

THE BIOCHEMICAL POWER OF CHORAL SINGING

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In a time where the state of the arts is ever more fragile, it is important to be reminded of the profound benefits of choral singing. It is well understood that music, in general, contributes to our emotional, physiological, and spiritual well-being. But what about choral music *specifically*? What if I told you that choral music could have an impact on our biochemistry, affecting areas including stress, social bonding, and our immune response? In the midst of a global health crisis where the fate of near-future singing is uncertain, discussing the biochemical benefits of choral singing is an essential concept.

Biochemistry and the Implications for Choral Music

Biochemistry is the branch of science that explores the chemistry in and related to living organisms. It brings together both biology and chemistry. By using chemical knowledge and techniques, biochemists can understand and solve biological problems.¹ Essentially, it's the chemistry of life. Photosynthesis in plants is a great example of biochemistry; plants use light energy to convert carbon dioxide and water into vital glucose. Digestion is a great example of the biochemistry in the human body, as pepsin is an enzyme in the stomach, which breaks down proteins into smaller, biomolecular pieces (more on this later). Our biochemistry plays an essential role in a large host of functions within our body. It's what allows our brain to respond to stimuli in our environment via neurotransmitters. It gives our muscles the capacity to repair and our legs the capacity to run. It even gives rise to our capacity to feel certain emotions. The chemistry you may feel between you and a prospective partner is not simply due to their beautiful smile but also to a *chemical reaction* within yourself. These reactions play an essential role in the way in which we respond to our environment. Understanding group interactions, and how those interactions may influence our biochemistry, play a critical role in understanding the complex human response to choral music.

Science has firmly established that music has profound effects on the mind and body. Moderate, early musical training has been shown to decrease age-related auditory declines, even if the training is discon-

tinued.² A study done by Toyoshima et al., found that playing the piano significantly reduced cortisol stress levels and anxiety. The effect of playing the piano was more profound than other activities, including calligraphy and clay molding.³ Even just listening to music has been shown to increase dopamine levels, make you consume less calories, and reduce pain.⁴ And those are just naming a few! As an anecdotal example, take Oliver Sacks's book *Musicophilia* in which a woman regains control over her leg by being bombarded with a plethora of dance tunes.⁵

In a choral rehearsal, although we may not consciously think about it, physical and mental health are often emphasized. Warm-ups involving motion and stretching are common practice and allow our bodies to feel alive and rejuvenated. Intimate connection to the music gives choristers a means of healthy emotional output, allowing them to be vulnerable in a safe space, reaping positive benefits for the collective mental health. But what about what's actually happening inside our bodies? Could the practice and performance of choral music really be modulating our biochemistry, affecting things like hormone, protein, and neurotransmitter levels? What if we could argue that choral music not only contributes to the wide range of musical, artistic, mental, and physical health benefits, but also benefits our immune system and modulates our brain chemistry?

We already know that singing, especially with others, does wonders for us. However, many of the currently discussed benefits of choral singing come from anecdotal tales of conductors and choristers. This is not to say that they are not reliable, for the individual experience of every person is of the utmost importance. It is, however, to say that using a data-driven approach to understand choral singing may be one of our best allies in supporting the choral art form. The more we understand about how choral singing affects our bodies, the more tools we have in our armory to promote its necessity. Moreover, through an increased understanding of choral singing, it allows us to develop better rehearsal strategies, become more compassionate leaders, and give way to a whole host of new research into the effects of choral singing. With that in mind, let's talk about some biochemistry.



Proteins

Before we dive into all the elements that these studies examine, let's talk about proteins. Now, if you don't feel like reading this entire set of background, no need. Simply use this as a reference as you go through the data, if you have questions. However, if you want to know a bit more about how our body operates, continue reading.

