting the negative effects of "performance adrenaline." The negative effects of raised blood pressure, heart rate, and respiratory rate can all be regulated by yoga.

Beta-Blockers

Beta-blockers are a class of drugs that block the transmission of neurotransmitters to beta-receptors in the sympathetic nervous system. The sympathetic nervous system is responsible for the body's response to anxiety, stress, and exercise. These beta-receptors are located throughout the sympathetic nervous system, specifically in the heart, blood vessels, and organs, and are subdivided into cardiac receptors and vascular, bronchial, and gastrointestinal smooth muscle receptors. Beta-blockers are divided into cardio-selective drugs, which act primarily on the cardiac receptors, and non-selective drugs, which act on both types of receptors. Once in the body, beta-blockers activate at the adrenal gland to block the beta-receptor sites, which is where the adrenaline hormone is produced. The drugs block the neurotransmissions initiated by the chemicals adrenaline and noradrenaline, a neurotransmitter and hormone similar to adrenaline, to the beta-receptors.[149]

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[149] "Beta-adrenoceptor-blocking Drugs (Beta Blockers)," in *Black's Medical Dictionary, 42nd Edition*, London: A&C Black, 2010, accessed January 15, 2015,

Beta-blockers obstruct the normal effects of adrenaline, and because of this, they affect heart rate, blood pressure, and respiration rate. Beta-blockers decrease heart rate and lessen the force of the heartbeat. Due to the decreased heart rate, the oxygen needed to supply the heart also decreases, which in turn lessens respiration rate. Additionally, beta-blockers reduce high blood pressure. The drugs attack the neurotransmissions created by adrenaline and counteract the negative effects of adrenaline and "performance adrenaline."[150]

Beta-blockers are used for a variety of reasons because of their effects on adrenaline, heart rate, blood pressure, and respiration rate. The first beta-blocker drug, propranolol, was introduced in 1964 and then marketed in 1968. It was originally advertised as a treatment for cardiac arrhythmias. Since propranolol was created and distributed, more drug companies have produced beta-blocking drugs that can be used for a variety of medical issues. Doctors prescribe beta-blockers for patients suffering from heart problems or have experienced a heart attack and for patients with high blood pressure. Beta-blockers help these patients by controlling heart rate and blood pressure.[151]

These drugs are also commonly used for people who suffer from psychological issues such as anxiety. Researchers have associated anxiety with the sympathetic nervous system and the noradrenergic system, which is the body system that produces

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http://literati.credoreference.com.

[150] Ibid.

[151] Peggy E. Hayes and S.Charles Schulz, "Beta-blockers in Anxiety Disorders," *Journal of Affective Disorders* 13, no. 2 (Sep-Oct 1987): 121.

noradrenaline. Patients suffering from anxiety show symptoms of increased adrenaline and noradrenaline such as increased heart rate and blood pressure. Due to this connection, beta-blockers can be used to treat patients with anxiety.[152]

Beta-blockers are used for many different anxiety issues including chronic or situational anxiety. These drugs have been prescribed to patients with chronic anxiety disorders such as generalized anxiety disorder, panic disorder, social anxiety disorder, obsessive-compulsive disorder, and post-traumatic stress disorder. Doctors prescribe beta-blockers for these patients either in conjunction with antidepressants or benzodiazepines, which is a class of drugs used to change brain function, or the beta-blockers are used alone. They can also be effective for situational anxiety. Some use beta-blockers for stressful events such as public speaking, medical procedures, musical performance, or other anxiety producing situations.[153]

Despite the benefits of beta-blockers, they have side effects. The possible side effects listed in drug information leaflets are extensive and range from cardiovascular to neurological issues.[154] Of these numerous effects, the most prominent are dizziness, hyperglycemia, or high blood sugar, diarrhea, fatigue, and bradycardia, or low heart rate.[155] These drugs can be especially dangerous for those with certain preexisting

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152 Ibid, 122.

153 Ibid, 120.

154 Anthony J. Barron et al., "Systematic Review of Genuine Versus Spurious Side-Effects of Beta-Blockers in Heart Failure Using Placebo Control: Recommendations for Patient Information." *International Journal of Cardiology* 168, no. 9 (Oct 2013): 3572.

155 Ibid, 3578.

respiratory or cardiac issues. Individuals with these conditions should not take beta-blockers. Musicians who do not have these preexisting issues still need a prescription for the drug and should only use them carefully and sporadically.[156]

Many studies have focused on the effects of beta-blockers on musical performance. These studies researched the drugs' effects on stage fright because many symptoms of stage fright are similar to the negative effects of "performance adrenaline," including increased heart rate, blood pressure, and respiratory rate. The studies proved the value of beta-blockers on these effects. Beta-blockers also improve the physical issues caused by stage fright or performance anxiety. A musician can experience physical tremors, decreased coordination, and/or dry mouth due to the pressures of a performance. Beta-blockers reduce these symptoms and improve the quality of performance in those suffering from these symptoms.[157]

When taking beta-blockers for performance, a musician should be careful. Performers only need a small dose of the drugs, and the effects will last for four to five hours.[158] If the user takes the drugs continuously and for a prolonged amount of time, withdrawal can be difficult and dangerous. Therefore, the drugs should only be used for isolated performances. For those truly suffering from the negative effects of a live performance, the beta-blockers should be used in conjunction with a retraining program

[156] C.O. Brantigan, T.A. Brantigan, and N. Joseph, "Effect of Beta Blockade and Beta Stimulation on Stage Fright," *The American Journal of Medicine* 72, no. 1 (Jan 1982): 93.

