EXPLORING THE SCIENCE OF ENSEMBLE GESTURES, EMOTION, AND COLLABORATION IN CHORAL MUSIC MAKING

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The whole *is* greater than the sum of its parts. Musicians in ensemble settings have felt this awareness for centuries. However, recent scientific studies are validating this adage by revealing the physiological and psychological processes of cooperative effort, especially musical collaboration. The implications of these ideas are beginning to shape our very definition of "ensemble," while providing new understandings of the benefits of group musical expression on the individual. Presently, topics pertaining to musical perception and creativity are highly popular in neuroscience research.

A major development in the field was the proposing of a human mirror neuron system (MNS).[1] After the discovery in rhesus monkeys of "mirror neurons" that fire during both action and observation of motor behavior, scientists detected a similar working system in the fronto-parietal region of humans. In other words, the brain distinguishes little between throwing a ball and watching another person throwing a ball. The existence of this system provides the neurological mechanism for emotional contagion, a concept developed by Elaine Hatfield, John Cacioppo, and Richard Rapson.[2] It is defined as "the tendency to automatically mimic and synchronize facial expressions, vocalizations, postures, and movements with those of another person and, consequently, to converge emotionally."[3]

There exist scores of clinical studies on mimicry and emotional contagion, and an extensive survey of these materials is beyond the scope of the present article. Moreover, the application of these concepts within the professional literature typically encountered by practicing musicians has focused on emotional contagion between conductor and ensemble. Amy Nagoski, in a thought-provoking April 2010 *Choral Journal* article, offered a theoretical conducting model based on the synchronous relationship between the conductor, ensemble, and audience. Synthesizing a sizable amount of research, Nagoski's article increased awareness of these clinically observed phenomena in order to maximize the effectiveness of conducting gestures. The current article intends to focus primarily on the psychophysiological relationship between individual choral singers independent of conducting gesture. Through these means, the conductor can more fully understand his or her role as an expressive collaborator with the ensemble.

Speech Therapy as Case In Point

To appreciate the powerful influence of nonverbal communication, we begin by examining cases when verbal transmission is significantly hampered. According to the *Stuttering Foundation,* approximately three million people in the United States suffer from this disorder.[4] While trauma and developmental issues are frequently associated with stuttering, the exact cause is still unknown. Neuroimaging data from observed speech-language behavior has, however, helped researchers better understand some of the mechanisms involved. Among other areas of inquiry, they have sought to uncover how individuals with stuttering issues are observed to dramatically improve speech when accompanied by a simultaneous external signal.

"Choral speech," not to be confused with any musical connotations, is one variation of this phenomenon in which the stutterer displays fluent speech patterns when speaking in unison with another individual or group of people. The effect is so pronounced that fluency is observed as being turned "on" or "off" simply with the addition and removal of other voices.[5] Variations of this effect have been similarly documented. In another study, stuttering was reduced by over 70 percent when the external auditory signal consisted of a continuous vowel [a] or sequence of vowels [a – i – u].[6] Interestingly, a sustained fricative consonant [s] had no positive effect on stuttering in the same study, which suggests that our brain differentiates voiced from unvoiced sounds as a means of stuttering inhibition.[7]

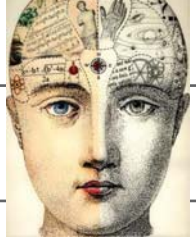
It has been demonstrated that even removal of the auditory signal entirely, if the subject observes another person silently mouthing the words, reduces stuttering by approximately 80 percent.[8] So long as the stutterer perceives the external signal as a form of speech, symptoms improve. Therapy methods incorporating the use of electronic devices that deliver altered auditory feedback (AAF) to emulate these signals have been developed as a result. Semantic content of the signals is also irrelevant, as it appears that the phenomenon is based on motor imitation.[9]

How are these techniques effective? According to Joseph Kalinowski and Tim Saltuklaroglu, choral speech and its variations employ a "gesturing matching system" in which the stutterer mirrors the gestural intent of the external signal.[10] Although the two speakers do not need to produce the aural or visual signals at precisely the same time for speech fluency to occur, mimicry such as mirrored facial expressions in other studies is known to occur in as little as tens of milliseconds.[11] These behaviors associated with emotional contagion, taken out of context from choral speech, are largely subconscious and automated. Synchronization of voice patterns during conversations are equally efficient and include the mimicry of many characteristics including vocal frequency, speech rate, accents, response time lapse, duration of vocalizations, and breathing rates.[12] Using magnetic resonance imaging, researchers found that the perception of emotions in facial expressions triggers certain brain activity involved in experiencing those same emotions.[13] This appears to give an observer access to the subjective state of another by creating an internal simulation of the same neural process, a mechanism argued to have deep evolutionary roots in its ability to help foster social bonds and promote group survival.[14] The relevance for ensembles is evident. But before this point is elucidated, we shall first explore the innate relationship between physical synchronization and collaborative thinking.