When you first hear the word proteins, you probably think of the typical things we associate with the term: steak, turkey, maybe a soy protein shake. However, protein in its most basic definition refers to a string of amino acids: 10 of these amino acids are made in the body, while we consume another 10 in our diet. Some proteins are rather large, and some can be quite small. Smaller proteins are usually categorized as peptides, as in the case of oxytocin. Many other proteins are built up of multiple protein strands and are intertwined in complex structures that dictate their function. Proteins are present in nearly every living creature, and even in some non-living creatures. In the human body, proteins play major roles in our physical structure along with the transport of molecules. Furthermore, these chains of amino acids play significant roles in catalyzing and facilitating biochemical reactions, known as enzymes. Some proteins, like oxytocin, act as signaling molecules within the body and work to regulate our physiology and influence behavior. These strands of amino acids work around the clock to perform a whole host of functions!

Oxytocin

Oxytocin is a peptide hormone that acts as a neurotransmitter in the brain and is therefore referred to as a neuropeptide. Neuropeptides are a class of neurotransmitters that send messages in your brain via nerve cells and allow these cells to communicate within the body. Similar to humans, where we communicate with others via a whole set of complex speech patterns, body language, and social cues, neurons communicate with each other via neurotransmitters! It's literally the fastest phone call ever (up to 268mph). Each neurotransmitter functions slightly differently, depending on the context of the situation. One of the most

famous neurotransmitters, epinephrine, plays a role in the fight-flight-freeze response.

Oxytocin plays a crucial part in social interactions and reproduction. It is famously known as "the love hormone," due to an increase in blood oxytocin levels after couple's hug or kiss.⁶ It plays a major role in social bonding, which is why it is noteworthy when studying choral singing. Furthermore, oxytocin has been shown to play a part in developing trust with others. One study found that those who inhaled oxytocin before a simulated investment game were more likely to entrust their money with a complete stranger.⁷ Not only does it play a significant role in social bonding, but it also showcases itself in situations where trust is generated.

Antibodies and Immunoglobulin A

Secretory Immunoglobulin A (S-IgA) is an antibody that plays a role in mucosal immunity. Immunoglobulins are also proteins in the most basic sense. They are composed of many different types of protein strands, and even some sugars. Immunoglobulins play an essential role in our fight against infection. Secretory Immunoglobulin A is found in the highest concentrations in tear glands, salivary glands, and mammary glands and in the genito-urinary tract, respiratory system, and gastrointestinal tract. This subclass of Immunoglobulin A plays a substantial role in protecting the oral cavity, lungs, and gut from disease. Levels of Salivary Immunoglobulin A fluctuate in response to physical and psychological stress, and a lack of secretory immunoglobulin can produce significant immunodeficiencies.⁸ Furthermore, this important immunoglobulin responds to the autonomic nervous system, which includes the part of our nervous system that controls our stress response.⁹ It is the human body's first line of defense to many pathogens that plague the mucus membranes.¹⁰ It is generally used as an indicator to measure immune system response.

ACTH and Cortisol

The adrenocorticotropic hormone (ACTH) regulates the secretion of cortisol in your body. ACTH is released via the pea-shaped gland in your brain called the

pituitary gland. This little ball of tissue is responsible for regulating many other hormone-secreting glands in your body. Cortisol, also known as the stress hormone, contributes to the flight-fight-freeze response. Unlike oxytocin, cortisol is a steroid hormone, rather than a protein. This just means that it is not composed of amino acids but instead is based on a four-ring chemical structure. It regulates blood sugar levels, metabolism, inflammation, and memory formation.¹¹ Cortisol levels increase when we experience stress, including both eustress (positive stress) and distress (negative stress). During the day, our cortisol levels rise and fall in response to our environment—a natural and necessary process as a part of our stress response. So, what do these biomolecules have to do with group singing?