[157] Ibid, 88.

[158] Sarah Bryan Miller, "Beta Blockers Help Some Musicians Fight Stage Fright," *McClatchy – Tribune Business News*, March 24, 2013.

that would teach the musician not to need beta-blockers. The diaphragmatic breathing or yoga previously mentioned could be an effective program to help eliminate the need for beta-blockers.[159]

The use of beta-blockers for musical performance is controversial. More recent surveys indicate that over half of professional musicians and music teachers have tried beta-blockers.[160] Musicians who use these drugs claim they are performance enablers rather than performance enhancers. In the athletic world, the World Anti-Doping Agency classified them as performance enhancers and banned their use in 18 different sports.[161]

Some musicians have tried beta-blockers and experienced negative results. The side effects of dizziness and lowered blood pressure can affect a performer's focus and can even cause fainting with improper use. One musician noted that he felt "dumbed-down" when performing and rehearsing on beta-blockers.[162] With medical approval and the proper dosage, beta-blockers can be effective for some and unhelpful for others.

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[159] Brantigan, Brantigan, and Joseph, "Effect of Beta Blockade," 93.

[160] Miller, "Beta Blockers."

[161] Vabren L. Watts, "Beta-blockers Used by Musicians, Athletes, Students to Enhance Performance," *McClatchy – Tribune Business News*, August 16, 2010.

[162] Ibid.

Chapter Four

Conclusions

"Performance adrenaline" generates many changes in the body because of the increased endorphin, serotonin, dopamine, and adrenaline levels. Though each of these chemicals can be useful to a performing singer, the singer should be conscious of these changes so it can enhance the singing and overall performance. "Performance adrenaline" can affect breath, and thus, the voice, but an experienced singer will allow the effects to improve rather than hinder the voice. However, each body is different and the effects of "performance adrenaline" will influence each singer differently. Additionally, each performance will be different, and a singer should be able to adapt to the anticipation and excitement of each unpredictable live performance. The effects of "performance adrenaline" will aid a singer in live performance if he is able to maintain his vocal technique and proper breathing during the excitement. The more practiced and experienced the singer, the better he is able to adapt to the changes.

The effects produced by the chemicals of "performance adrenaline" are extensive. The primary results of endorphin release include pain relief, and regulation of blood pressure, body temperature, respiration, and memory. Serotonin regulates nearly all brain function and, thus, influences most human behavioral processes. It can affect mood, appetite, sexuality, attention, memory, and other behavioral processes. Serotonin also helps regulate blood pressure, cardiac function, and respiratory rate and controls pain. Dopamine primarily affects motor control and cognition. The effects on cognition can influence memory, problem solving, attention, expression, decision-making, and other cognitive functions. Adrenaline increases heart rate, blood pressure, and respiratory rate. It also provides temporary muscle strength and a boost in energy.

These various changes can affect a performing singer positively and/or negatively. Breath, one of the central components of singing, can be the most affected by these changes. The positive and negative effects of "performance adrenaline" can influence many aspects of breath. The depth of the singing breath, the balance of phonation, and the vibrato can be affected by "performance adrenaline," which can affect singing and performance.

Experienced performing singers are able to utilize the positive affects while counteracting the negative effects of "performance adrenaline." Some of the most effective techniques to combat these chemical changes include diaphragmatic breathing, yoga, and beta-blockers. Each method varies greatly from the others; however, each singer should find the most effective technique or combination of techniques that best suits her.

Every singer should strive to experience the positive effects of "performance adrenaline." Shirlee Emmons and Alma Thomas describe the ideal performance as the "peak performance."[163] This thrilling type of performance is not characterized by fear or anxiety. It is a confident, well-prepared, and strong performance supplemented with control, calmness, and focus. It is the ultimate performance wherein a singer sings and

[163] Shirlee Emmons and Alma Thomas, *Power Performance for Singers: Transcending the Barriers* (USA: Oxford University, 1998), 11.

performs her best. This experience is exhilarating and is the reason most singers love to perform.[164]

By being aware of the bodily changes caused by "performance adrenaline," a singer can optimize the positive effects. When the effects of "performance adrenaline" become too overwhelming, a singer should utilize various methods, such as diaphragmatic breathing, yoga, and/or beta-blockers, to counteract the negative effects. With the knowledge and understanding of this "performance adrenaline" phenomenon, a singer can experience the "peak performance" more consistently and more powerfully.

[164] Ibid.

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BIOGRAPHICAL SKETCH

Belinda Paige was born and raised in Western Kansas. She earned her Bachelor of Music degree in Vocal Performance at Boston University as a student of Phyllis Hoffman. She earned her Master of Music degree in Opera Performance at Arizona State University studying voice with Jerry Doan. During her work on the Doctor of Musical Arts degree, she studied with Carole FitzPatrick. She is a member of Phi Kappa Phi and teaches piano and voice in the Phoenix area. She is an active vocalist: her most recent performances have been with the Arizona State University Lyric Opera Theater. Paige initially became interested in the topic of this paper while performing in her undergraduate degree. Before an operatic performance, she fell very ill, but found she was able to perform satisfactorily due to the positive effects of "performance adrenaline." This incident sparked her fascination and desire to research the positive and negative effects of "performance adrenaline."