A singer's gesticulations to produce expressive sound include the engagement of muscles for proper breathing, coordination of muscles surrounding the laryngeal cavity and the manipulation of resonators during the onset/prolongation of phonation, and peripheral body motion associated with musical expression.

"Muscular Bonding"

Prominent historian and National Humanities Medal recipient William McNeill offers descriptions of military drills, factory worker exercises, and dancing, among other examples, to illustrate how groups of people use visceral movement to emotionally connect through a means he calls "muscular bonding."[15] This rhythmic element, and the sensations created by it, give way to greater potential for cooperation. While conscious effort plays a role when two figure skaters are synchronizing a routine, it is the unconscious empathizing and prediction of each other's movement that allow for smooth and fast coordination. Joint action theory has examined how individuals share movement schemes, identify others' actions with their own, predict others' motions, and jointly plan



ahead.[16] If we relied solely on reacting to other people, we would never achieve the coordination necessary to engage in any variety of activities such as paired figure skating, driving through traffic, or ensemble performance. Joint action theory also connects with the broader topic of *embodied cognition,* which asserts that our physical bodies, not just our brain processes, carry their own cognitive abilities that affect how we perceive things and function in the world around us.[17] This is related to body mapping procedures that notably shed light on the inverse direction of this mind-body communication and prescribe more intellectual awareness of our anatomical characteristics in order to avoid misuse.

Ensemble as Mutual Gesture

> "Finding 'motion' in melodic structures is common enough in music theory, but relating this motion to the movements of a body, in breathing, gesturing, or forming a movement 'phrase'… is an important part of what it is to hear a virtual subjectivity in melodic shapes, the body inscribed in sound."[18]

Just as figure skaters coordinate movements through visceral bonding, most music is produced out of carefully intended physical motion. The late musicologist Naomi Cumming described a listener hearing strength in a particular violin passage and imagining the "tension of her muscles," the "weight of the arm," and the "degree of friction in an attack."[19] A singer's gesticulations to produce expressive sound include the engagement of muscles for proper breathing, coordination of muscles surrounding the laryngeal cavity and the manipulation of resonators during the onset/prolongation of phonation, and peripheral body motion associated with musical expression. Kate Overy and Istvan Molnar-Szakacs suggest that listeners and performers mutually understand these physical precursors of sound production on a deeper level and therefore recruit the same neural networks during performance, which fosters empathy and social attachment.[20] This shared affective motion experience (SAME) model recognizes musical

communication not just in terms of its aural properties but as an intentional, hierarchically organized sequence of expressive motor acts.[21]

The twenty-first century has experienced a resurgence of conductorless ensembles following the wide popularity of the Orpheus Chamber Orchestra, founded in 1972 (Photo 1). The autocratic conductor symbol that reached its zenith in the early to mid-twentieth century is declining as more egalitarian approaches to music making become the trend. Even conductors of large amateur ensembles now routinely offer encouragement for players and singers to perform as "chamber musicians," with string quartets often serving as the classic archetype. Research supports that individuals can coordinate very complex, improvised physical movements without an assigned leader (entering a state of "co-leadership") with the range of group synchronization to less than 40ms apart.[22] These numbers are too fast to be determined by reactive visual feedback alone and imply that the mimicked behavior must also have a predictive element.[23]

The expressive body movement of choral singers in a non-choreographed setting may be considered improvisational and holds the same potential in synchronization rates. Note that these figures are not in reference to the coordination of aural signals but simply peripheral body movement. Nor does this imply that singers should move at exactly the same rate and direction during performance. What is signified is that humans are designed to have the capacity for extremely subtle collaboration through innately predictive behaviors. When there is prediction during complex joint actions, there is shared intention and emotion.[24]

Preparatory Breath as Emotional Synchrony

Much of this "predictive element" in achieving smooth coordination among musicians occurs during the preparation of the musical gesture—the breath. Recent research has linked ensemble singing with various synchronized physiological conditions. In one study, synchronization of both respiration and heart rate variability increased between subjects performing together in unison and in canon.[25] Both of these physical measures are related to one another

Photo 1. Orpheus Chamber Orchestra, January 2009. Photography by Larry Fink.

since the heart accelerates during inhalation and decelerates during exhalation, a coupling affect known as respiratory sinus arrhythmia (RSA).