The Data

In a study done at Western Michigan University entitled *The Neurochemistry of Social Singing: Bonding and Oxytocin*, researchers examined both standard and improvised performance in a group of four jazz singers.¹² In one case, they were given music and sang exactly what was written (standard performance). In the other condition, improvised embellishments were made throughout the piece (improvised performance). Levels of both oxytocin and ACTH were measured before and after each set of conditions, with recovery time between each session. There was a mean decrease in plasma ACTH after participants sang together. The change in this level was also 21% greater in the improvised performance compared to that of the standard performance. Other studies have also observed similar effects with cortisol and ACTH. For example, a study done at the University of Regensburg found that cortisol levels decreased significantly through all of the rehearsal processes.¹³ However, in the case of performances, other researchers have found data to support the contrary. There seems to be an experiential difference in stress when comparing a rehearsal versus a performance. A rehearsal may exhibit a reduction in stress, given the right environment, whereas a performance may illicit experiences like performance anxiety that would contribute to an increase in cortisol.

Oxytocin levels increased in the improvised perfor-

mance, while there was a mean decrease in the standard performance condition. Interestingly, these levels decreased in the standard performance in stark contrast to the improvised performance. These results imply that the improvised performance was much more conducive to social bonding, compared to the standard performance. This could be due to a number of factors, but may be primarily due to the more active behaviors involved in improvisation, such as listening, responding, and eye contact, among others. But what facilitates this social bonding? Could it be simply due to the social aspect of choir, or is there something more significant at play?

In a study by Kreutz et al., choristers took part in a thirty-minute rehearsal and were assessed for their positive and negative feelings along with levels of cortisol, oxytocin, and DHEA.¹⁴ DHEA is used to calculate a more reliable cortisol level. In order to determine if group singing played a more significant role than verbal interaction, the researchers also had a “chatting” control group. This control group chatted with their neighbors, switching every ten minutes, for a total of three sessions. This was an important control group, as researchers were interested in understanding if verbal interaction alone was enough to elicit the oxytocin response. It was found that oxytocin levels increased in the group rehearsal but not with chatting. Furthermore, positive feelings increased and negative feelings decreased after a choral rehearsal. In the chatting condition, positive feelings also increased, but negative feelings stayed the same.

This is a striking finding with the incorporation of the control group. What this study seems to showcase is that although both chatting and group singing are social exercises, choral singing facilitates social bonding, while verbal communication does not. This increase in oxytocin is similar to that seen in intimate relationships.¹⁵ It was also shown that choral singing increases positive feelings while decreasing negative ones, at least in a rehearsal setting. What is even more interesting is that most of these individuals were amateur singers, underscoring the fact that it is not necessary to be professionally trained in order to elicit these biochemical responses.

In a study by Beck et al., members of the Pacific



Chorale were evaluated in preparation for a performance of Beethoven's *Missa Solemnis*.¹⁶ Changes in S-IgA levels, along with cortisol, were evaluated in two rehearsals and a performance. It was found that secretory IgA levels increased in all three conditions but especially after the performance condition. Cortisol levels increased after the performance but decreased in the rehearsals. It is important to note that these reactions often go hand-in-hand, as stress may also promote an immune response. Moreover, both positive and negative feelings were more closely associated with the performance condition. The primary purpose of this study was to see if certain emotions and experiences associated with singing could be predictors of enhanced immune responses. From largest to smallest predictor, the researchers found that these six phrases were correlated to modulations in S-IgA levels:

- I feel relaxed when singing.
- Singing gives me a kind of high.
- Before singing, my mood usually rises.
- I usually feel detached while singing.
- I was satisfied with my performance.
- I usually feel stressed during performances.