Graphic analysis of the data in this study even showed the differentiation between voice parts during four-part singing based on the measured levels of cardiac and respiratory synchronization. When the respiration and heart rate variability for both the conductor leading the ensemble and the individual singers were compared, clear correlations emerged. Measurements for the ensemble members and the conductor matched; however, changes in the respiration and heart rate variability of the ensemble occurred slightly after that of the conductor. This unintentional effect reinforces the pedagogical ideal that conductor movements be preparatory in nature. Similarly, Geoff Luck and Petri Toiviainen, citing that aural stimuli tend to be favored over visual stimuli in synchronization activities, propose that ensemble musicians will synchronize between themselves before following the visual-only gestures of the conductor.[26] They deduce that an ensemble may contain its own "inertia" whose resistance to changes in motion represents a natural disposition to time lag behind a conductor.[27]

An even more recent study closely examined the specific effects of musical structure on heart rate variability by measuring subjects as they (a) sustained a hum at their own rate of breathing; (b) sang a mantra with equal and clearly defined breath indications; and (c) sang a hymn composed of two eight-bar phrases with breaths indicated at both two- and four-bar intervals.[28] The study found a strong connection between song structure and heart rate patterns. The heart rates of the subjects tended to accelerate and decelerate simultaneously during hymn and especially mantra singing. In addition, the researchers noted that the phase scores of the mantra singing tended to approach zero, meaning that a longer duration of the exercise would have likely allowed complete synchrony in heart rate phase/frequency among the subjects.

The rate of synchronization between ensemble members is also affected when a specific emotional stimuli is introduced in the musical communication. This notion follows a main tenet of Stephen Porges's Polyvagal Theory that explains how one's "physiological state dictates the range of behavior and psychological experiences."[29] Movement analysis in a study involving musicians in a string quartet revealed that synchrony of head movement among all of the players increased when one of them was asked to invoke a positive emotion such as joy.[30] It also found physiological synchronizations between structural changes and perceived moments of difficulty in the music. Lastly, the study determined that the ability to differentiate between the effects of one's own actions and the actions of others is lessened when the cooperative outcome is more important than the individual's actions.[31] During a choral rehearsal even when everyone appears highly engaged, this means that each singer can begin to lose the ability to distinguish his or her own errors among the ensemble even though they can perceive their occurrence.

Shared Faces and Chemistry Among Us

Singers utilize facial muscles for communicating musical expression and as a necessary function for vocal production. Besides its functional value, Livingstone *et al* suggest that muscular movement in the face may also play a role in emotional planning for the singer.[32] It has already been demonstrated that deliberate manipulation of facial expressions can dramatically influence self-reports of felt emotions and their intensity.[33] There are even neural studies suggesting that emotional experience may follow facial expressions rather than precede them.[34]

Biochemical levels serve as another mechanism that connects facial expression with emotion in individuals. In all, singing has been linked with several chemical changes in the body; these various correlations with chemical balancing strengthen the argument that individuals who sing together synchronize physiologically.

Synchronized coordination of facial muscles to create a uniform formation of vowels and consonants in an ensemble setting may be a contributing factor to emotional contagion among singers. Involuntary mimicking of vowel formation between conductor and choristers, observed through motion-captured video, has already been clinically demonstrated to occur in a choral rehearsal setting.[35] Establishing such a link between shared vowels and emotional synchrony among singers may make a valuable conjecture for further study.

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chemical changes in the body, including: (a) decreased cortisol levels which is linked to low levels of stress[36]; (b) increased levels of salivary immunoglobulin A (S-IgA) which is a protein that helps the immune system[37]; (c) increased oxytocin concentrations that have been long associated with improved social bonding[38]; and (d) decreased levels of TNF-alpha in amateur singers.[39] The latter is a protein in the body's stress regulatory system associated with decreased immunity, inflammation, and rheumatoid arthritis. Besides these studies that suggest singing can be beneficial for health purposes, these various correlations with chemical balancing strengthen the argument that individuals who sing together synchronize physiologically.

The Quantum Choir

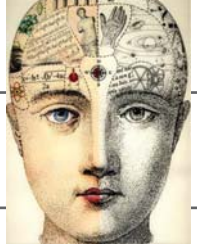
A new wave of scientific inquiry focused on musical perception has given rise to various subdisciplines such as cognitive musicology, music psychology, biomusicology, psychoacoustics, neuromusicology, and others. With this explosion of new data, it is tempting to surmise that someday all aspects of musical performance may be quantified mathematically. For most of us, however, the very idea of deducing our art to mere statistical figures is antithetical to the spirit in which we interact with music. We know that the very nature of ensemble presumes an enormous host of complex interpersonal dynamics and ever-changing emotional forces that directly affect musical performance. Hence, no method of scientific inquiry will lead to complete understanding of the choral art or its fullest potential for emotional contagion.