This study showcases that we as human beings are pretty complex, experiencing both more positive and negative emotions within a choral performance. It is important to keep in mind, however, that this is a group of experienced singers who have had at least a decade of experience performing and rehearsing in the choral world. Interestingly, we experience an increase in S-IgA both in performance and rehearsal conditions, showcasing the positive benefit choral singing has on the immune system. The researchers also measured cortisol, but it was later eliminated due to a lower-than-average baseline level. Although seemingly insignificant, this implies that prolonged participation in a choral group may decrease the baseline levels of cortisol in the body. This is a perceived health benefit, as chronic, high lev-

els of cortisol have been associated with anxiety, depression, heart disease, and insomnia.¹⁷ Moreover, high levels of cortisol increase your insulin resistance, which could potentially lead to type 2 diabetes.¹⁸

Other studies have examined immune responses due to choral singing and found similar results. A study done by the Royal College of Music and Tenovus Cancer Care found that singing in a choir for just one hour resulted in significant reductions of cortisol and an in-

“CHORAL SINGING INCREASES POSITIVE FEELINGS WHILE DECREASING NEGATIVE ONES, AT LEAST IN A REHEARSAL SETTING.”

creased number of cytokines (proteins of the immune system), which they believe may benefit the immunity of these cancer patients.¹⁹ Another study done with amateur singers also observed the increased amount of S-IgA in a choral rehearsal but found no observable effect when only listening to choral music.²⁰

The Breakdown

What does this all mean and how can we apply it to choral singing? As evidenced, there seems to be a significant biochemical effect that occurs during group singing. The research indicates that this effect is not based merely on the social interaction itself or the music that is being performed. The act of choral singing generates a complex web of social, emotional, psychological, and physiological factors that generate these biochemical benefits.

Certainly, the data indicates that choral singing increases our S-IgA levels, thereby ramping up one of the first lines of defense in our immune system. Cortisol levels have been shown to increase or decrease based on whether the situation is a rehearsal or performance. Oxytocin levels, however, remain inconclusive, increasing in one study but decreasing in another. It is important to consider when studying the complex interaction and biochemical response of human beings that there

are many variables that cannot be controlled.

One of the most significant results that comes from these studies is that stress plays a very important role in modulating our cortisol levels. The data indicates that we generally see a decrease of cortisol levels in a rehearsal setting. This showcases the generally lower stress conditions of a choral rehearsal, compared to that of a performance. Taking time to address stress and performance anxiety especially in a choral performance is extremely important in attempting to reduce stress levels. It may even contribute to long-term reductions in baseline cortisol levels. It has been found that early exposure to mild stressors increases our ability to regulate emotions and also allows us to develop resilience.²¹ Prolonged exposure, on the other hand, has been shown to have a negative impact on human health, even resulting in immunosuppression.²² Taking time for deep breathing has been shown to decrease cortisol levels significantly, under high stress conditions.²³ Furthermore, cracking a joke or two may positively benefit cortisol levels, as a study of 18 adults showed decreased cortisol in response to laughter.²⁴ What these studies have not done is evaluate higher stress rehearsal conditions. If a performance elicits spikes in cortisol levels due to a combination of more positive and negative feelings, why couldn't a rehearsal? Even small activities such as deep breathing or small bits of physical exercise put an emphasis on the chorister's overall well-being. According to the data, there seems to be a relationship between the positive and negative effects of choral singing and our body's actual biochemical response. In a study of orchestra musicians, there were several positive coping strategies that were related to reducing performance anxiety. These included increased practice, deep breathing and other relaxation techniques, positive self-talk, and mock performance practice.²⁵ Running through a mock performance, when accessible, and promoting positive coping mechanisms, may lead to decreased stress levels during a choral performance. This may benefit the overall health and well-being of your choristers, while giving them positive tools that contribute to their overall mental health! It is important to note, however, that these stress-management strategies have yet to be researched in a choral setting. Nevertheless, managing stress in the choral rehearsal

could ultimately modulate the levels of cortisol and S-IgA within the body, improve our physical health, and benefit our mental well-being.

Oxytocin levels, and its role in social bonding, also requires further exploration. Choral singing is not only a musical activity but also an extremely social one. Whether oxytocin levels decrease or increase after a choral rehearsal varies among studies. As shown in the study done at Western Michigan University, improvisation led to an increase in oxytocin levels, therefore potentially leading to increased social bonding. Incorporating improvisation into the choral rehearsal will not only impact our biochemistry but also our mental health. Studies have shown that the use of improvisation in music therapy enhances self-esteem, self-confidence, emotional well being, and self-awareness.²⁶ See Patrick Freer's article for a practical discussion on incorporating improvisation into the choral classroom.²⁷ Although this may seem dismissible, it is important to note that social bonding is an extremely complex phenomenon. As stated previously, oxytocin levels increase in the space of intimate connections. It is still unclear as to what influences intimate connection in a group setting and how that may relate to oxytocin. However, social connectedness does have a positive impact on health and well-being. According to Stanford Medicine's Center for Compassion and Altruism, strong social connection leads to a 50% increased chance of longevity, strengthens your immune system, contributes to lower levels of anxiety and depression, higher self-esteem, and greater empathy for others.²⁸ These positive benefits showcase the necessity of encouraging connectedness within an ensemble. Generating a choral culture of connectedness is pivotal to experiencing the effects of social bonding. It is not explicitly clear in the data what factors could have contributed to the reduction in oxytocin levels in one study but an increase in another. It would be especially intriguing to look at what factors facilitate social bonding in a choral rehearsal and if those activities lead to an increase in oxytocin levels. Nevertheless, it has been shown that oxytocin levels increase and stay increased in individuals who are in intimate relationships. Yes, it is important to listen and respond to each other in a choral rehearsal. However, without *intimate* social connection, it doesn't



seem that this biochemical effect could be possible.

Final Thoughts


Although the data we have looked at is intriguing, as with all science, there are variables that must be discussed that could have influenced the final results. Although not an exhaustive list, this outlines a few of the potential circumstances to consider when contextualizing this information.

First and most importantly, many of the studies presented did not have an actual control group. A control group is an important part of determining what factors actually played a role in producing the expected outcome rather than other variables that could have influenced the data. Generating control groups for these studies is, however, often difficult, as trying to determine which variables can be controlled and what factors can influence the data in humans is tedious and sometimes impossible. Sample size is also very important. Many of these studies had a relatively small sample size, even as small as four singers. This leads to higher levels of variability among the actual data. Humans are unique, and evaluating individual levels of these biochemical molecules can also be highly variable. It can be difficult to normalize these levels when many of the studies are not done on a larger scale. Larger scale studies are necessary in order to establish precision.

These studies viewed momentary snapshots of modulations in biochemical levels. Understanding the long-term effects of choral singing on our biochemistry, in comparison to other social activities, may be most beneficial. Furthermore, understanding the factors that play a role in facilitating these effects, such as social bonding, are pivotal in understanding how choral singing affects our biochemistry and how we may modify our rehearsals in order to reap these positive benefits. Finally, an increase or decrease in the levels of these neuropeptides, steroids, and antibodies does not necessarily mean they will have a profound influence on human behavior or physiology. Consider this example.

You are having a group of friends over for dinner. You make a nice pasta dish but realize that you added way too much salt to the tomato sauce. You serve it to your guests and half of them have a disgusted look on

their face, while the other half of them did not even notice. Even though the level of salt was too high, only half of the individuals at your dinner party had some sort of response. It's the same way with our biochemistry. Although the levels of oxytocin, cortisol, and S-IgA may have changed, it doesn't mean they will illicit the same physiological or behavioral response in every individual.

All things considered, these studies showcase how choral singing influences our biochemistry and how it affects, and is affected by, social bonding, trust, attachment, stress, and our immune system. For the most part, these are positive impacts, related to positive affects emphasized by many of the researchers. It's a pivotal starting point in researching the effects of choral singing on the individual and on the group. We now understand that choral singing not only impacts our physical and mental health but also contributes to modulations within our biochemistry. We can use this understanding to have more well-rounded discussions regarding the necessity of choral music. Furthermore, we can use these foundational studies as a means to promote and support further research. Choral music is an absolute necessity; it feeds our soul, our heart, our mind, *and* our biochemistry. 

NOTES

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