We should, then, consider these uncertainties as typical attributes of "ensemble," since music itself is constantly changing in emotional sentiment, intensity, and gesture shapes—what Eduard Hanslick aptly called *tonend bewegte Form* "sounding form in motion."[40] The embrace of these variables may best be characterized by using the term "Quantum Choir," which alludes to the paradigm shift between classical (Newtonian) physics—believing the universe followed universal and measureable laws—to the modern quantum physics model—based on the concept of the uncertainty principle. With the advent of powerful microscopes, scientists discovered that subatomic particles did not always follow the laws established by classical physics. They found the subatomic world to be a seemingly chaotic system in which particles would disappear and reappear in different locations, be influenced by other particles located enormous distances away, and even exist in two places at once.

The uncertainty principle (or Heisenberg's uncertainty principle, named after one of the key originators of quantum physics) implies that one cannot measure the exact physical properties of an object without himself affecting these properties. The significance of this statement goes beyond the "observer effect" already known in classical physics but has further implications on the role of consciousness and free will. Unlike classical physics, which attempted to measure in exact values (fine for apples but not subatomic particles, which ultimately make up apples), quantum physics is based on probability of action. The insertion of a single particle in a system allows for any number of consequences on how the rest of the particles will interact, resulting in many possible outcomes.

Empathy as the Engine of Ensemble

"Whether making entirely different musical contributions to weave a musical texture, or all producing exactly the same sounds, the whole is much greater than the individual parts, from a choir to a drum circle to the stadium bleachers. The emerging sound is a group sound,



> almost 'larger than life,' created by a sense of shared purpose. The intentional gestures and actions are simply a means to an end: coordinated activity and the affective experience that results from the sound."[41]

In his best seller *The Tipping Point,* Malcolm Gladwell argues that social epidemics and ideas are not spread uniformly throughout a population. Individuals contribute to the diffusion of trends and fashions with varying degrees. Gladwell's "Law of the Few" principle dictates that some people are imbued with specific gifts such as "social connections and energy and enthusiasm and personality."[42] Emotions within an ensemble are similarly strewn since empathetic abilities (both as a receiver and infector of emotions) vary not only between singers but also within the individual depending on his or her particular mood or circumstance that day.

As conductors, we must be able to gauge the overall mood in a rehearsal by being sensitive to things such as our singers' body language and our own subtle effects through postures, facial expressions, and tone of voice. Any emotional "baggage," even resulting from a difficult commute to rehearsal, translates into information that can be perceived by those around us. We should encourage our singers to be receptive to emotional contagion and can achieve this through example and by trust.

Ramona Wis applies this thinking when she describes the conductor's role as a "servant leader" and draws the sharp distinction between inspiring others and simply managing.[43] In their book *Fusion Leadership,* Robert Daft and Robert Lengel equate this to "unlocking the subtle forces" in individuals that "encourages conversations, information sharing, and joint responsibility."[44] A popular quote by American author Daniel Pink recognizes that "the future belongs to a very different kind of person with a very different kind of mind—creators and empathizers, pattern recognizers, and meaning makers."[45]

Understanding subconscious, collaborative forces such as emotional contagion, joint action theory, and even biochemical influences provides another tool for the conductor who seeks to realize the ensemble's full musical and interpersonal potential. A discussion of conducting technique and its obvious application was deliberately avoided in order to place sole focus on the properties of the ensemble-as-instrument. Conductors are responsible for inspiring their singers just as they are ultimately responsible for their musical performance. If the theory of emotional contagion tells us anything, it teaches us that these two goals are intrinsically related.

Effectual leaders (a) sense and help alleviate increased anxiety in a group, (b) determine how far members can be challenged before breaching morale, and (c) know when to give up control in allowing the whole to supersede the parts. Moreover, the quantum physics model reminds us that one's willingness to give up control is not only valid but at times preferable. The idea of ensemble having some basis on uncertainty does not invalidate the growing scientific research regarding music and emotion. Rather, it opens our eyes to possibility and the understanding that although cause-effect relationships have their necessary place in collaborative performance, they are not the entire answer. Conductors must embrace those unexpected moments and understand them as part of the interconnected fabric that makes ensemble music making such a powerful human experience.

NOTES

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